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SOIL STABILIZATION BY USING LIME

A Projected Thesis

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In Partial Fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Civil Engineering.

November- 2019

A Project and Thesis

Supervised by

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CERTIFICATION

This is to certify that the Project report on **"Soil Stabilization by Using Lime"** is the bonfire of project work done by Robiul Aowal, ID # CEN05909193, Md. Naiem Ahmmed, ID # CEN05909089 Md. Maksudur Rahman, ID # CEN05909124 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,

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DECLARATION

We do hereby solemnly declare that the works presented in this project report on **"Soil Stabilization by Using Lime"** 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.

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DEDICATION

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

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Firstly, we offer thanks to the Almighty Allah without whom we would not have the ability to the opportunity to perform this thesis work.

The project and thesis **"Soil Stabilization by Using Lime"** 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 can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. Lime is the oldest traditional stabilizer used for soil stabilization. The mechanism of soil-lime treatment involves cation exchange, which leads to the flocculation and agglomeration of soil particle.

The high pH environment then causes a pozzolanic reaction between the free [Ca+2] cations and the dissolved silica and alumina. Lime treated soil effectively increases the strength, durability and workability of the soil. Such treatment also improves soil compressibility. A fluctuation behavior was observed on the influence of lime on soil permeability. The main Objectives of the soil stabilization is to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction of project depends on the soundness of the underlying soils.

Unstable soils can create significant problems for pavements structures; therefore, soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the super- structure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil.

In this research, compaction behavior (maximum dry density, optimum moisture content), are observed by performing laboratory test. These parameters are tested for both bare soil and using lime (2%, 4%, 6%) to understand the benefits of lime to use as soil stabilizer. All the results showed good agreement with the fact that lime can be used as an effective soil stabilizer to improve the soil stability.

In this research we find that:

1. The soil Type is Silty Clay.
2. The specific gravity of soil without lime=2.659 and with lime 2%=2.69,with lime 4%=2.68, and with lime 6%=2.66.
3. Particle Size Analysis by Hydrometer Test. D_{30} = 0.004 mm & D_{60} = 0.025 mm
4. Liquid Limit for 57%.
5. Final results of compaction test 0% lime ρd =1.70(gm/cm^3), OMC = 13.5%.
   2% lime ρd =1.75(gm/cm^3), OMC = 12.4%. 4% lime ρd =1.73(gm/cm^3), OMC = 12%. 6% lime ρd =1.66(gm/cm^3), OMC = 14%

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CHAPTER ONE

INTRODUCTION

Introduction

l.0 Background:

Bangladesh Soil The major part of Bangladesh is on the delta formed by the three major rivers Brahmaputra, Ganges and Meghna. These rivers and many of the country's other minor rivers originate outside the national boundary of the country and make up the Ganges-Brahmaputra-Meghna river system. Soil formation Regarding soil formation, two distinct conditions occur in Bangladesh: alternating seasonal wet or inundated and dry conditions, as prevalent on most of the floodplain areas, and intermittently wet or moist or dry conditions, as on the upland areas of hills and terraces. This is due to variation of agro climatic parameters in different seasons. The soil formation process differs significantly between floodplain, hill and uplifted terrace.

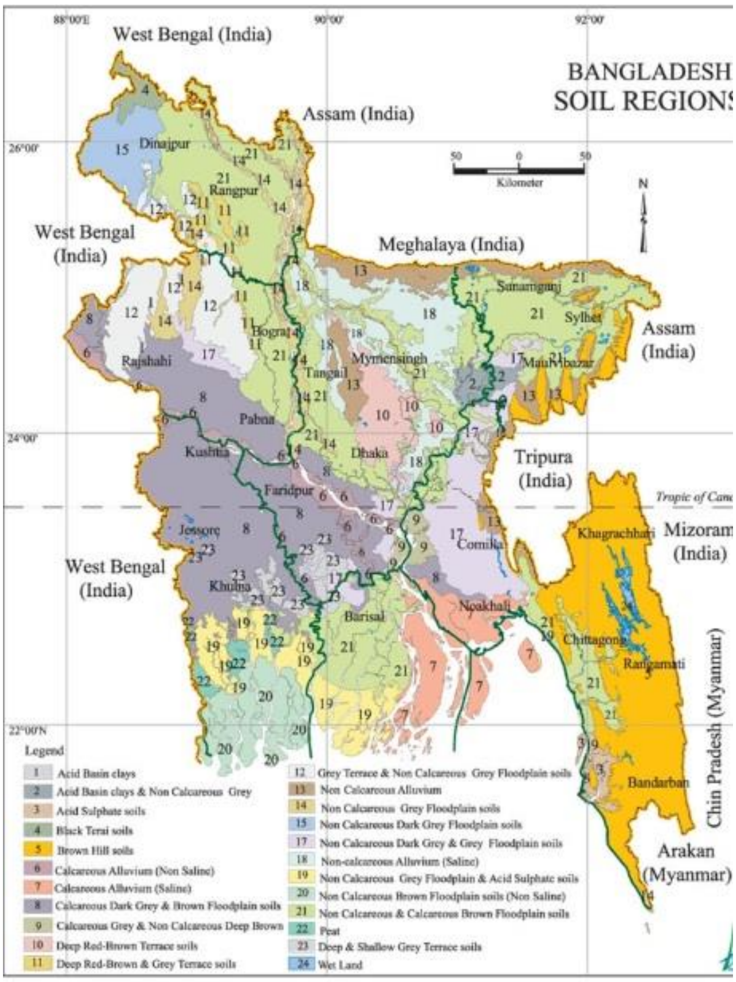


Figure 1.1: Soil map of Bangladesh

l.1 General:

Proper treatment of problem soil conditions and the preparation of the foundation are extremely important to ensure the long-lasting pavement structure that does not require excessive maintenance. Some agencies have recognized certain materials simply do not perform well, and prefer to remove and replace such soils (e.g. a state specification dictating that frost susceptible loess cannot be present in the frost penetration zone). However, in many cases, this is not the most economical or even desirable treatment (e.g. excavation may create disturbance, plus additional problems of removal and disposal).

The stabilization process can result in higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness etc. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and improves the strength of soils [3]. Instead of borrowing a suitable soil from a long distance it is more applicable to use the locally available clay after stabilization with lime powder [4].

Lime is a soil amendment made from ground limestone rock, which contains calcium carbonate and magnesium carbonate. When lime is added to soil, these compounds work to increase the soil's pH, making soil less acidic and more alkaline. On the other hand, in the world, lime production amount was increased from 21.7 million tons to 51 million tons in 10 years. Increasing demand for Lime product rises the generation of waste Lime material. The proportion of lime discharged as waste during block production at the quarries is equal to 40-60% of the overall production volume. Large pieces of lime waste can be used as embankment or pavement material. But only small portion of lime products are stored economically and most of them are stored on lands. Increasing the usage of lime will eliminate the harmful effects on environment.

Soils that are highly susceptible to volume and strength changes can cause severe roughness and accelerate the deterioration of the pavement structure in the form of increased cracking and by the decreased ride quality when combined with truck traffic. Generally, the stiffness (in terms of the resilient modulus) of some soils is highly dependent on moisture and stress state (see Section5.4). In some cases, the subgrade soil can be treated with various materials to improve the strength and stiffness characteristics of the soil. Stabilization of soils is usually performed for three reasons;

1. As a construction platform to dry very wet soils and facilitate compaction of the upper layers-for this case, the stabilized soil is usually not considered as a structural layer in the pavement design process.
2. To reduce moisture susceptibility of fine grain soils.
3. To strengthen a week soil and restrict the volume change potential of a highly plastic or compressible soil-for this case, the modified soil is usually given some structural value or credit in the pavement design process.

1.2 Objectives:

The objectives of the study are to understand and the improvement of geotechnical properties of soil. For this purpose, different properties of the soil are studied.

1. To identify the soil by field identification test.
2. To determine the specific gravity of soil without and with lime.
3. To analysis the particle size by Hydrometer Test.
4. To determine the atterberg limit (LL, PL, PI) of the soil.
5. To study the comp active effort of 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.

CHAPTER TWO

LITERATURE REVIEW:

CHAPTER TWO

2.0 Literature Review:

Improving an on-site soil's engineering properties is called soil stabilization. Soils containing significant levels of silt or clay, have changing geotechnical characteristics: they swell and become plastic in the presence of water, shrink when dry, and expand when exposed to frost Site traffic is always a delicate and difficult issue when projects are carried out on such soils.
In other words, the re-use of these materials is often difficult, if not impossible. Once they have been treated with lime, such soil can be used to create embankments or sub grade of structures, thus avoiding expensive excavation works and transport Use of lime significantly changes the characteristics of a soil to produce long-term permanent strength and stability, particularly with respect to the action of water and frost.

2.1 Chemistry of Lime Treatment:

Drying: If quicklime is used, it immediately hydrates (i.e., chemically combines with water) and releases heat Soils are dried, because water present in the soil participates in this reaction, and because the heat generated can evaporate additional moisture. The hydrated lime produced by these initial reactions will subsequently react with clay particles (discussed below). These subsequent reactions will slowly produce additional drying because they reduce the soil's moisture holding capacity. If hydrated lime or hydrated lime slurry is used instead of quicklime, drying occur only through the chemical changes in the soil that reduce its capacity to hold water and increase its stability. In Fig: l water content win is reduced to win after treatment with lime.

Modification: After initial mixing, the calciumions (Ca++) from hydrated lime migrate to the surface of the clay particles and displace water and other ions. The soil becomes friable and granular, making it easier to work and compact at this stage the Plasticity Index of the soil as showing in fig.1decrease. The process, which is called "flocculation and agglomeration," generally occurs in a matter of hours.

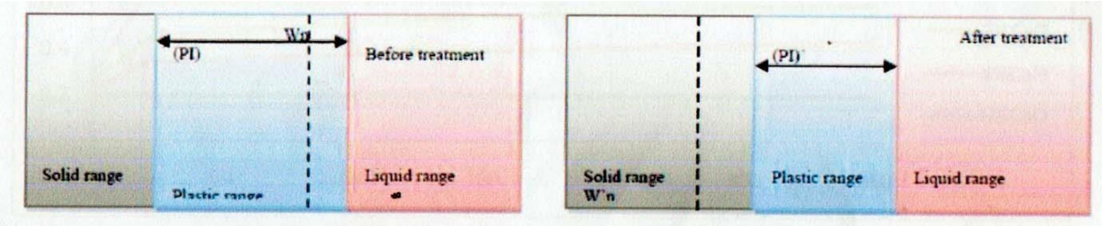


Figure 2.1: Effect of Liming on the consistency of soil

Stabilization: When adequate quantities of lime and water are added, the pH of the soil quickly Increases to above 10.5, which enables the clay particles to break down. Silica and alumina are released and react with calcium from the lime to form calcium -silicate-hydrates (CSH) and calcium-aluminate-hydrates (CAR). CSA and CAH are cementations products similar to those formed in Portland cement. They form the matrix that contributes to the strength of lime-stabilized soil layers. As this matrix forms, the soil is transformed from a sandy, granular material to a hard, relatively impermeable layer with significant load bearing capacity. The process begins within hours and can continue for years in a properly designed system. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible.

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 lime 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.

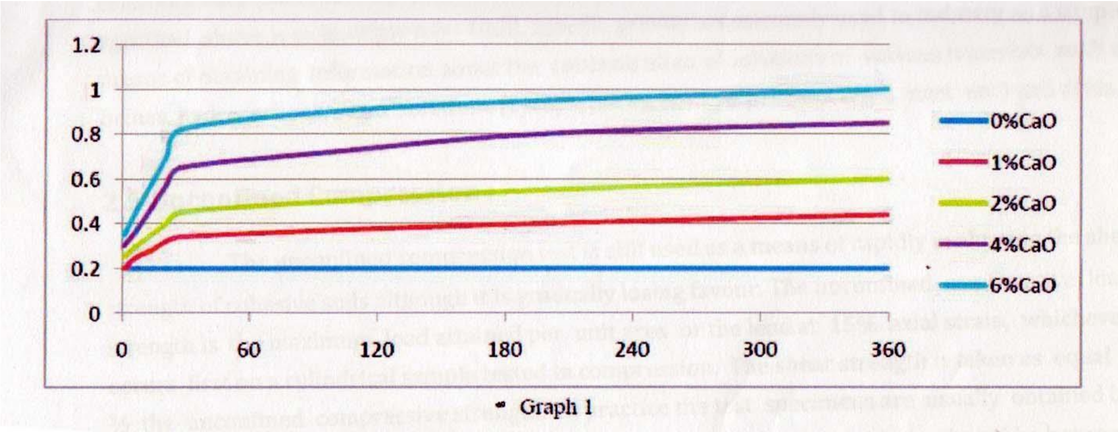


Figure 2.2: Immediate Effect Soil Improvement

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 densest(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.

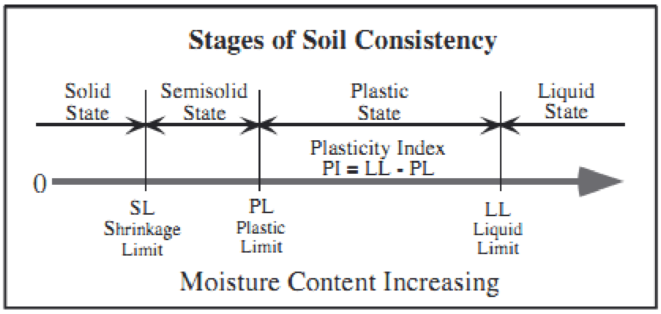


Figure 2.3: Atterberg Limits (Principles of Geotechnical Engineering, B. M. Das)

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.

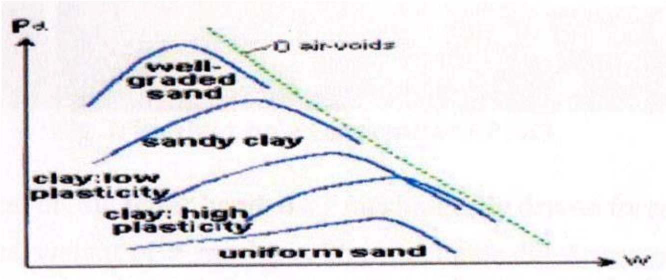


Figure 2.4: Pd vs W

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 Proctor test 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 lime 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.

Scarifications zone because a scarified or pulverized sub grade offers more soil surface contact area for the lime at the time of lime application.

Figure 2.5: Pd vs W

2.9 Lime Spreading:

The soil is generally scarified and the slurry is applied by distributor truck. Because lime in slurry form is much less concentrated than dry lime, often two or more passes are required to provide the specified amount of lime solids. To prevent runoff and consequent on- uniform lime distribution, the slurry is mixed into the soil immediately after each spreading pass.

Figure 2.6: Spreading of lime over scarified soil

2.10 Preliminary Mixing and Watering:

Preliminary mixing is required to distribute the lime throughout the soil and to initially pulverize the soil to prepare for the addition of water to initiate the chemical reaction for stabilization. During this process or immediately after, water should be added to ensure the complete hydration and a quality stabilization project.

Figure 2.7: Adding water after dry lime application

2.11 Final Mixing and Pulverization:

To accomplish complete stabilization, adequate final pulverization of the clay fraction and thorough distribution of the lime throughout the soil are essential.

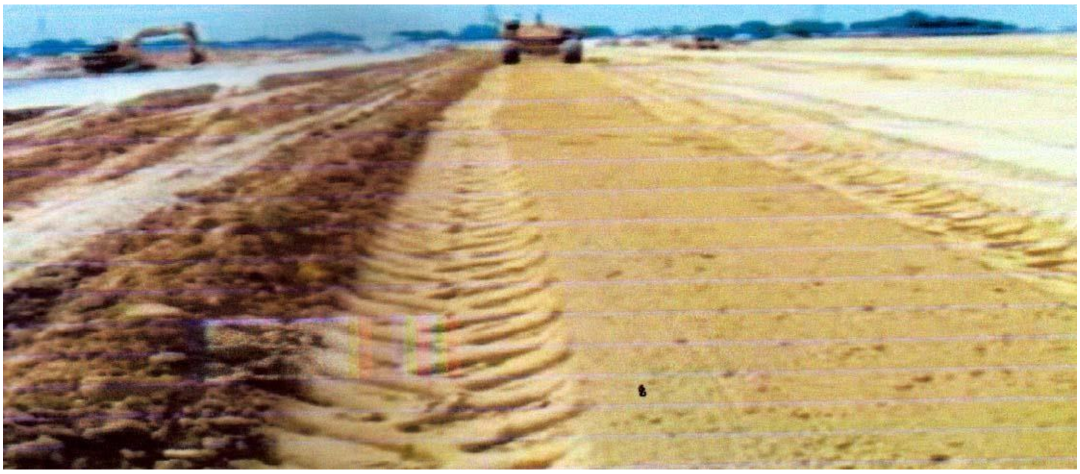


Figure 2.8: Mixing and pulverization

2.12 Compaction:

Initial compaction is usually performed as soon as possible after mixing, using a sheep foot type roller or a vibratory pad foot roller. After the section is shaped, final compaction can be accomplished using as smooth drum roller. The equipment should be appropriate for the depth of the section being constructed.

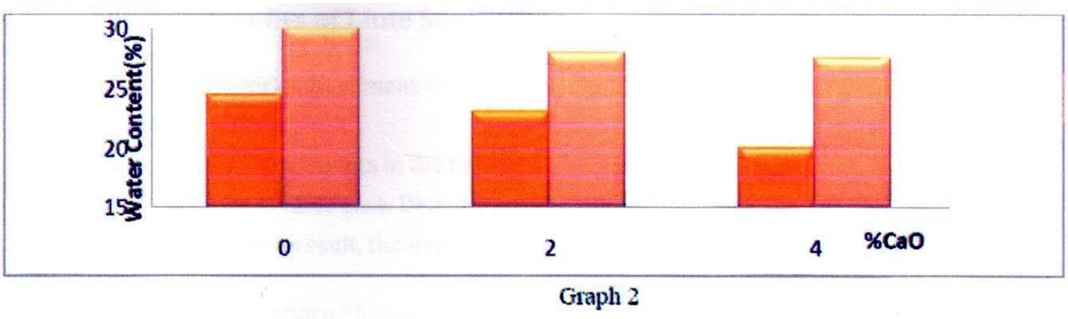


Figure 2.9: Compaction

2.13 Factors Affecting Lime Stabilization:

The following factors affect lime stabilization process.

1. Type of soil: Lime stabilization is useful for stabilization of clayey soils but it is not effective for sandy soils.
2. Amount of lime: The amount of lime requires for stabilization varies between 2 to 10% of the soil.
3. Ratio of fly ash to lime: The ratio of fly ash to lime generally varies in between 3 to 5. The fly ash used is about 10 to 20% of the soil weight.
4. Different type of lime: The quick lime is more effective but for safety and convenience to handle the hydrated lime is generally used.
5. Soil becomes more workable.
6. Strength is generally improved.
7. Lime stabilization increases the compressive strength sometimes as high as 60 times.
8. It is effective for soils.
9. Lime is produced by burning of lime stone in kilns, so that it is harmful for environment
10. It needs more cost to burnt limestone.
11. It is not effective for sandy soils.
12. There is limited percentage of amount of lime required about 2 to 10% of the soil.

2.14 Economic Benefits of Lime Stabilization:

Limitation of the need for embankment materials brought in from outside and the elimination of their transporting costs. Reduction of transport movements in the immediate vicinity of the construction site. Machines can move about with far greater ease. Delays due to weather conditions are reduced, leading to Improved productivity. As a result, the overall construction duration and costs can be dramatically reduced. Structures have a longer service life (embankments, capping layers) and are cheaper to maintain.

2.15 Advantages and Disadvantages of Different Lime Applications: Advantages of Lime Stabilization

- Soil becomes more workable.
- Strength is generally improved.
- Lime stabilization increases the compressive strength sometimes as high as 60 times.
- It is effective for soils.

Disadvantages of Lime Stabilization

- It needs more cost to burnt limestone.
- It is not effective for sandy soils.
- There is limited percentage of amount of lime required about 2 to 10% of the soil.
- Lime is produced by burning of lime stone in kilns, so that it is harmful for environment

CHAPTER THREE

METHODOLOGY

CHAPTER THREE

3.0 Material:

We use sandy soil and lime as a tool for testing in the laboratory. We collect the sandy soil from the construction site of the Kamalapur. The first soil depth collected is 5 feet and the second is 10 feet. Then the lime is used for various tests. We collect powder lime from the Mailbag market.

3.1 Methodology:

3.1.1 Identification Test:

Identification tests are a broad category of tests intended to verify the presence of a specific element, functional group or compound. Galbraith Laboratories provides identification testing by USP <191>, Spectra photo metric Identification by USP <197>and Thin-Layer Chromatography by USP <201>.

3.1.2 Compaction Test:

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. There are two types of Compaction Test: **1. standard proctor test 2. Modified proctor test.**

Compaction of the soil generally increases its shear strength, decreases its compressibility, and decreases its permeability. in addition, compaction reduces the voids ratio making it more difficult for water to flow through soil. 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, 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 the optimum water content results in a relatively dispersed soil structure that is weaker, more ductile, less pervious, softer. The soil compacted lower than the optimum water content typically results in a flocculated soil structure that has the opposite characteristics of the soil compacted wet of the optimum water content to the same density.

Figure 3.1: Compaction test for standard proctor test

3.1.3 Specific Gravity Test:

The term "Specific Gravity" (SG) is used to define the weight or density of a liquid as compared to the density of an equal volume of water at a specified temperature. The temperature used for measurement is usually 39.2oF (4^{o}C), because this temperature allows water to assume its maximum density.

Specific gravity is an important property of fluids being related to density and viscosity.

Knowing the specific gravity will allow determination of a fluid's characteristics compared to a standard, usually water, at a specified temperature.

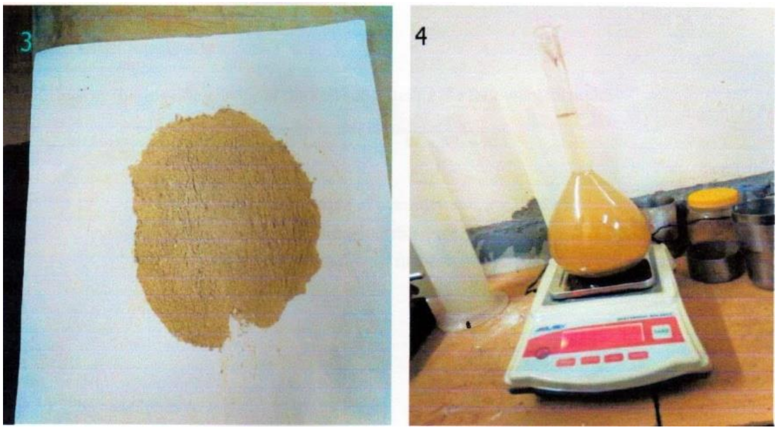


Figure 3.2: Field test of specific gravity

3.1.4 Atterberg Limit Test:

We used casagrandis apparatus to calculate the blow number needed to obtain liquid limit. From the LL test, no of blow and water content for different sample (based on water mixture) are record. Calculate the water content of each of the plastic limit moisture cans after they have been in the oven for at least 16 hours. Compute the average of the water contents to determine the plastic limit, PL. Check to see if the difference between the water contents is greater than the acceptable range of two results (2.6%). Calculate the plasticity index, PI=LL-PL. Report the liquid limit, plastic limit, and plasticity index to the nearest whole number, omitting the percent designation.

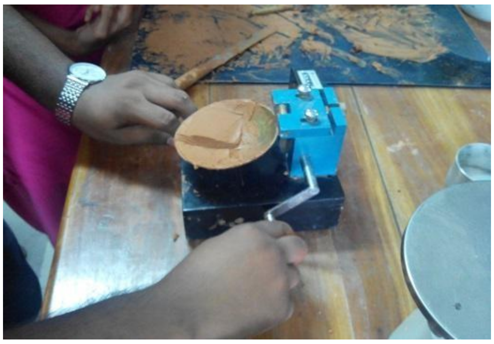



Figure 3.3: Atterberg Limit Test.

3.1.5 Hydrometer test:

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 hexa metaphosphate (40 g/L)) solution. Stir the mixture until the soil is thoroughly wet. Let the soil soak for at least ten minutes. While the soil is soaking, add 125mL of dispersing agent into the control cylinder and fill it with distilled water to the mark. Take the reading 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. 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). 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.

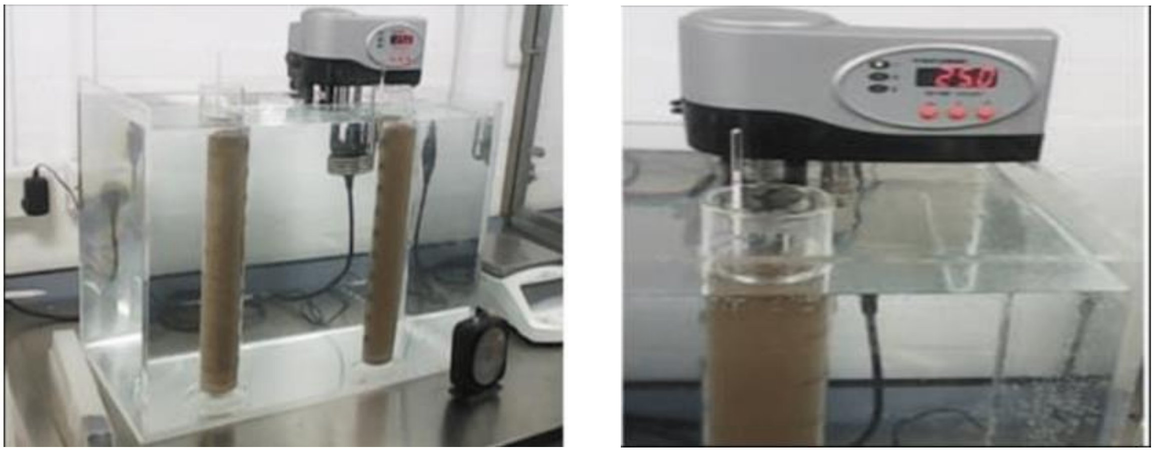


Figure 3.4: Hydrometer Test.

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.

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

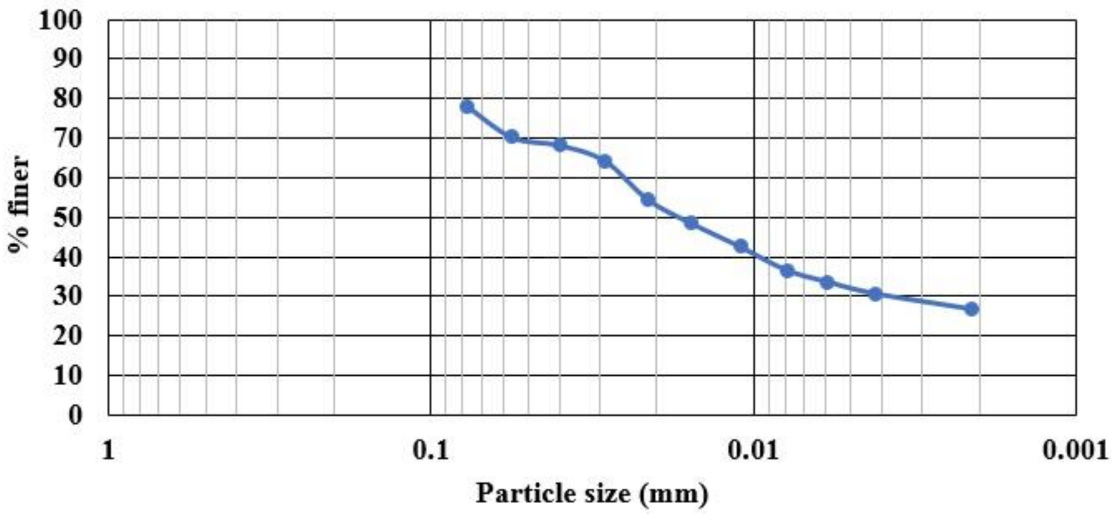
4.1 Specific Gravity

% lime	Specific gravity
0%	2.659
2%	2.695
4%	2.68
6%	2.66

4.2 Particle Size Analysis by Hydrometer Test

Elapsed Time,t(min)	Actual Reading Ra	RL=Ra meniscus Correction	Corrected Readig RC=RL-zero correction+ct	Effective depth L	$-\sqrt{\frac{L}{t}}$	K (mm)	Particle size, $D=k\sqrt{\frac{L}{t}}$	% finer $P=\frac{Rc}{Ms}*a*100$
.25	38	39	39.50	9.894	6.29	0.0123	0.0774	78.21
.50	35	36	35.50	10.386	4.56	0.0123	0.056	70.29
1.0	33	34	34.50	10.714	3.27	0.0123	0.040	68.31
2.0	31	32	32.50	11.042	2.35	0.0123	0.0289	64.35
4.0	26	27	27.50	11.862	1.72	0.0123	0.0212	54.45
8.0	23	24	24.50	12.354	1.24	0.0123	0.0156	48.51
16	20	21	21.50	12.846	0.90	0.0123	0.011	42.57
32	17	18	18.50	13.338	0.65	0.0123	0.0079	36.63
60	15.5	16.5	17.0	13.584	0.416	0.0123	0.0059	33.66
120	14	15	15.50	13.83	0.34	0.0123	0.0042	30.69
480	12	13	13.50	14.16	0.172	0.0123	0.0021	26.73

Particle Size Analysis by graph

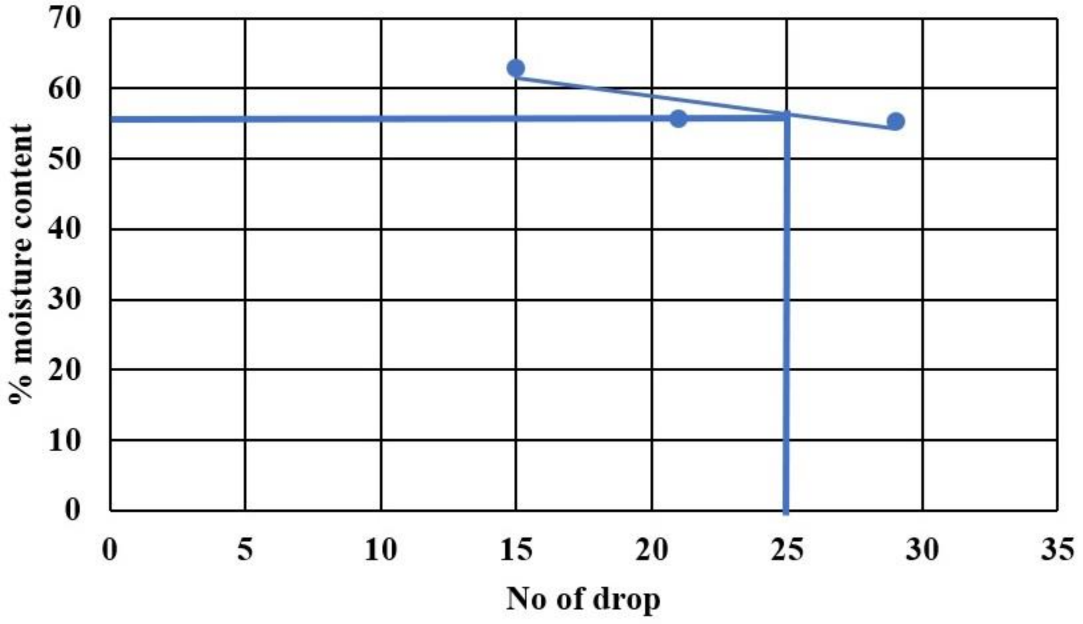


$D_{30} = 0.004$ mm

$D_{60} = 0.025$ mm

4.3 Atterberg Limit (Without lime):

Sample No	1	2	3
Can No	10	6	7
Can weight M_o	17.28gm	20.84	21.96
Can+wet soil M_1	26.33gm	33.47	34.21
Can + dry soil M_2	23.22gm	28.59	29.83
Weight of water M_3	3.11gm	4.88	4.38
Water content w%	52.36	62.97	55.65
No. of drop	29	15	21

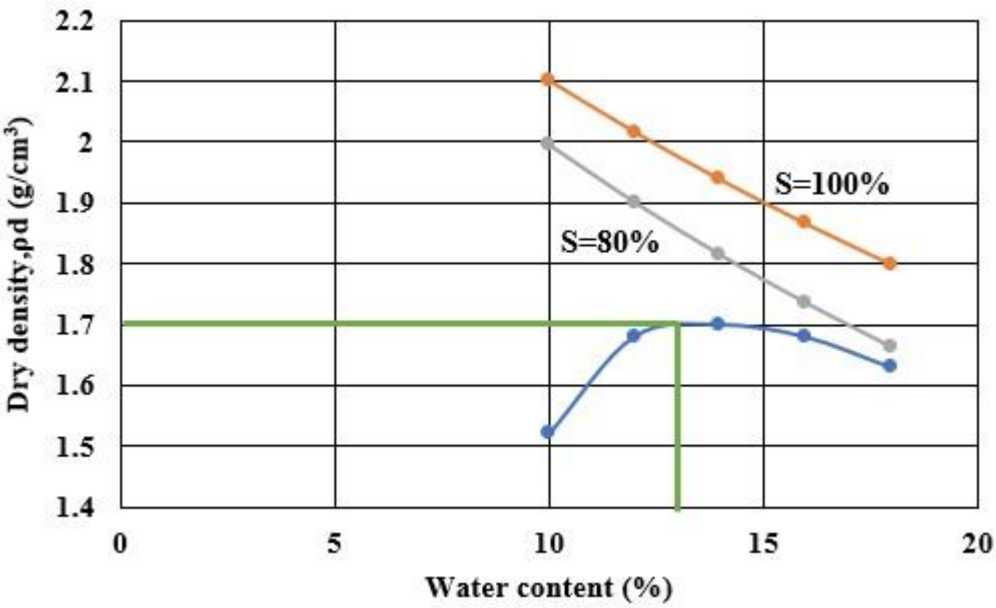


Liquid Limit determination

Liquid Limit for 25 blows from graph = 57%

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

Compacted soil sample no	1	2	3	4	5
W= Assume Water Content W%	10%	12%	14%	16%	18%
Weight of empty can (gm)	20.84	21.94	14.71	21.50	17.28
Can+ moist soil, (gm)	52.23	62.02	47.58	44.64	43.47
Can + Dry soil (gm)	48.43	56.54	42.40	40.67	38.63
Mass + Soil Solids (gm)	27.59	34.6	27.69	19.17	21.35
Mass of pore Water	3.8	5.48	5.18	3.97	4.384
Water content, %	13.77	16.14	18.71	20.71	22.67
Wet density, ρ (g//cm^3)	1.73	1.978	2.04	2.06	2.01
Dry density, ρd (g / cm^3)	1.52	1.69	1.70	1.69	1.63
γ_d,for 80% saturated line	1.99	1.90	1.81	1.73	1.66
γ_d,for 100% saturated line	2.10	2.01	1.93	1.86	1.79

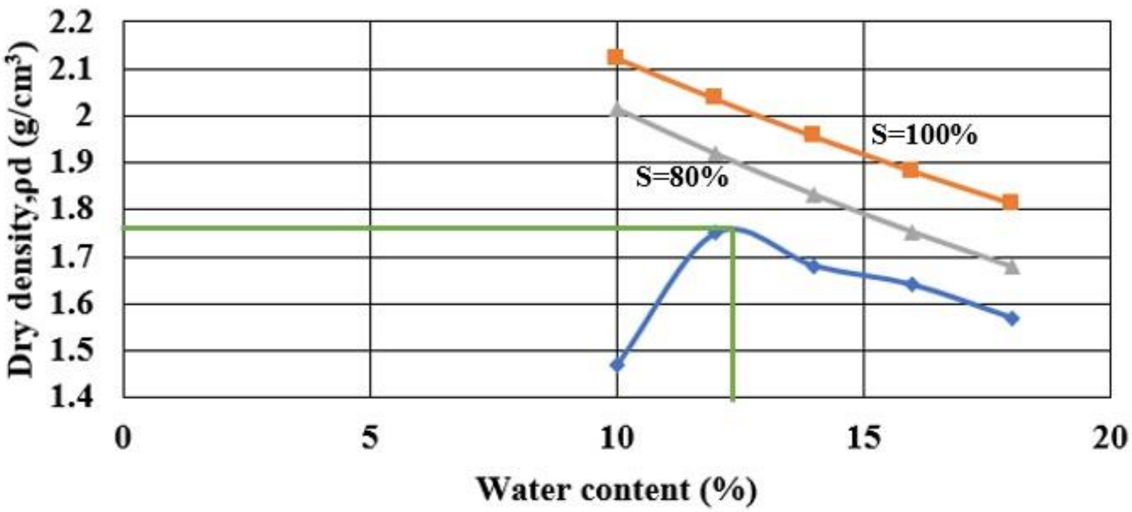


OMC = 13.5 %

Dry density, ρd =1.70 (gm/cm^3)

4.5 Density Determination table & graph for 2% Lime

Compacted soil sample no	1	2	3	4	5
W=Assumed water content W %	10%	12%	14%	16%	18%
Actual average water content, W%	8.5	4.20	7.46	10.02	12.50
Mass of compacted soil and mold (gm)	5060	5268	5268	5238	5220
Mass of mold (gm)	3580	3580	3600	3580	3580
Weight of empty can (gm)	15.31	24.94	22.5	22.02	23.14
can + moist soil, M2	31.14	80.76	44.82	58.57	52.11
Can + Dry Soil, M1	29.89	78.51	43.27	55.24	48.89
Wet density, ρ (g//cm^3)	1.60	1.82	1.80	1.80	1.77
Dry density ρd(gm/cm3)	1.47	1.75	1.68	1.64	1.57

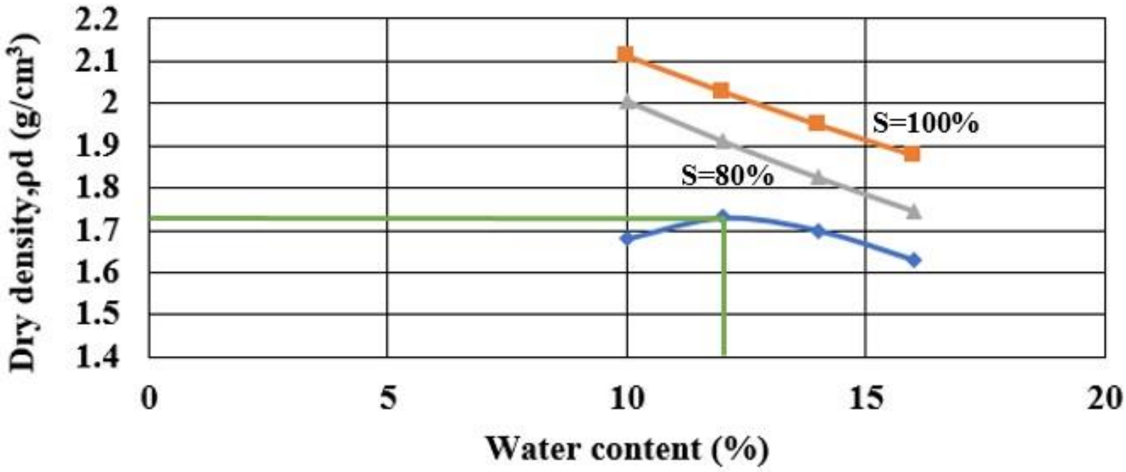


OMC = 12.4 %

Dry density, ρd =1.75 (gm/cm^3)

4.6 Density Determination table & graph for 4% Lime

Compacted soil- sample no	1	2	3	4
W = Assumed water content, W%	10%	12%	14%	16%
Actual average water content, W%	3.23	4.20	7.46	10.02
Mass of compacted soil mold (gm)	5200	5240	5268	5238
Mass of mold (gm)	3580	3580	3580	3580
Weight of empty can (gm)	26.35	32.98	43.07	22.02
Can + Dry Soil, M2 (gm)	43.83	86.55	63.84	55.24
Can+ Moist soil, M1 (gm)	44.57	88.80	65.39	58.57
Wet density, ρ (g//cm3)	1.75	1.80	1.82	1.79
Dry density, ρd(g/cm^3)	1.68	1.73	1.70	1.63

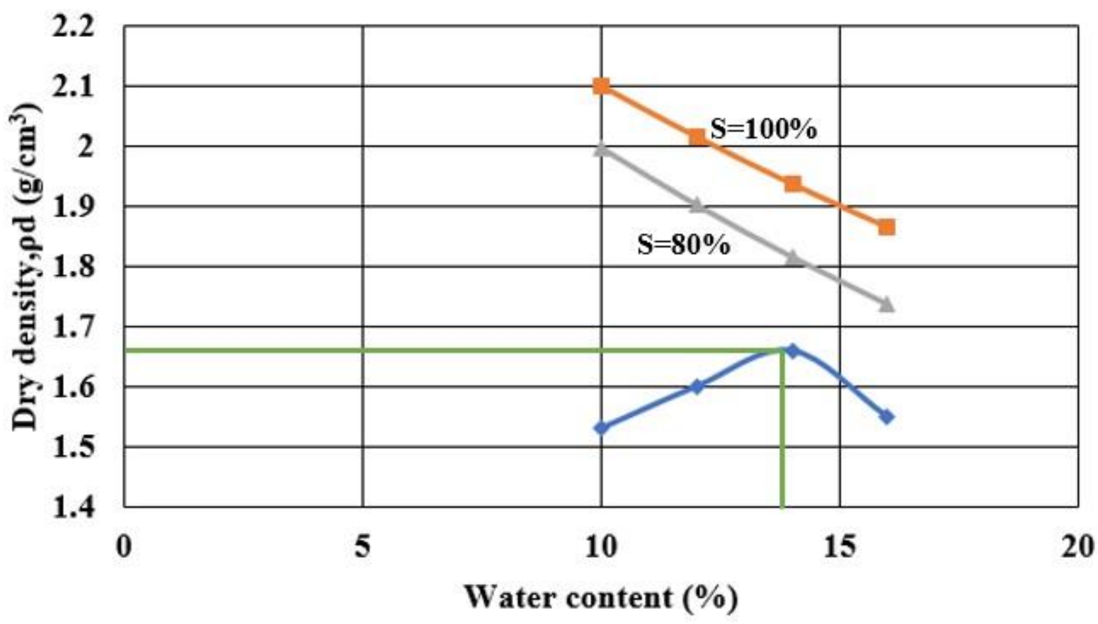


OMC = 12 %

Dry density, ρd = 1.73 (gm/cm^3)

4.7 Density Determination table & graph for 6% Lime

Compacted soil- sample no	1	2	3	4
W = Assumed water content, W%	10%	12%	14%	16%
Actual average water content, W%	5.49	7.66	9.80	10.96
Mass of compacted soil mold (gm)	5199	5210	5215	5280
Mass of mold (gm)	3580	3580	3580	3580
Weight of empty can (gm)	42.48	22.94	41.59	35.00
Can + Dry Soil, M2 (gm)	73.21	54.69	80.35	55.15
Can+ Moist soil, M1 (gm)	71.61	52.43	76.89	5.16
Wet density, ρ(g//cm^3)	1.75	1.76	1.76	1.83
Dry density, ρd(g/cm^3)	1.53	1.6	1.66	1.55

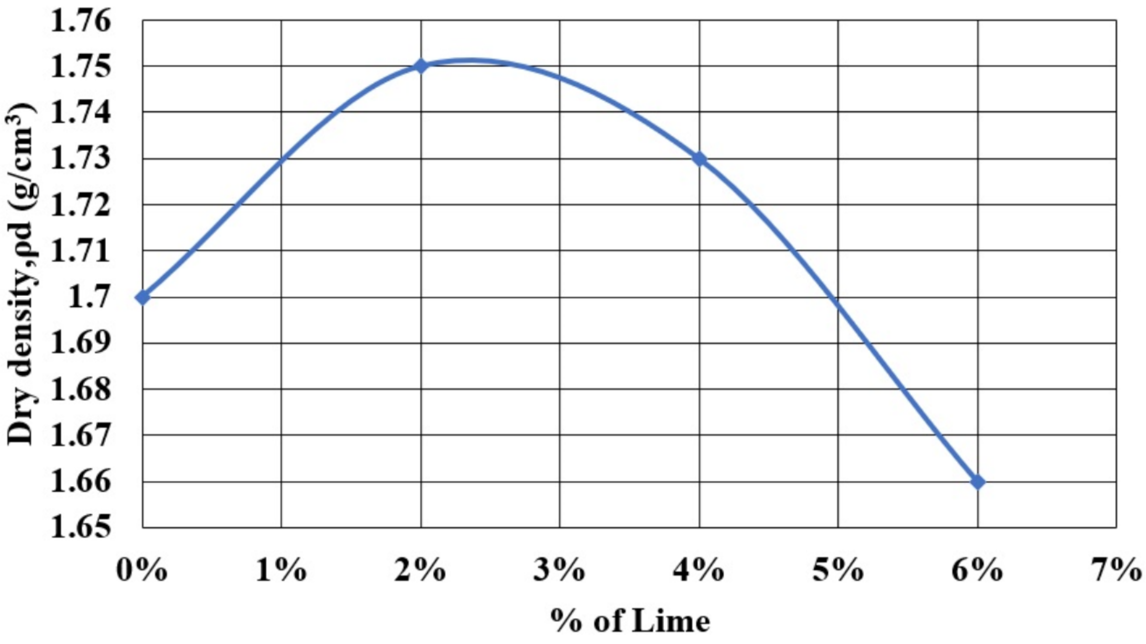


OMC = 14%

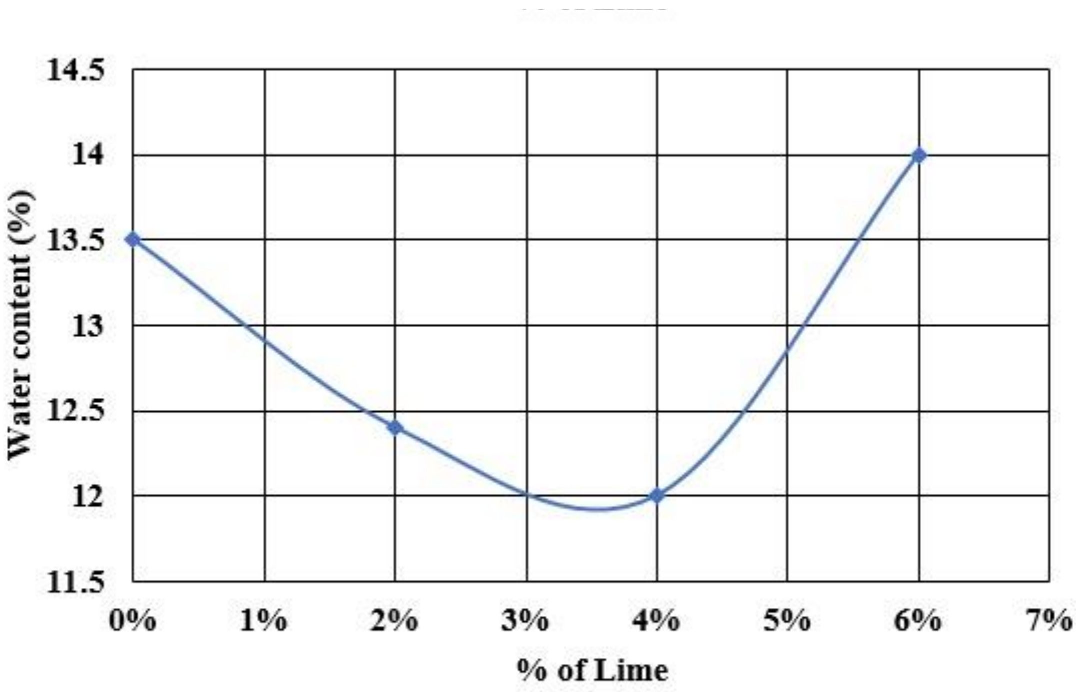
Dry density, ρd = 1.66 (gm/cm^3)

Final Results of compaction test Maximum Dry density(ρd) & O.M.C. value from graph:

Soil Sample (gm)	ρd maximum (gm/cm^3)	OMC (%)
0% lime	1.70	13.5
2% lime	1.75	12.4
4% lime	1.73	12
6% lime	1.66	14



Effect of lime on dry density of soil



Effect of lime on optimum moisture content of soil

CHAPTER FIVE

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION & RECOMMENDATION

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

Compaction is a process that brings about an increase in soil density or unit weight, accompanied by a decrease in air volume. There is usually no change in water content. 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 lime using into soil i.e. 0%,2%,4%, &6% lime in to the soil sample & we find out that dry density increases in increasing percentage of lime and optimum moisture content decreases. 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 lime improves the density of soil.

In this research we find this result:

1. Our soil Type is Silty Clay.
2. The specific gravity of soil without lime=2.659, with lime 2%=2.695, with lime 4%=2.68, and with lime 6%=2.66.
3. Particle Size Analysis by Hydrometer Test. $D_{30} =$ 0.004 mm & $D_{60} =$ 0.025 mm
4. To identify Liquid Limit for 57%.
5. Final results of compaction test 0% lime ρd =1.70(gm/cm^3), OMC = 13.5%.
   2% lime ρd =1.75(gm/cm^3), OMC = 12.4%. 4% lime ρd =1.73(gm/cm^3), OMC = 12%.
   6% lime ρd =1.66(gm/cm^3), OMC = 14%

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 cement, wood as, fly ash etc.

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