Stabilization of Clay Soil Using Lime and Waste Plastic

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***Abstract*- Soil stabilization can be done through many ways. But the stabilization using waste plastic is an economic method since the stabilizer used here is a waste plastic material, which is easily available. The main objective of this study is to investigate the use of waste plastic materials in geotechnical applications and to evaluate the effects of waste plastic powder on bearing capacity of clay soil by carrying out CBR tests on different soil samples. The results obtained are compared for the samples and inferences are drawn towards the usability and effectiveness of plastic powder stabilization as a replacement for deep foundation or raft foundation, as a cost effective approach.**

Use of plastic products such as polyethene bags, bottles, containers, packing strips etc are increasing day by day. As a result amount of waste plastic is also increased. This results in various changes in environmental condition. Many of the waste produced today will remain in the environment for many years leading to various environmental pollutions. Therefore it is necessary to utilize the wastes effectively with technical development in each field. Many by-products are being produced using the plastic wastes. Various research works are done on the possible use of waste plastic for soil stabilization and the results indicate that by the addition of plastic powder in soil, there is an increase in shear strength, tensile strength, California Bearing Ratio and decreases in the swelling and cracking effects of soil. In this project I am going to compare the effects of lime and waste plastic in soil stabilization.

I.INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Geotechnical Engineers will design the foundations and other structures on the soil only after investigating the type of soil, its characteristics and its extent. If the soil is good at shallow depth below the ground surface, shallow foundation such as footings and rafts are generally preferred which are considered to be most economical. However if the soil just below the ground surface is of not good but a strong stratum exists at a greater depth, deep foundations such as piles, wells and caissons are preferred. Deep foundations are quite expensive and are of cost effective only for the structures which are to be supported are quite heavy and huge. Sometimes the soil conditions are very poor even at greater depth and it is not even practical to construct deep foundation. In such cases various soil stabilization methods and reinforcement techniques are adopted. The main objective is to improve the characteristics of soil at site and make it capable to carry more loads and also to increase its shear strength and to decrease its compressibility.

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

PRINCIPLES OF SOIL STABILIZATION

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.
- Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

NEEDS AND ADVANTAGES

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases.

- It improves the strength of the soil, thus, increasing the soil bearing capacity.
- It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
- It is also used to provide more stability to the soil in slopes or other such places.
- Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
- Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.
- It helps in reducing the soil volume change due to change in temperature or moisture content.

Stabilization improves the workability and the durability of the soil. The term soil stabilization refers to the improvement of the stability or bearing power of the soil by adopting controlled compaction, proportioning and/or by the addition of suitable admixtures or stabilizers.

In this project I am stabilizing the soil using waste plastic powder and lime. The use of waste plastic as stabilizer is found to be an economic method since plastic is commonly available. It is very effective and efficient method for stabilizing the soil.

In this project we have collected the soil sample from our college premise which is used for testing purposes. The soil is clayey in nature. Since the clay soil is affected more by cracking and swelling characteristics, stabilization is done which will give drastic changes in construction field. The addition of plastic powder to the soil reduces the volumetric changes that are happening in the clayey soil and thus stabilizing it by increasing its strength.

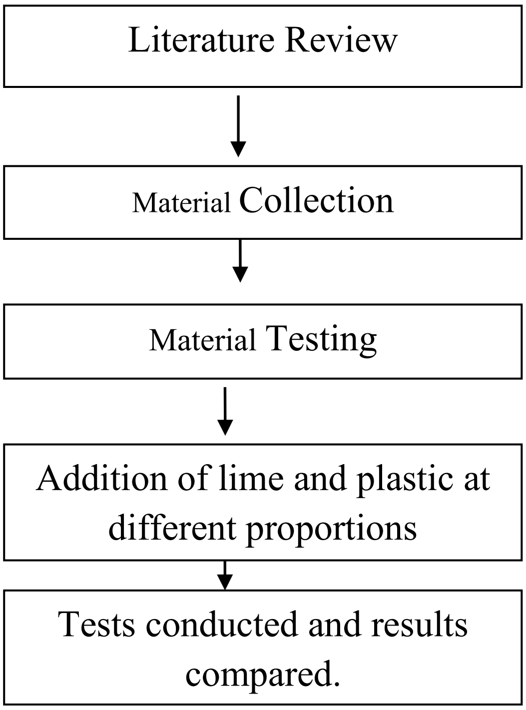
In order to find the effective stabilizer, the traditionally used stabilizer (Lime) and the innovative stabilizer (plastic) are tested separately by mixing with soil at certain percentage and their stabilizing properties are compared.

Here lime and plastic powder is added in 1%, 2% and 3%. Sieve analysis, Specific gravity test, Field density test, Proctor compaction test and Atterbergs limits are conducted for finding the soil properties and various strength tests such as CBR and Consolidation tests were carried out.

Moreover an environmental concern is also included by utilization of waste plastic materials and they can be made useful for improving the soil characteristics and to solve the problems related to the disposal of waste plastic material.

III.METHODS AND MATERIALS

METHODOLOGY



EXPERIMENTAL INVESTIGATION AND RESULTS

SOIL

SPECIFIC GRAVITY

Specific gravity is defined as the ratio of the unit weight of soil solids to unit weight of water. The Specific Gravity is needed for various calculations purposes in Soil Mechanics, e.g. void ratio, density and unit weight

Specific gravity of soil grains, $G = \frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$

Specific gravity of the soil sample, G = 2.75

SIEVE ANALYSIS

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material.

From Graph,

Effective size of soil, D_{10} =170µ

Effective size of soil, D_{30} =440µ

Effective size of soil, D_{60} =1300µ

1. Uniformity Coefficient $Cu = \frac{D_{60}}{D_{10}}$
2. Coefficient of curvature $Cc = \frac{D_{30}}{D_{10} \times D_{60}}$

Percentage of gravel = 12%

Percentage of coarse sand = 14%

Percentage of medium sand = 46%

Percentage of fine sand = 25%

Percentage of clay and silt = 3%

Uniformity coefficient, Cu = 7.65

Coefficient of curvature, Cc = 0.88

BIS Classification of soil = Sandy Soil

FIELD DENSITY TEST (CORE CUTTER METHOD)

Field density is defined as the weight of unit volume of soil present in site. Field density is used in calculating the stress in the soil due to its overburden pressure it is needed in estimating the bearing capacity of soil foundation system, settlement of footing earth pressures behind the retaining walls and embankments. Dry density for most soils varies within a range of 1.1-1.6 g/cm^3.

Field density of soil, $\gamma = \frac{(W_2-W_1)}{V}$

Field density of the soil = 1.98g/cc

STANDARD PROCTOR COMPACTION TEST

Compaction is the process of densification of soil mass by reducing air voids under dynamic loading. This test is conducted in order to find out the optimum moisture content and maximum dry density of the soil.

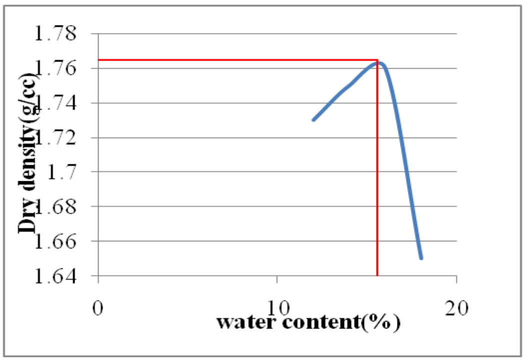


Fig: Water Content Vs Dry Density

Optimum moisture content = 15.4 %

Maximum dry density = 1.762g/cc

PLASTIC LIMIT

Plastic limit is defined as the lowest moisture content and expressed as a percentage of the weight of the oven dried soil at which the soil can be rolled into threads one-eighth inch in diameter without the soil breaking into pieces. This is also the moisture content of a solid at which a soil changes from a plastic state to a semisolid state.

$$\text{Plastic Limit} = \frac{(W_2 - W_3) \times 100}{(W_3 - W_1)}$$

Plastic limit value of the soil = 23%

LIQUID LIMIT

Liquid Limit (LL) is defined as the moisture content at which soil begins to behave as a liquid material and begins to flow. The importance of the liquid limit test is to classify soils. Different soils have varying liquid limits. Also, one must use the plastic limit to determine its plasticity index.

Plasticity index, $I_P = W_L - W_P$

$$\text{Flow index, } I_f = \frac{W_1 - W_2}{\log (N_1/N_2)}$$

Toughness Index, $I_t = I_p/I_f$

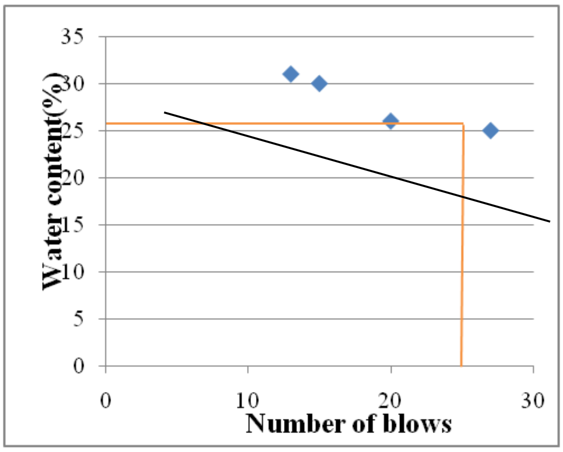


Fig: Number of blows Vs Water content

Liquid limit of the soil sample, W_L = 26.5%

Plasticity index, I_p = 3.5%

Flow index, I_f = 18.9

Toughness index, I_T = 0.19

SHRINKAGE LIMIT

As soil is dried below the plastic limit it shrinks and gets brittle until finally all the particles are in contact and the soil can shrink no further. This point is called the shrinkage limit. The soil still has moisture within it but if any of this moisture is lost by further drying, air has to enter the soil to replace it. The shrinkage limit is the best moisture at which to compact many non-plastic soils.

Shrinkage limit, $W_s = w - [(V - V_d) / M_d \times 100]$

Shrinkage limit of the soil, W_s = 16.72%

CALIFORNIA BEARING RATIO TEST

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of soil.

$$\text{CBR} = \frac{\text{Test unit load}}{\text{Standard unit load}} \times 100$$

CBR value of soil = 0.355%

LIME

SPECIFIC GRAVITY OF LIME

Specific gravity of lime = 3.434

PROCTOR COMPACTION TEST ON SOIL WITH LIME

ADDING 1% LIME

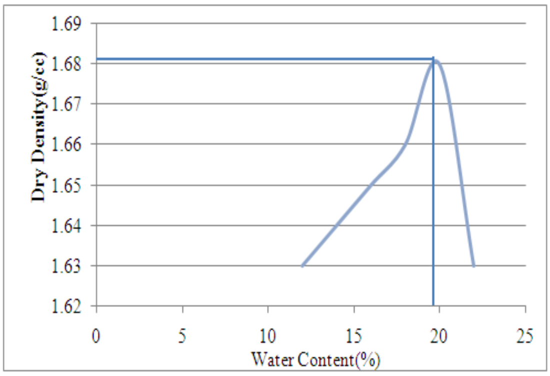


Fig: Water content Vs Dry density

Optimum moisture content =19.8%

Maximum dry density =1.682g/cc

ADDING 2% LIME

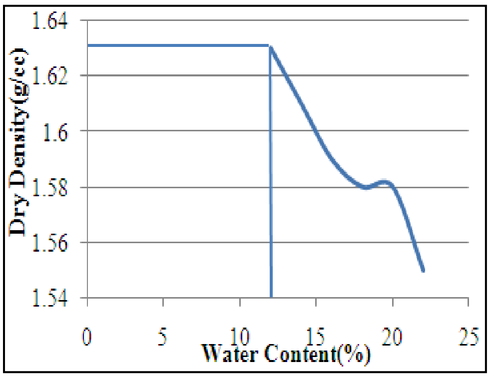


Fig: Water content Vs Dry density

Optimum moisture content = 12%

Maximum dry density = 1.63g/cc

ADDING 3% LIME

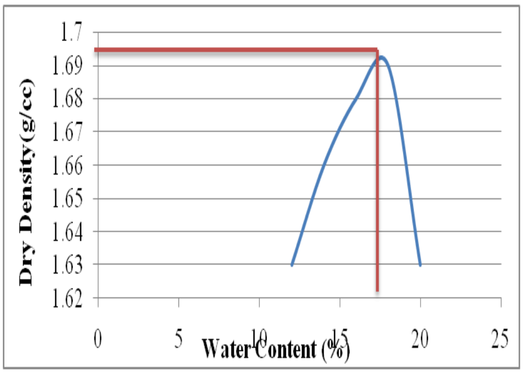


Fig: Water content Vs Dry density

Optimum moisture content = 17.5%

Maximum dry density = 1.69 g/cc

CBR OF SOIL WITH LIME

CBR value of soil with lime = 0.710%

PLASTIC

SPECIFIC GRAVITY OF PLASTIC POWDER

Specific gravity of plastic powder = 0.424

PROCTOR COMPACTION TEST ON SOIL WITH PLASTIC

ADDING 1% PLASTIC POWDER

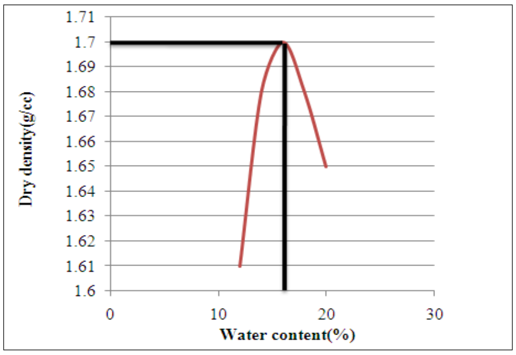


Fig: Water content Vs Dry density

Optimum moisture content = 18%

Maximum dry density = 1.70g/cc

ADDING 2% PLASTIC POWDER

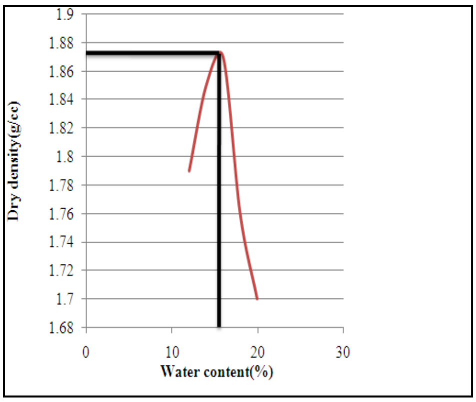


Fig: Water content Vs Dry density

Optimum moisture content = 17%

Maximum dry density = 1.875g/cc

ADDING 3% PLASTIC POWDER

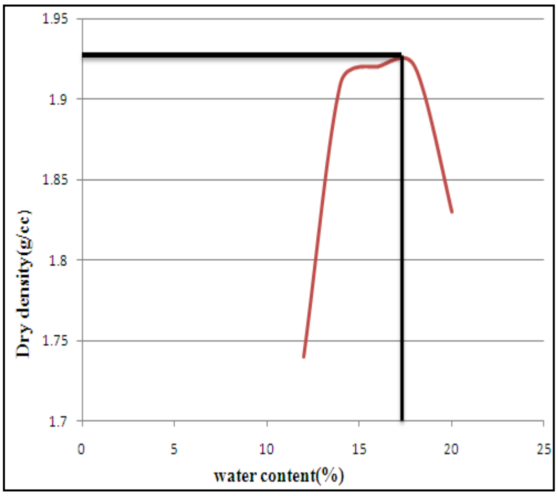


Fig: Water content Vs Dry density

Optimum moisture content = 16.5%

Maximum dry density = 1.935g/cc

CBR OF SOIL WITH PLASTIC

CBR value of soil with plastic powder = 0.913%

IV. CONCLUSION

The study after several experiments, found following significances in using plastic powder as a stabilizing agent.

1. The addition of plastic waste materials to local soil increases the CBR value more than that by adding lime.
2. The soil stabilization with waste plastic powder improves the strength behavior of clayey soil
3. It can potentially reduce ground improvement costs by adopting this method of stabilization. Based on the findings waste plastic could be used as an alternative stabilizer in place of conventionally used stabilizing materials.

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