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February-2020

SOIL STABILIZATION BY USING CEMENT

A Projected Thesis

Submitted by

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In Partial Fulfillment of the requirements for the degree

of Bachelor of Science (B.Sc.) in Civil Engineering

February-2020

A Projected Thesis

Submitted by

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February-2020

CERTIFICATION

This is to certify that the Project report on **"Soil Stabilization by Using Cement** is the bonfire of project work done by Md. Mahfujul Islam, ID: CEN05909198, Muntasir Alam, Id: CEN05909142 Md. Shamim Ferdous,ID: CEN05408451, M.M. Mahbubur Rahman, ID: CEN05108009 impartial fulfillment of the requirements of the Degree of Bachelor of Science in Civil Engineering from the Stamford University Bangladesh.

This Project work has been carried out under my guidance and is a record of successful work.

Thesis Supervisor,

....

Berjees Anisa Ikra

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DECLARATION

We do hereby solemnly declare that the works presented in this project report on **"Soil Stabilization by Using Cement"** has been carried out by us. It has not been previously submitted to any University/Collage/Organization for any academic qualification or for any professional qualification. We hereby ensure that the presented project work does not breach any existing copy right etc.

We are further giving undertake to indemnify the University against any loss or damage arising from breach of forgoing obligations.

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DEDICATION

We dedicate this thesis to all the teacher in our life. We would also like to dedicate our work to our mentor, **Berjees Anisa Ikra** (Supervisor, Project and Thesis and Profession, Dept. of Civil Engineering, Stamford University),

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The project and thesis **"Soil Stabilization by Using Cement"** has been conducted partial fulfillment of the requirement for the degree of Bachelor of Science (B.Sc.) in Civil Engineering.

Firstly, we should like to show our highest gratitude to the Almighty Allah for his kindness on us that make it possible for us to complete this study and preparation of the project and thesis. The completion of this work has become possible for us due to unconditional help and co-operation in different ways from many people. We express our gratefulness thanks to them for their best co-operation they have rendered. We are grateful to **Berjees Anisa Ikra,** Department of Civil Engineering, Stamford University Bangladesh for such opportunity for us to pursue studies in acquiring the degree of B.Sc. in Civil Engineering, who helped us a lot of by giving patient hearing sufficient time for discussions and continuous suggestions and guidance for preparation of this project &thesis.

Finally, we also express our heartiest thanks to the faculty members of the Dept. of Civil Engineering, Stamford University Bangladesh, Dhaka, for providing important suggestions & valuable time to fulfill the entire project.

ABSTRACT

Soil stabilization of soil is done by mixing Portland cement with water and compacting the mix to attain a strong material. The material obtained by mixing soil and cement is known as soil-cement. The soil cement becomes a hard and durable structural material as the cement hydrates and develops strength.

Cement stabilization is done while the compaction process is continuing. During the compaction process we use some amount of cement. Some void space can be found in soil particle. Cement is just like paw, so cement can fill the void space of soil easily. As a result, void ratio of soil may reduce. After this primary tasks, when we add water in the compaction the cement reacts with water and become hard. So unit weight of soil is also may increased .Soil-cement is sometimes called cement-stabilized base, or cement-treated aggregate base. We used standard proctor test for laboratory experiment, in the laboratory experiment, we added .8%, 10%, 12%, 14%, water in the soil. From the observed data we found that for a certain limit with the of water content the value of dry density in increased, after attaining a peak point the value of dry density in decreased when we increase the amount of moisture content. From the peak value of the graph we determined maximum dry density and optimum moisture content. We continued the same experiment for different percentage of cement mixing with soil. From the experimental value we observed that maximum dry density of the sample in increase with increasing percentage of cement with sample.

In this research we find that:

- The soil type is Silty Clay (Lean Clay, CL).
- The specific gravity of soil without cement=2.72 and with cement 2%=2.74, with cement4%=2.76, and with cement 6%=2.79.
- Particle Size Analysis by Hydrometer Test. (D_{30})= 0.007 mm &(D_{60})= 0.031mm
- Liquid Limit for37%.plastic limit=25.71 &plasticity index=11.29
- Final results of compaction test 0% cement ρd =1.67(gm/cm^3), OMC =17.70%. 2% cement ρd =1.71(gm/cm^3), OMC = 18.30%. 4% cement ρd =1.74(gm/cm^3), OMC = 19.20%. 6% cement ρd =1.77(gm/cm^3), OMC = 21.09%

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INTRODUCTION

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Introduction

1.1 Background

Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. It is required when the soil available for construction is not suitable for the intended purpose, in its broadest senses, stabilization includes compaction reconsolidation, drainage and many other such processes. However, the term stabilization is generally restricted to the processes which alter the soil material itself for improvement of its properties. A cementing material or a chemical is added to a natural soil for the purpose of stabilization. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures and to increase its shear strength. Soil stabilization is required to increase the bearing capacity of foundation soils. However, the main use of stabilization is to improve the natural soils for the construction of highways and airfields. The principles of soil stabilization are used for controlling the grading of soils and aggregates in the construction of bases and sub-bases of the highways and airfields. Soil stabilization is also used to make an area trafficable within a short period of time for military and other emergency purposes. Sometimes, Soil stabilization is used for city and suburban streets to make them more noise-absorbing.

The mixing of soil and cement and increase the stabilization capacity of soil is called soil stabilization. The mixture is also called soil cement. Soil-cement is a highly compacted mixture of soil/aggregate, cement, and water. It is widely used as a low-cost pavement base for roads, residential streets, parking-areas, airports, and shoulders and materials-handling and storage areas. It advantages of great strength and durability combine with low firstcost to make it the outstanding value in its field. A thin bituminous surface is usually placed on the soil-cement to complete the pavement,

Soil-cement is sometimes called cement-stabilized base, or cement-treated aggregate base. Regardless of the name, the principles governing its composition and construction are the same. Soil compaction occurs when soil particles are pressed together, reducing pore spaces between them. Soil compaction increases soil strength-the ability of soil to resist the failure.

Soil compaction changes pores pace, particle size, particle distribution and soil strength. One way to quantify the change is by measuring the bulk density. As the pore space is decreased within a soil, the bulk density is creased (Compaction Handbook, 2008) If compaction is performed improperly, settlement of the soil could occur and result in unnecessary maintenance costs or structure failure. Almost all types earth work projects and other construction projects utilize mechanical compaction techniques.

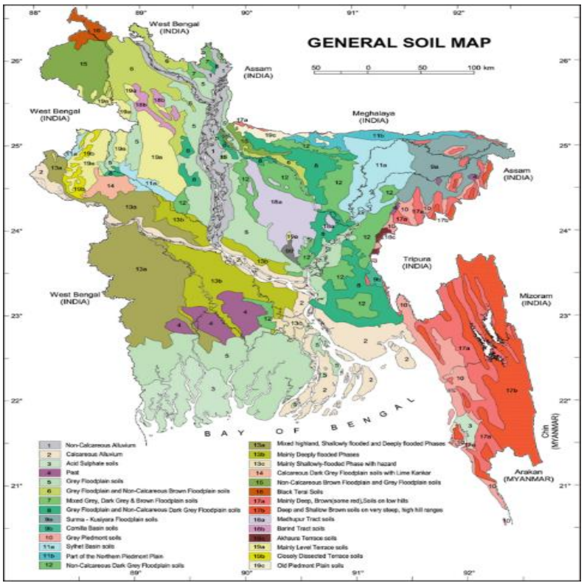

Figure 1: Soil map of Bangladesh

1.2 Purpose

The purpose of compaction is to improve the qualities of the soil used either as a sub-grade materials for roads or in the fills of any project. There are five principle reasons to compact soil:

a. Increases density of soil.

b. Prevents soil settlement and frost damage.

c. Provides stability.

1.3 Objective

1. To Specify the soil sample by USCS method and field identification test.
2. To determine specific gravity of soil.
3. To determine gradation curve
4. To determine the Atterberg Limit of the soil.
5. To determine optimum moisture cement w% with different % of cement.
6. To determine maximum dry density of soil with different % of cement.

CHAPTER-2

LITERATERATURE REVIEW

CHAPTER 2

LITERATERATURE REVIEW

2.0 Literature Review:

Stabilization with cement is a common treatment technology for the safe management, reuse and treatment for disposal of contaminated waste. Portland cement is composed of calcium-silicates and calcium-aluminates that, when combined with water, hydrate to form the cementing compounds of calcium-silicate hydrate and calcium-aluminates-hydrate, as well as excess

Calcium hydroxide. Because of the cementations material, as well as the calcium hydroxide (Cement) formed, Portland cement may be successful in stabilizing both granular and fine-grained soils, as well as aggregates and miscellaneous materials. The permeability of cement stabilized material is greatly reduced. The result is a moisture-resistant material that is highly durable and resistant to leaching over the long term. Cement-soil Stabilization is another technique, Where Portland cement can be used to stabilize and strengthen certain type of soils. CSB constructed in accordance of the requirements of the RDA standard specifications for construction of roads & bridges sub sections 1708.3 for soils and 1703 for cement. In this regard granular soils are very effective for cement stabilization. The required quantity of Portland cement is mixed with soil, which is to be stabilized, followed by mixing with water uniformly, preferably with a pulverize-type machine like pug mill, and transported and deposited at the site and spread to the specified depth, followed by fine grading compaction. The principal materials used for the cementations stabilization of highway pavement materials with Portland cement. Stabilization projects are almost always site-specific, requiring the application of standard test methods, along with fundamental analysis and design procedures, to develop an acceptable solution. As with any such process, adherence to strict environmental constraints is vital to project success. The use of cementations materials makes a positive contribution to economic and resource sustainability because it allows enhancement of both standard and substandard in situ soils to levels consistent with the requirements of a given application. The behavior of every foundation, roads, airfields etc. Depends primarily on the engineering characteristics of the underlying deposits of soil or rock. The proper compaction of the soil is intended to ensure that the compacted soil will reliably and safely withstand loads of various kinds. Soil compaction on construction sites occurs either deliberately when foundations and sub grades are prepared or as an unintended result of vehicular traffic (Randrup and Dralle 1997). Soil compaction decreases porosity (e.g. Harris 1971). To determine whether a soil is compacted or not, and thus whether a treatment is necessary for the alleviation of soil compaction, the degree of compaction needs to be quantified.

Experiment of soil is very important & must needed for safe and economic design for any project. By experiment we can find out the characteristics of soil and its capacity. In this book we described about cement stabilization of soil using proctor compaction test. The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. These laboratory tests generally consist of compacting soil at known moisture content into a cylindrical mold of standard dimensions using a comp active effort of controlled magnitude. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content.

2.1 Cement Stabilization

- Most commonly used for road constructor,
- heavy clays are difficult to pulv1ri2e and not suitable.
- Well graded sand and gravel mixtures with up to 10% fine binder material <passing# 200 sieve:).
- Quantum of cement to be determined on trial basis in lab.
  Minimum strength required 3.5N/mm2-7 Days Cube Strength.
- Compaction to foe completed within two hours after laying mixing with water.
- Central Plant Method: Faster construction, expansive, dry mix and then wet thoroughly, spreading and compaction.
- Mix in Place Method: Similar to agriculture rotary cultivation, firstly soil is pulverized then dry cement is spread over, then water sprinkled in layers, again remixed and shaped to camber, compacted using rollers.

2.2 Immediate Effect Soil Improvement:

1.A reduction in the plasticity index: The soil suddenly switches from being plastic (yielding and sticky) to being crumbly (stiff and grainy), in the latter condition it is easier to excavate, load, discharge, compact and level.

2.An improvement in the compaction properties of the soil: The maximum dry density drops while the optimal water content rises, so that the soil moves into a humidity range that can be easily compacted. This effect is clearly advantageous when used on soils with a high-water content, A treatment with quick therefore makes it possible to trans form a sticky plastic soil, which is difficult to compact, into a stiff, easily handled material. After compacting, the soil has excellent load -bearing properties.

3. Improvement of bearing capacity. In most cases, two hours after treatment, the CBR (California Bearing Ratio) of a treated soil is between 4 and 10 times higher than that of an untreated soil. This reaction greatly relieves on-site transportation difficulties.

2.3 Moisture-Density Relationship (compaction):

Soil compaction means increasing soil density that makes working with soil easy, helps in erecting stable structures, and reduces maintenance costs. Read to learn about the desirable, and undesirable, effects of mechanical soil compaction on construction and agricultural works.

Compaction of soil brings stability and strength with it, Foundations fail most commonly Because of improper compaction methods or poorly compacted soil that allows water to seep through the foundation and cause structural damage. Implementing mechanical methods to the compact soil means dandifying the soil, filling the pore spaces, improving the shear resistance of soil, and providing better water movement through the soil particles. The compaction process largely depends upon the type of soil you are dealing with because different soils have different physical properties and accordingly different compaction methods should be adopted. Compaction also prevents frost damage of soil and increases its durability.

2.4 Specific Gravity:

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference to the substance for the same given volume. *Apparent* specific gravity is the ratio of the weight of volume of the substance to the weight of an equal volume of the reference substance. The reference substance is nearly always water at its density (4°C) for liquids; for gases it is air at room temperature (21°C). Nonetheless, the temperature and pressure must be specified for both the sample and the reference pressure is nearly always 1 atm (101.325 kPa). In British beer brewing, the practice for specific gravity as specified above is to multiply it by 1000. Specific gravity is commonly used in industry as a simple means of obtaining information about the concentration of solutions of various materials such as brines, hydrocarbons, sugar solutions (syrups, juices, honeys, brewers wort, must etc.) and acids.

2.5 Atterberg Limit

The Swedish soil scientist Albert Atterberg originally defined seven -limits of consistency to classify fine-grained soils, but in current engineering practice only two of the limits, the liquid and plastic limits, are commonly used. (A third limit, called the shrinkage limit, is used occasionally.) The Atterberg limits are based on the moisture content of the soil. The plastic limit is the moisture content that defines where the soil changes from a semi-solid to a plastic (flexible) state. The liquid limit is the moisture content that defines where the soil changes from a plastic to a viscous fluid state. The shrinkage limit is the moisture content that defines where the soil volume will not reduce further if the moisture content is reduced. A wide variety of soil engineering properties have been correlated to the liquid and plastic limits, and these Atterberg limits are also used to classify a fine-grained soil according to the Unified Soil Classification system or AASHTO system.

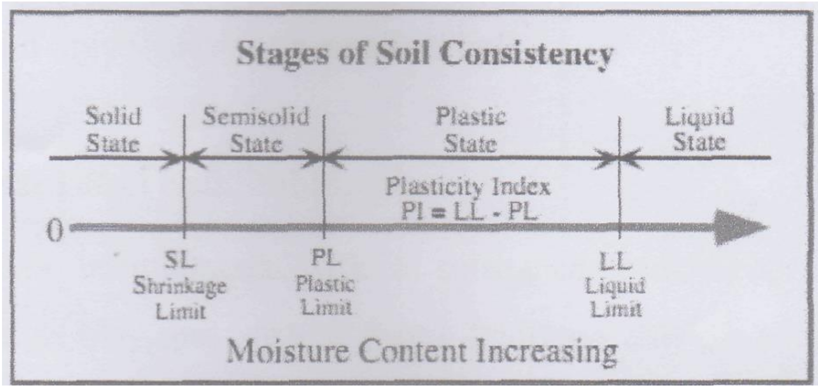

Figure 2: Atterberg Limits (Principles of Geotechnical Engineering, B.M.Das)

2.6 Factors Affecting the Compaction Process:

Compaction of soil depends upon various factors. Among them, grain size distribution of soil optimum moisture content, maximum dry density, layer thickness, and environmental factors are some of the important things to consider. Optimum moisture content (OMC) is the percentage of water present in soil mass at which a specific compaction force can dry the soil mass to its maximum dry Figure shows that the void ratio at QMC is approximately zero and soil is densely compacted. For different types of soils, OMC and maximum dry density curves are different.

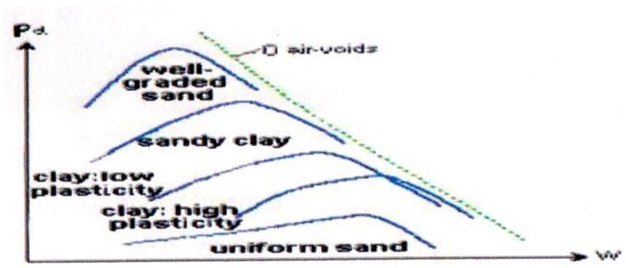

Figure 3: Pd vs W

In the figure, W stands for water content and p(d) stands for Dry Density of soil mass. Standard Proctor and Modified Proctor tests are conducted to determine OMC and the dry density of soil masses. The basic difference between these two tests is the size and weight of hammer used to compact the soil mass. The number of blows remains the same, but the falling height is changed from 12 inches to 18 inches in the modified Proctortest other popular methods of determining OMC and maximum dry density are mentioned below.

- **Sand Cone Test** - Suitable for a large sample, delivers accurate results but requires huge area and more time to perform.
- **Shelby Tube Test** - Suitable for deep and under pipe haunches, not suitable for gravels and only works for a small sample.

2.7 Medium Term Effect Soil Stabilization:

When Cement, comes into contact with a substance containing soluble silicates and aluminates (such as clay and silt), it forms hydrated calcium aluminates and calcium silicates. As with cement, this gives rise to a true bond upon crystallization. As low curing process during road construction is a marked advantage, as it allows greater flexibility when working with the treated soil. The long-term hardening facilitates the design of foundations for industrial platforms. The stabilizing effect gives load-bearing qualities to the treated soil.

2.8 Scarification and Initial Pulverization:

After the soil has been brought to line and grade, the sub grade can be scarified to the specified depth and width and then partially pulverized. It is desirable to remove non-soil materials larger than 3 inches, such as stumps, roots, turf, and aggregates.

2.9 Soil-Cement Stabilization

- Cement stabilization is generally the best type of admixture to be used with soil. It is also commonly available but it is often expensive**.**
- Mixing cement with expansive soils reduces swell potential.
- Generally, the amount of cement required to stabilize expansive soils ranges from 2 to 6% by weight.
- When the pore water in soil encounters the cement, hydration of the cement occurs rapidly and the major hydration products are hydrated calcium silicates, hydrated calcium aluminates, and hydrated Cement**.**
- The hydration of cement leads to a rise in pH value of the pore water, which is caused by the dissociation of the hydrated Cement.

2.10 Factors affecting Cement Stabilization

1) Granular soils with .sufficient soil fines are ideally suited
2) All inorganic soils
3) Soils with 20% of organic matter are generally considered as unsuitable
4) Expansive soils (B.C. soil) are difficult to. Stabilized with cement.

2.11 Cement Stabilization process:

1. Excavation and spreading of material to the required layer thickness for stabilizing
2. lime or cement spreading, with regular checks to control dosage
3.Mixing, to a depth depending on the soil and on the design requirements
4. Sealing the material, preventing carbonization of the while it reacts with the moisture in the soil. This involves trimming of the treated layer using bulldozers and passing over by a smooth roller
5. Allowing (or maturation) period - to allow time for the exothermic chemical reaction to take place between the U and clay
6. Compacting the treated layer with a roller until required compaction is achieved.

2.12. Types of cement Used in Construction:

1.Ordinary Portland Cement (OPC) :Ordinary Portland cement is the most common and versatile type of cement manufactured and used worldwide. It is used for all ordinary purposes, such as making concrete, mortar, and plaster. OPC is available in three different grades namely grade 33, 43, and 53.

2.Portland Pozzolana Cement (PPC): Portland pozzolana cement is prepared by grinding pozzolanic clinker with Portland cement. It is also produced by adding pozzolana with the addition of gypsum or calcium sulfate or by intimately and uniformly blending Portland cement and fine pozzolana.

3.Rapid Hardening Cement: Rapid hardening cement attains high strength in early days it is used in concrete where formworks are removed at an early stage and is similar to ordinary Portland cement (OPC). This cement has increased lime content and contains higher c3s content and finer grinding which gives greater strength development than OPC at an early stage.

4.Extra Rapid Hardening Cement: Extra rapid hardening cement is obtained by addition of calcium chloride to rapid hardening cement. Calcium chloride helps in accelerating the hardening and setting processes of cement. The compressive strength of Extra Rapid

Hardening cement is about 25% higher than that of Rapid Hardening Cement at one or two days.

Pozzolana: Pozzolana, also known as pozzolanic ash (pulvis puteolanus in Latin), is a siliceous or siliceous and aluminous material which reacts with calcium hydroxide in the presence of water at room temperature (cf. pozzolanic reaction).

2.13 Advantages of Cement Stabilization

1.While several reagents can be used for S/S, Portland cement has advantages that make it more economical and easy to use than others:

2.Cement is manufactured under strict ASTM standards, ensuring uniformity of quality and performance,

3.Cement's success in S/S is supported by more than 50 years of use on a variety of projects.

4. Cement has a long-term performance record,

5. Using cement can minimize volume increase compared with other reagents.

6. Cement is a non-proprietary manufactured product, readily available across the country in bag or bulk quantities.

2.14 Disadvantages

1. Can not operate if moisture of soil above 10%.

2 .Cracks may form in soil cement.

3. It is harmful for environment.

4. It requires extra labor.

5. The quantity of water must be sufficient for hydration of cement and making the mixture workable.

CHAPTER-3

METHODOLOGY

CHAPTER-3

METHODOLOGY

3.0 Material:

We use clay soil and cement as a tool for testing in the laboratory. We collect the clay soil from the construction site of the Banshee. The soil depth collect is 70 feet. Then the cement is used for various tests. We collect cement from moghbazar market.

3.1 Field Identification of Soils:

The following chart is used to classify the soil according to USCS system.

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D2488

MAJOR DIVISION			GROUP SYMBOL	LETTER SYMBOL	GROUP NAME
COARSE GRAINED SOILS CONTAINS MORE THAN 50% FINES	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH <5% FINES		GW	Well-graded GRAVEL
				GP	Poorly graded GRAVEL
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GW-GM	Well-graded GRAVEL with silt
				GW-GC	Well-graded GRAVEL with clay
				GP-GM	Poorly graded GRAVEL with silt
				GP-GC	Poorly graded GRAVEL with clay
		GRAVEL WITH ≥ 15% FINES		GM	Silty GRAVEL
				GC	Clayey GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH <5% FINES		SW	Well-graded SAND
				SP	Poorly graded SAND
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND with silt
				SW-SC	Well graded SAND with clay
				SP-SM	Poorly graded SAND with silt
				SP-SC	Poorly graded SAND with clay
		SAND WITH ≥ 15% FINES		SM	Silty SAND
				SC	Clayey SAND
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY	LIQUID LIMIT LESS THAN 50		ML	Inorganic SILT with low plasticity
				CL	Lean inorganic CLAY with low plasticity
				OL	Organic SILT with low plasticity
		LIQUID LIMIT GREATER THAN 50		MH	Elastic inorganic SILT with moderate to high plasticity
				CH	Fat inorganic CLAY with moderate to high plasticity
				OH	Organic SILT or CLAY with moderate to high plasticity
HIGHLY ORGANIC SOILS				PT	PEAT soils with high organic contents

Figure 4: Unified Soil Classification System (USCS)

Select a representative sample of the material for examination. Silt and clay particles are not visible to eye the amount of silt and clay in a soil sample can be identified by the following field tests:

- Dispersion Test
- Dry strength Test
- Dilatancy Test
- Plasticity Test

Dispersion Test:

- A small quantity of the collected soil sample is dispersed or mixed with water in a glass cylinder or test tube or beaker and then allowed to settle.
- Silt particles usually settle in 15 to 60 min. whereas clay particles will remain in suspension for at least several hours or may remain even for several days. If some sand particles are present in sample, then it settles in 30 to 60 sec.

2. Dry Strength Test:

- At first the soil samples are molded. Then prepare four or five pats from this molded sample, about 25 mm in diameter and 6 mm in thickness.
- Dry all the pats completely (either naturally or in an oven).
- Measure its resistance to crushing between the fingers. This resistance, called the dry strength or crushing strength, is a measure of the plasticity of the soil.
- Crushing of dry clay lumps is relatively difficult, whereas silt lumps break quite easily.
- Test the strength of the dry pats or lumps by crushing between the fingers and note the strength in accordance with the criteria.

3. Dilatancy Test:

From the specimen select enough material to mold into a ball about 0.5" in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. "Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or punching the soil between the "mgers, and note the reaction in accordance with the criteria.

4. Plasticity Test:

- Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in, in diameter. If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.
- Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumbles at a diameter of 1/8 in, when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit.
- Also note the strength of the thread. After the thread crumbles, note the toughness of the materials during kneading.

3.2 Compaction Test

This laboratory test is performed to determine the relationship between the moisture content and the dry density of a soil for a specified compactive effort. The compactive effort is the amount of mechanical energy that is applied to the soil mass. Several different methods are used to compact soil in the field, and some examples include tamping, kneading, vibration, and static load compaction. This laboratory will employ the tamping or impact compaction method using the type of equipment and methodology developed by R. R. Proctor in 1933, therefore, the test is also known as the Proctor test Two types of compaction tests are routinely performed: l)The Standard Proctor Test, *(2)* The Modified Proctor Test. Each of these tests can be performed in three different methods as outlined in the attached Table 1. In the Standard Proctor Test, the soil is compacted by a 5.5 Ib hammer falling a distance of one foot into a soil filled mold. The mold is filled with three equal layers of soil, and each layer is subjected to 25 drops of the hammer. The Modified Proctor Test is identical to the Standard Proctor Test except it employs, a 10 Ib hammer falling a distance of 18 inches, and uses five equal layers of soil instead of three. There are two types of compaction molds used for testing. The smaller type is 4 inches in diameter and has a volume of about 1/30ft^3(944 cm^3), and the larger type is 6 inches in diameter and has a volume of about 1/13.333 ft^3(2123 cm^3). If the larger mold is used each soil layer must receive 56 blows instead of 25.

Figure 5: Compaction test

3.21 Standard Reference:

ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbs/ft^3 (600 KN-m/m3)) ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/ft^3 (2,700 KN-$^{m/m3))}$.

3.22 Significance:

Mechanical compaction is one of the most common and cost effective means of stabilizing soils. An extremely important task of geotechnical engineers is the performance and analysis of field control tests to assure that compacted fills are meeting the prescribed design specifications. Design specifications usually state the required density (as a percentage of the "maximum" density measured in a standard laboratory test), and the water content. In general, most engineering properties, such as the strength, stiffness, resistance to shrinkage, and imperviousness of the soil, will improve by increasing the soil density. The optimum water content is the water content that results in the greatest density for a specified compactive effort. Compacting at water contents higher than (wet of) the optimum water content results in a relatively dispersed soil structure (parallel particle orientations) that is weaker, more ductile, less pervious, softer, more susceptible to shrinking, and less susceptible to swelling than soil compacted dry of optimum to the same density. The soil compacted lower than (dry of) the optimum water content typically results in a flocculated soil structure (random particle orientations) that has the opposite characteristics of the soil compacted wet of the optimum water content to the same density.

3.23 Equipment:

a) Molds

b) Manual rammer

c) Extruder

d) Balance

e) Drying oven

f) Mixing pan

g) Trowel

h) #4 sieve

i) Moisture cans

j) Graduated cylinder

k) Straight Edge.

3.24 Test Procedure:

1) Depending on the type of mold you are using obtain a sufficient quantity of air-dried soil in Large mixing pan. For the 4-inch mold take approximately 10 Ibs and for the 6-inch mold take roughly 15 Ibs. Pulverize the soil and run it through the # 4 sieve.

2) Determine the weight of the soil sample as well as the weight of the compaction mold with its base (without the collar] by using the balance and record the weights.

3) Compute the amount of initial, water to add by the following method: (a) Assume water content for the first test to be 10 percent 100 soil mass in grams 10 water to add (in ml)= Where "water to add" and the "soil mass" are in grams. Remember that a gram of water is equal to approximately one milliliter of water.

(4) Measure out the water, add it to the soil, and then mix it thoroughly into the soil using the trowel until the soil gets a uniform color.

(5) Assemble the compaction mold to the base, place some soil in the mold and compact the soil in the number of equal layers specified by the type of compaction method employed The number of drops of the rammer per layer is also dependent upon the type of mold used. The drops should be applied at a uniform rate not exceeding around 1.5 seconds per drop, and the rammer should provide uniform coverage of the specimen surface. Try to avoid rebound of the rammer from the top of the guide sleeve.

(6) The soil should completely fill the cylinder and the last compacted layer must extend slightly above the collar joint If the soil is below the collar joint at the completion of the drops, the test point must be repeated. (Note: For the last layer, watch carefully, and add more soil after about 10 drops if it appears that the soil will be compacted below the collar joint.)

(7) Carefully remove the collar and trim off the compacted soil so that it is completely even with the top of the mold using the trowel. Replace small hits of soil that may fall out during the trimming process.

(8) Weigh the compacted soil while it's in the mold and to the base, and record the mass. Determine the wet mass of the soil by subtracting the weight of the mold and base.

(9) Remove the soil from the mold using a mechanical extruder and take soil moisture content samples from the\top and bottom of the specimen. Fill the moisture cans with soil and determine the water content \

(10) Place the soil specimen in the large tray and break up the soil until it appears visually as if it will pass through the # 4 sieve, add 2 percent more water based on the original sample mass, and re-mix as in step 4, Repeat steps 5 through 9 until, based on wet mass, a peak value is reached followed by two slightly lesser compacted soil masses.

3.3 Specific gravity

3.31 Purpose:

This lab is performed to determine the specific gravity of soil by using a pycnometer. Specific Gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

3.32Standard Reference:

ASTM D 854-00 - Standard Test for Specific Gravity of Soil Solids by Water Pycnometer.

Significance: The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

3.33 Equipment:

a) Pycnometer

b) Balance

c) Vacuum pump

d) Funnel

e) Spoon.

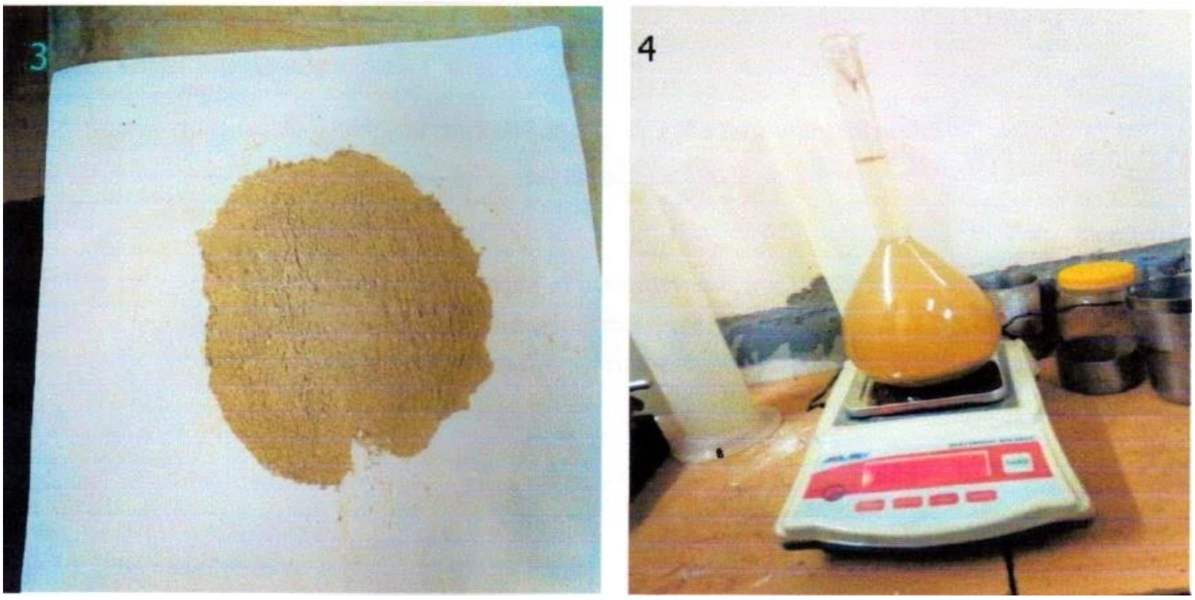

Figure 6: Field test of specific gravity

3.34 Test procedure:

1. Determine and record the weight of the empty clean and dry pycnometer .

2.place10g of a dry soil sample (passed through the sieve no.10) in the pycnometer.determine the record the weight of the pycnometer containing the dry soil.

3. Add distilled water to fill about half to three-fourth of the pycnometer.soak the sample for 10 minutes.

4. Apply a partial vacuum to the contents for 10 minutes,to remove the enrapped air.

5.Stop the vacuum and carefully remove the vacuum line from pycnometer.

6.Fill the pycnometer with distilled(water to the mark),clean the exterior surface of the pycnometer with a clean, dry cloth.determine the weight of the pycnometer and contents.

7.Empty the pycnometer and clean it.then fill it with distilled water only (to the mark)clean the exterior surface of the pycnometer with a clean,dry cloth.determine the weight of the pycnometer and distilled water.

8.Empty the pycnometer and clean it.

3.4 Atterberg limits

Purpose:

The Atterberg limits can be used to distinguish between silt and clay, and to distinguish between different types of silts and clays. The water content at which the soils changes from one state to the other are known as consistency limits or Atterberg's limit.

3.41 Standard Reference

SIM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. ASTM D 427-04 - Standard Test Method for Shrinkage Factors of Soils by the Mercury Method

3.42 Significance

The Swedish soil scientist Albert Atterberg originally defined seven "limits of consistency" to classify fine-grained soils, but in current engineering practice only two of the limits, the liquid and plastic limits, are commonly used. (A third limit, called the shrinkage limit, is used occasionally.) The Atterberg limits are based on the moisture content of the soil. The plastic limit is the moisture content that defines where the soil changes from a semi-solid to a plastic (flexible) state. The liquid limit is the moisture content that defines where the soil changes from a plastic to a viscous fluid state. The shrinkage limit is the moisture content that defines where the soil volume will not reduce further if the moisture content is reduced. Awide variety of soil engineering properties have been correlated to the liquid and plastic limits, and these Atterberg limits are also used to classify a fine-grained soil according to the Unified Soil Classification system or AASHTO system.

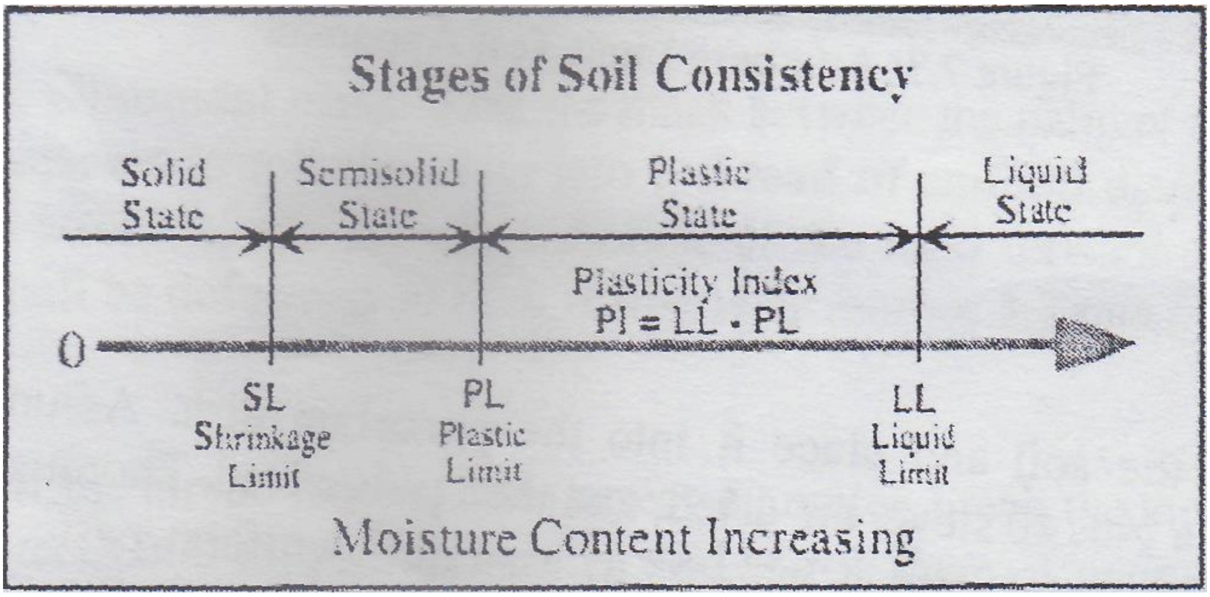

Figure 7; Atterberg Limits (Principles of Geotechnical Engineering, B. M. Das)

3.43 Equipment

- Liquid limit device
- Porcelain (evaporating) dish
- Flat grooving tool with gage,
- Moisture cans
- Balance
- Glass plate
- Spatula
- Wash bottle filled with distilled water
- Drying oven set at 105°C

Figure 8: Atterberg Limit Test Apparatus

Test Procedure

3.43 Liquid Limit

(1) Take roughly 3/4 of the soil and place it into the porcelain dish. Assume that the soil was previously passed through a No. 40 sieve, air-dried, and then pulverized. Thoroughly mix the soil with a small amount of distilled water until it appears as a smooth uniform paste. Cover the dish with cellophane to prevent moisture from escaping.

(2) Weigh four of the empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

(3) Adjust the liquid limit apparatus by checking the height of drop of the cup. The point on the cup that comes in contact with the base should rise to a height of 10 mm. The block on the end of the grooving tool is 10 mm high and should be used as a gage. Practice using the cup and determine the correct rate to rotate the crank so that the cup drops approximately two times per second.

(4) Place a portion of the previously mixed soil into the cup of the liquid limit apparatus at the point where the cup rests on the base. Squeeze the soil down to eliminate air pockets and spread it into the cup to a depth of about 10 mm at its deepest point. The soil pat should form an approximately horizontal surface,

(5) Use the grooving tool carefully cut a clean straight groove down the center of the cup. The tool should remain perpendicular to the surface of the cup as groove is being made. Use extreme care toprevent sliding the soil relative to the surface of the cup.

(6) Make sure that the base of the apparatus below the cup and the underside of the cup is clean of soil. Turn the crank of the apparatus at a rate of approximately two drops per second and count the number of drops, N, it takes to make the two halves of the soil pat

come into contact at the bottom of step eight and do not record the number of drops, otherwise, record the number of drops on the data sheet.

(7) Take a sample, using the spatula, from edge to edge of the soil pat. The sample should include the soil on both sides of where the groove came into contact. Place the soil into a moisture can cover it. Immediately weigh the moisture can containing the soil, record it's mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 16 hours. Place the soil remaining in the cup into the porcelain dish. Clean and dry the cup on the apparatus and the grooving tool.

(8) Remix the entire soil specimen in the porcelain dish. Add a small amount of distilled water to increase the water content so that the number of drops required closing the groove decrease.

(9) Repeat steps six, seven, and eight for at least two additional trials producing successively lower numbers of drops to close the groove. One of the trials shall be for a closure requiring 25 to 35 drops, one for closure between 20 and 30 drops, and one trial for a closure requiring 15 to 25 drops. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

3.44 Plastic limit Test Procedure:

(1) Weigh the remaining empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

(2) Take the remaining 1/4 of the original soil sample and add distilled water until the soil is at a consistency where it can be rolled without sticking to the hands.

(3) Form the soil into an ellipsoidal mass. Roll the mass between the palm or the fingers and the glass plate. Use sufficient pressure to roll the mass into a thread of uniform diameter by using about 90 strokes per minute. (A stroke is one complete motion of the hand forward and back to the starting position.) The thread shall be deformed so that its diameter reaches 3.2 mm (1/8 in.), taking no more than two minutes.

(4) When the diameter of the thread reaches the correct diameter, break the thread into several pieces. Knead and reform the pieces into ellipsoidal masses and re-roll them. Continue this alternate rolling, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling and can no longer be rolled into a 3.2 mm diameter thread.

(5) Gather the portions of the crumbled thread together and place the soil into moisture can, and then cover it. If the can does not contain at least 6 grams of soil, add soil to the can from the next trial. Immediately weigh the moisture can containing the soil, record it's mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 16 hours.

(6) Repeat steps three, four, and five at least two more times. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

3.5 Hydrometer test Purpose:

This test is performed to determine the percentage of different particle sizes contained within a soil. The hydrometer method is used to determine the distribution of the finer particles.

3.51 Significance:

Grain size distribution of soil which contain significant amount of finer particles (silt and clay) cannot be done by sieve analysis. Hydrometer analysis is required to determine the grain size distribution of the finer portion. For many natural soils we require both sieve analysis and hydrometer analysis to obtain the complete gradation of the coarse and fine fraction. In the sieve analysis test you have used #200 sieve (opening 0.074 mm) as the finest sieve. Now you will perform hydrometer analysis on a fine grained soil that passes #200 sieve.

According to ASTM D422, when combined analysis is required, the sample is to be divided into two parts. Sieve analysis is to be done on the coarser portion and hydrometer analysis is to be done into finer portion. Division of the sample into two portion is to be done by either of #4 (4.75mm), #10 (2.00 mm), #40 (0.425mm) or #200 (0.074 mm) sieve depending on the sp.gr. of particles. However, for our natural soils separation on #200 sieve will be sufficient.

3.52Equipment

- Sedimentation Cylinder
- Hydrometer
- Hydrometer Jar bath
- Dispersive agent, Sodium hexametaphosphate (NaPOS)

- Thermometer

Figure 9: Hydrometer Test Apparatus

3.53 Test Procedure

(1) Take the fine soil from the bottom pan of the sieve set, place it into a beaker, and add 125 mL of the dispersing agent (sodium hexametaphosphate (40 g/L)) solution. Stir the mixture until the soil is thoroughly wet. Let the soil soak for at least ten minutes.

(2) While the soil is soaking, add 125rnL of dispersing agent into the control cylinder and fill it with distilled water to the mark. Take threading at the top of the meniscus formed by the hydrometer stem and the control solution. A reading less than zero is recorded as a negative (-) correction and a reading between zero and sixty is recorded as a positive (+) correction. This reading is called the zero correction. The meniscus correction is the difference between the top of the meniscus and the level of the solution in the control jar (Usually about -1). Shake the control cylinder in such a way that the contents are mixed thoroughly. Insert the hydrometer and thermometer into the control cylinder and note the zero correction and temperature respectively.

(3) Transfer the soil slurry into a mixer by adding more distilled water, if necessary, until mixing cup is at least half full. Then mix the solution for a period of two minutes.

(4) Immediately transfer the soil slurry into the empty sedimentation cylinder. Add distilled water up to the mark.

(5) Cover the open end of the cylinder with a stopper and secure it with the palm of your hand. Then turn the cylinder upside down and back upright for a period of one minute. (The cylinder should be inverted approximately 30 times during the minute.)

(6) Set the cylinder down and record the time. Remove the stopper from the cylinder. After an elapsed time of one minute and forty seconds, very slowly and carefully insert the hydrometer for the first reading. (Note: It should take about ten seconds to insert or remove the hydrometer to minimize any disturbance, and the release of the hydrometer should be made as close to the reading depth as possible to avoid excessive bobbing).

(7) The reading is taken by observing the top of the meniscus formed by the suspension and the hydrometer stem. the hydrometer is removed slowly and placed back into the control cylinder. Very gently spin it in control cylinder to remove any particles that may have adhered.

(8) Take hydrometer readings after elapsed time of 2 and 5,8,15,30,60 minutes and 24hours

CHAPTER FOUR

RESULT AND DISCUSSION

4.0 Field Identification Test

Based on the procedure of field identification test, following results are found. According to the results it is seen that the sample soil is silty clay. Based on USCS, the soil is Lean Clay, CL.

Dry Strength	Dilatancy Reaction	Toughness of Plastic	Time to settle	Type of Soil
High	Slow	Medium	15 min	Silty clay

4.1 Specific Gravity

% Cement	Specific gravity
0%	2.72
2%	2.74
4%	2.76
6%	2.79

4.2 Particle Size Analysis by Hydrometer Test

Elapsed Time, t (min)	Actual Reading Ra	RL=Ra + Meniscus Correction	Corrected Reading RC=RL-Zero Correction+CT	L=(16.29-0.1641R)	$-\sqrt{(L/t)}$	k	Particle size, D=K.$\sqrt{\frac{L}{t}}$	% finer P= $\frac{Rc}{Ms} * a * 100$
.25	42	43	41	9.2	6.07	0.01273	0.0772	80.36
.50	39	40	38	9.7	4.40	0.01273	0.0560	74.48
1	34	35	33	10.6	3.25	0.01273	0.0413	64.68
2	30	31	29	11.2	2.36	0.01273	0.0300	56.84
4	27	28	26	11.7	1.71	0.01273	0.0217	50.96
8	23	24	22	12.4	1.24	0.01273	0.0157	43.12
15	20	21	19	13.2	0.94	0.0127	0.0119	37.24
30	18	19	17	13.5	0.67	0.01273	0.0085	33.32
60	16	17	15	13.8	0.48	0.0127	0.0061	29.40
120	14	15	13	14.2	0.34	0.01273	0.0043	25.48
240	13	14	12	14.3	0.24	0.01273	0.0030	23.52
480	12	13	11	14.5	0.17	0.01273	0.0021	21.56
960	11	12	10	14.7	0.12	0.01273	0.0015	19.60

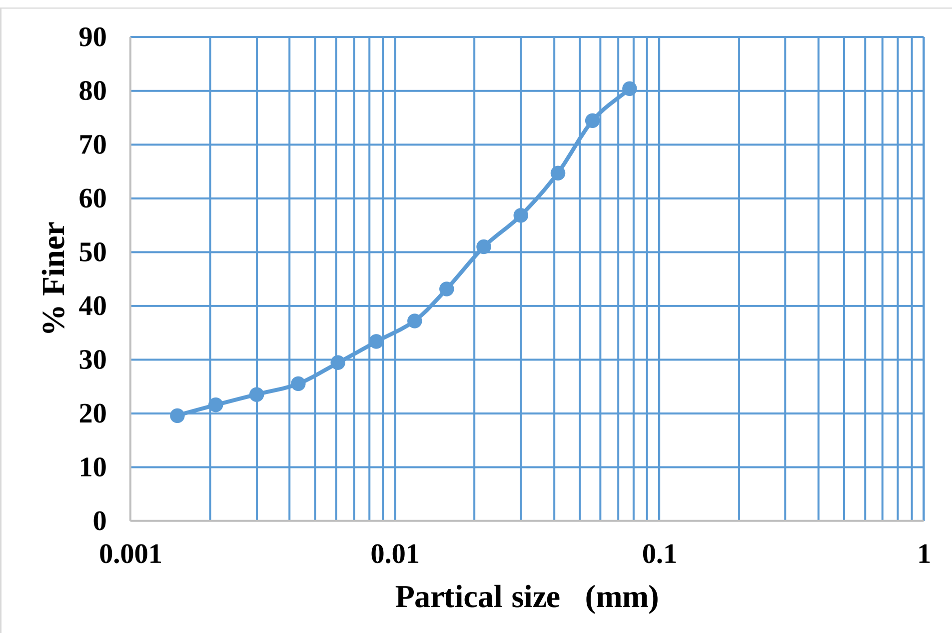

Figure 10: Particle Size Analysis by graph

D_{60}=0.031mm

D_{30}=0.007mm

4.3 Atterberg Limit (Without Cement):

Sample No	1	2	3
Can No	c7	c9	c5
Can weight Mo	19.56	26.51	28.31
Can+wet soil M1	51.17	45.56	53.43
Can + dry soil M2	41.63	40.23	47.02
Weight of water M3	9.54	5.33	6.41
Water content w%	43.22	38.84	34.26
No. of drop	16	21	28

Liquid Limit determination

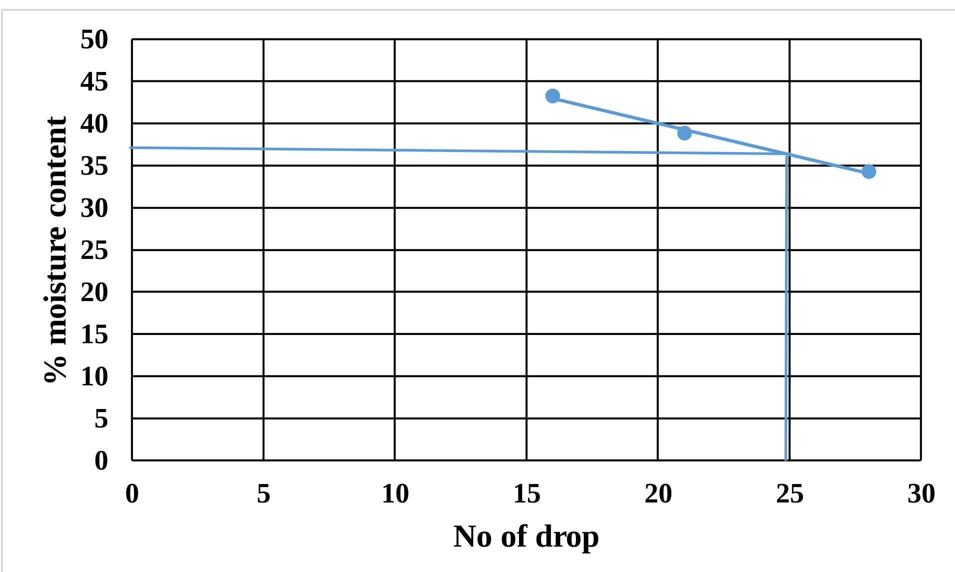

Figure 11:Liquid limit chart

Liquid Limit = 37%

Plastic Limit determination:

Sample No	1	2	3
Can No	C3	C1	C4
Can weight Mo	16.79	17.85	19.21
Can+wet soil M1	43.34	36.72	44.23
Can + dry soil M2	37.84	33.06	38.92
Weight of water M3	5.50	3.66	5.31
Water content w%	26.13	24.06	26.94

$$W = \frac{26.13+24.06+26.94}{3}$$

$$=25.71\%$$

Plasticity Index PI =LL-PL

=37-25.71

=11.29

4.4. Density Determination of Compaction test table & graph for 0% Cement

Compacted Soil Sample No	1	2	3
W=Assumed Water Content W%	8%	10%	12%
Actual Average water contact W%	15.57	17.70	20.65
Mass of Compacted soil and Mold	5309	5430	5378
Mass of Mold	3580	3580	3580
Weight of empty can	41.45	42.49	36.36
Can+Moisture Soil (M_2)	29.24	29.65	39.45
Can + Dry soil (M_1)	25.24	25.19	32.86
Wet density p (g/ cm^3)	1.86	1.96	1.94
Dry density pd (g/ cm^3)	1.61	1.67	1.62
γd for 80% saturated line	2.14	2.02	1.93
γdfor 100% saturated line	2.33	2.14	2.05

γd for 100% saturatation for 8%

$$p_{d}=\frac{p_w}{\frac{w}{100}+\frac{1}{Gs}}$$

$$=\frac{1}{\frac{8}{100}+\frac{1}{2.72}}$$

= 2.33

γd for 80% saturatation for 8%

$$p_{d}=\frac{p_w}{\frac{w}{80}+\frac{1}{Gs}}$$

$$=\frac{1}{\frac{8}{80}+\frac{1}{2.72}}$$

= 2.14

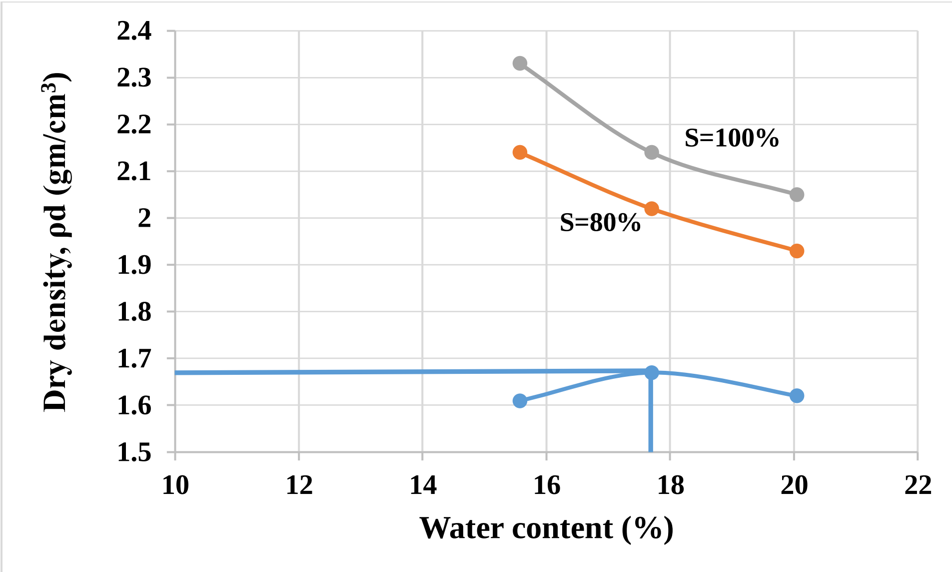

Figure12:0% cement

OMC = 17.70 %

Dry density,ρd =1.67 (gm/cm^3)

4.5 Density Determination table & graph for 2% Cement

Compacted Soil Sample No	1	2	3	4
W=Assumed Water Content W%	8%	10%	12%	14%
Actual Average water contact W%	16.02%	17.72	18.30	20.39
Mass of Compacted soil and Mold	5330	5385	5435	5420
Mass of Mold	3580	3580	3580	3580
Weight of empty can	15.15	42.31	36.35	22.03
Can+Moisture Soil (M_2)	29.47	29.83	32.85	28.34
Can + Dry soil (M_1)	25.40	25.34	32.85	23.54
Wet density p (g/cm^3)	1.89	1.97	2.02	1.99
Dry density pd(g/ cm^3)	1.63	1.67	1.71	1.65
γdfor 80% saturated line	2.15	2.04	1.94	1.85
γd for 100% saturated line	2.25	2.15	2.06	1.98

γd for 100% saturatation for 8%

$$p_{d}=\frac{p_W}{\frac{W}{100}+\frac{1}{Gs}}$$

$$=\frac{1}{\frac{8}{100}+\frac{1}{2.74}}$$

= 2.25

γd for 80% saturatation for 8%

$$p_{d}=\frac{p_W}{\frac{W}{80}+\frac{1}{Gs}}$$

$$=\frac{1}{\frac{8}{80}+\frac{1}{2.74}}$$

= 2.15

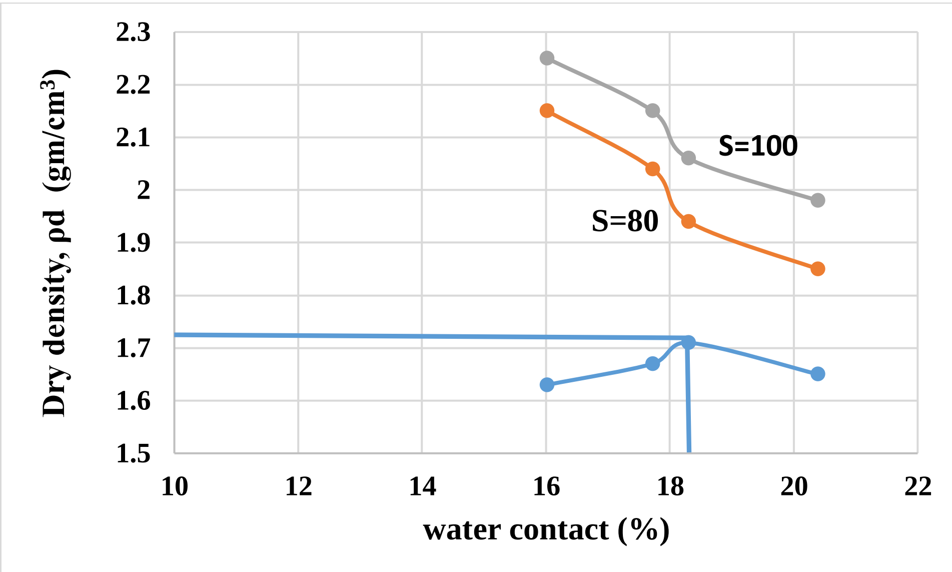

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Figure13:2% cement

OMC = 18.30 %

Dry density, ρd =1.71 (gm/cm^3)

4.6 Density Determination table & graph for 4% Cement

Compacted Soil Sample No	1	2	3	4
W=Assumed Water Content W%	8%	10%	12%	14%
Actual Average water contact W%	16.16	17.33	19.20	21.46
Mass of Compacted soil and Mold	5345	5405	5500	5478
Mass of Mold	3580	3580	3580	3580
Weight of empty can	21.95	17.71	21.50	23.21
Can+Moisture Soil (M_2)	40.09	32.49	22.85	22.47
Can + Dry soil (M_1)	34.51	27.69	19.17	18.50
Wet density p (g/cm^3)	1.91	1.97	2.07	2.05
Dry density pd(g/ cm^3)	1.64	1.68	1.74	1.69
γd,for 80% saturated line	2.16	2.05	1.95	1.86
γd, for 100% saturated line	2.26	2.16	2.07	1.99

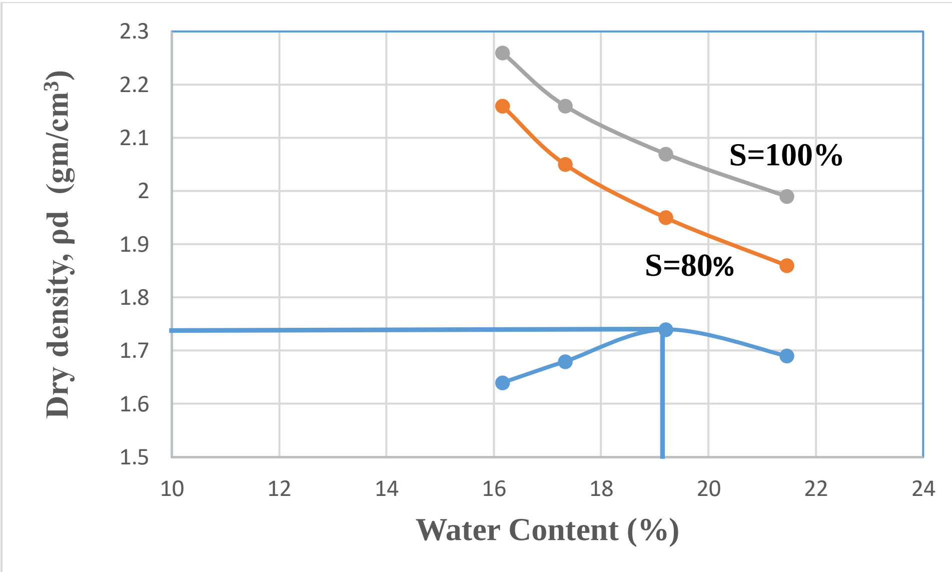

Figure14:4% cement

OMC = 19.20 %

Dry density, ρd =1.74 (gm/cm^3)

4.7 Density Determination table & graph for 6% Cement

Compacted Soil Sample No	1	2	3	4
W=Assumed Water Content W%	8%	10%	12%	14%
Actual Average water contact W%	16.74	18.20	21.09	23.88
Mass of Compacted soil and Mold	5375	5450	5570	5515
Mass of Mold	3580	3580	3580	3580
Weight of empty can	22.21	15.21	23.51	22.05
Can+Moisture Soil (M_2)	41.10	33.09	22.43	29.05
Can + Dry soil (M_1)	35.20	27.99	18.54	23.45
Wet density p (g/cm^3)	1.94	2.01	2.15	2.09
Dry density pd(g/ cm^3)	1.66	1.70	1.77	1.69
γdfor 80% saturated line	2.18	2.06	1.97	1.87
γdfor 100% saturated line	2.28	2.18	2.09	2.01

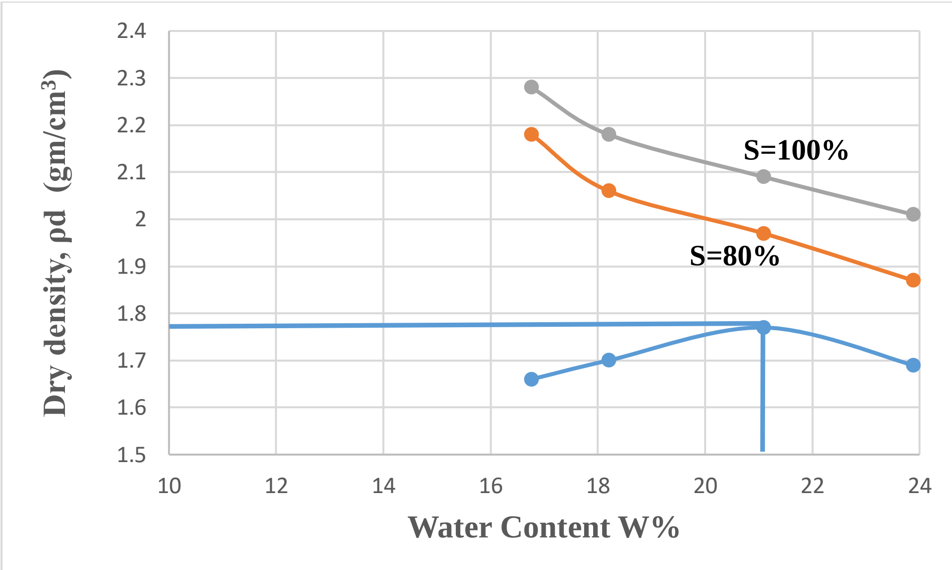

Figure15:6%cement

OMC = 21.09 %

Dry density, ρd =1.77 (gm/cm^3)

Final Results of Compaction test MaximumDry density (ρd) & O.M.C. value from graph :

Soil Sample (gm)	ρd maximum (gm/cm^3)	OMC(%)
0% cement	1.67	17.70
2% cement	1.71	18.30
4% cement	1.74	19.20
6%cement	1.77	21.09

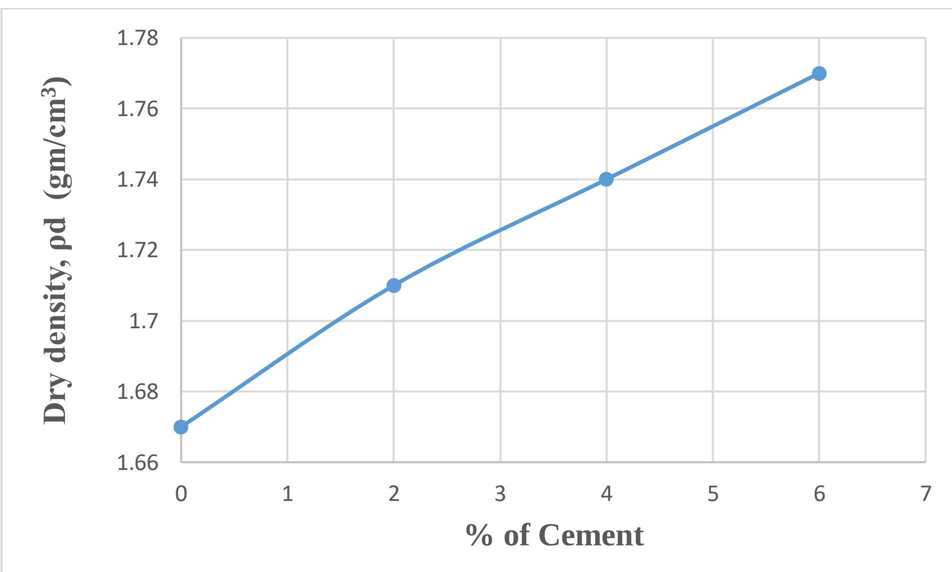

Figure16: Effect of Cement on dry density of soil

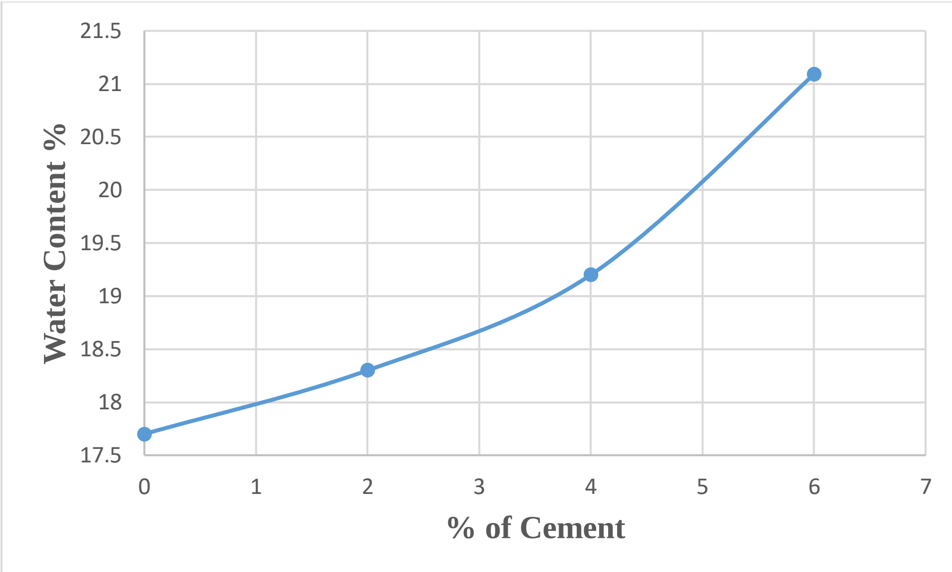

Figure17: Effect of Cement on optimum moisture content of soil

CHAPTER-5

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION & RECOMMENDATION

Cement is used as an excellent soil stabilizing material for highly active soils which undergo through frequent expansion and shrinkage. Cement acts immediately and improves various property of soil such as density bearing capacity.

Compaction is a process that brings about an increase in soil density or unit weight, accompanied by a decrease in air volume. The degree of compaction is measured by dry unit weight and depends on the water content and compactive effort. In this research, we used different percentage of Cement using into soil i.e. 2%,4%, &6% Cement in to the soil sample & we find out that dry density increases in increasing percentage of cement and optimum moisture content also increase. It can be said that, if we use 6% cement we will get the maximum benefit (as it's giving the maximum density) for this specific soil sample. It is not economical to use stabilizer more than 10%. We also conducted grain size analysis by hydrometer test. Zero air void line was drawn for 100% & 80% saturation. In both cases we find good results. That means mixing with cement improves the density of soil.

In this research we find this result:

- The soil Type is Silty Clay (Lean clay, CL).
- The specific gravity of soil without cement=2.72 and with cement 2%=2.74,with cement 4%=2.76, and with cement 6%=2.79.
- Particle Size Analysis by Hydrometer Test. D_{30}= 0.007 mm &D_{60} = 0.031
- Liquid Limit for37%.plastic limit=25.71 &plasticity index=11.29
- Final results of compaction test 0% cement ρd =1.67(gm/cm^3), OMC =17.70%. 2% cement ρd =1.71(gm/cm^3), OMC = 18.30%. 4% cement ρd =1.74(gm/cm^3), OMC = 19.20%. 6% cement ρd =1.77(gm/cm^3), OMC = 21.09%

This research can be extended by testing other different properties of soil like permeability, Atterberg limit, unconfined compressive tests etc. Improvement of soil properties by mixing with stabilizers can also be tested by using different other materials like lime, wood as, fly ash etc.

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