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RESEARCH ARTICLE

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STABILIZATION OF SOIL BY USING LIME & WASTE PLASTIC FIBRES

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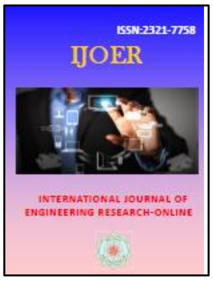


ABSTRACT

Safe and Economic disposal of industrial wastes and development of economically feasible ground improvement techniques are among the important challenges being faced by the engineering community.

In this investigation, an attempt has been made to study the possibility of utilizing lime & plastic fibers these are the hazardous industrial waste for stabilization of soil, since bulk utilization of lime & plastic fibers is feasible in the case of geotechnical applications like construction of embankments, earth dams, and highway and air field pavements. 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, preconsolidation, drainage and much other such process. However, the term stabilization is generally restricted to the process which alters 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 to control the grading of soils and aggregates in the construction of bases and sub bases of the highways and airfields.

Keywords —Plastic Fibers, Lime , Geotechnical Properties, Laboratory Tests.

1. INTRODUCTION

Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub- grade to support pavements and foundations. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials.

Geotechnical properties of problematic soils such as soft fine-grained and expansive soils are improved by various methods. The problematic soil is removed and replaced by a good quality material or treated using mechanical and/or chemical stabilization. The chemical stabilization of the problematic soils (soft fine-grained and expansive soils) is very important for many of the geotechnical engineering applications such as pavement Q1structures, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, and sewer lines to avoid the damage due to the settlement of the soft soil or to the swelling action (heave) of the expansive soils.

Chemical stabilization involves mixing chemical additives (binding agents) with natural soils to remove moisture and improve strength properties of the soil (sub-grade). Generally, the role of the stabilizing (binding) agent in the treatment process is either reinforcing of the bonds between the particles or filling of the pore spaces.

Chemical (Additive) soil stabilization is achieved by the addition of proper percentages of cement, lime, fly ash, bitumen, or combinations of these materials to the soil. The selection of the type and the determination of the percentage of the additive to be used are dependent upon the soil classification and the degree of improvement in soil quality desired. In general, smaller amounts of additives are required when it is simply desired to modify soil properties such as gradation, workability, and plasticity. When it is desired to improve the strength and durability significantly, larger quantities of additive are used. After the additive has been mixed with soil, spreading and compaction are achieved by conventional means.

When building in clay soil, you have a few things to worry about. Most important, you will need to adjust for the actions of the soil. You don't want to have your foundation and basement walls cracked during the first year due to moisture changes. As moisture in the soil changes expansive soil will move. During wetter seasons clay grows, during dry seasons clay shrinks. This can be seen in the soil itself if you watch the ground you will notice the cracks and shrunken appearance the ground has, especially in areas that may have had a pond or a creek.

2. LITERATURE REVIEW

A pavement is a relatively stable crust constructed over the natural soil for the purpose of supporting and distributing wheel loads and for providing an adequate wearing course. These pavements are damaged at a shorter period due to change in the soil properties and due to the repeated application of wheel loads which may result in excessive settlement. Further moisture variation, frost action, increase (or) decrease of water content in the clay soil causes further deterioration of the pavement which necessitates repair process at a higher cost.

Mechanics of Soil Stabilization: The strength of the soil is improved by stabilization.

The term soil stabilization means the improvement of the stability or bearing power of soil by the use of controlled compaction, proportioning and or the addition of suitable admixture or stabilizer. Soil stabilization deals with physical, physicochemical and chemical methods to make the stabilized soil serve its purpose as pavement component materials. The basic principles in soil stabilization may be stated as follows:

- Evaluating the properties of given soil
- Deciding the method of supplementing the lacking property by the effective and economical method of stabilization
- Designing the stabilized soil mix for desired stability values.
- Considering the construction procedure by adequate compaction of stabilized layers.

Mechanical stabilization: The Objective of mechanical stabilization is to blend different available soils so that when compacted, they give the desired stability. In some areas the natural soil at an existing location may have weak in nature (poor CBR). It may due to clay, silt or fine sand. Suitable soil may be selected (contains granular material) and this is to be blended with the available soils to improve the soil properties at a lesser cost in manpower and materials to achieve best results (Increase of CBR). The mechanical stability of soil-aggregate mixtures depends upon the mechanical strength of aggregate, the mineral composition of the materials, the gradation of the mixture, the plasticity characteristics of the binder soil and the compaction. With respect to mineral composition, any material which is resistance to weathering can be used. Sodium sulphate and sodium carbonate have a detrimental effect on the stability because of their high volume changes caused by hydration and dehydration. Presence of chlorides and carbonates are beneficial.

Chemical stabilization:

These are chemical substances that can enter in the natural reactions of the soil and control the moisture getting to the clay particles, therefore converting the clay fraction to permanent cement that holds the mass of aggregate together. The chemical stabilizer in order to perform well must provide strong and soluble cat-ions that can exchange with the weaker clay cat-ions to remove the water from the clay lattice, resulting in a soil mass with higher density and permanent structural change. It uses the following

- Cement
- Lime
- Fly ash
- Bituminous materials
- Other stabilizing chemical admixtures

3. EXPERIMENTAL STUDY

Materials: For the purpose of stabilization soils, lime in the form of powder is collected at KAVALI and plastic fibers are collected from a scrap shop in KAVALI have been used in this study.

Atterberg Limits: The tests were performed according to IS 2720-Part 15, (1985) on soil passing 425µ sieve. For saline water, this test was performed at different concentrations.

Specific Gravity: The Specific gravity (G) of the soil has been determined by exploited some density bottle and pycnometer as per the guidelines provided by IS 2720-Part 3, (1980). The average value has been taken from the three trials was obtained and the result as shown in the table.

Standard Proctor Compaction Test: The soil sample was oven dried at 110^{O}C for about 24 hours. Later, as per standards, the soil is mixed with the various concentrations (0.001 M, 0.01 M and 0.05M) of salt in weight and then this mix has been compacted in three equal layers with each set of experiments with increasing the water content. Later, based on the compaction curves plotted for the different mix, optimum moisture content (OMC) and maximum dry density (MDD) for each test specimens were obtained.

CBR Test:

The load is applied by loading frame through a plunger of 50 mm diameter on the specimen in the mould compacted to Maximum Dry Density @ OptimLU11Moisture content. Dial gauges are used for the measurements of the expansion of specimen on soaking and for measurement of penetration.

There are two types' of procedures to find the CBR Value

. i) Unsoaked CBR

ii) Soaked CBR

Index Properties

Table 01: Properties of the selected material

S.NO	PROPERTY	VALUE
1	LIQUID LIMIT %	32.5
2	PLASTIC LIMIT %	13.96
3	PLASTICITY INDEX %	18.54
4	O.M.C. %	12
5	M.D.D. g/cm^3	1.95
6	CBR VALUE(UN SOAKED) %	10.33
7	PERMEABILITY OF THE SOIL (cm/sec)	$3.0156*10^{-3}$

PROPERTIES OF PLASTIC FIBERS: A typical analysis of plastic fibers is shown in table. The content of each of them depends on rice variety, soil chemistry, climatic conditions, and even the geographic localization of the culture.

PROPERTY	RANGE
Chemical formula	$(C_{10}H_8O_4)_n$
Molar mass	variable
Density	1.38 g/cm^3 (20 ^{o}c), Amorphous: 1.370 g/cm^3 Single crystal : 1.455 g/cm^3
Melting point	>250 ^{o}c
Boiling point	>350 ^{o}c (decomposes)
Solubility in water	Practically insoluble
Thermal conductivity	0.15 to 0.24 w m^{-1} k^{-1}
Refractive index	1.57-1.58
Young's modulus	2800-3100 Mpa
Tensile strength	55-75 Mpa
Elastic limit	50-150%
Notch test	3.6 kj/m^2
Glass transition temperature	67 to 81 ^{o}c

Vicat	82 °c
Linear expansion coefficient	$7x10^{-5}$/k
Water absorption	0.16

LIME AS A STABILIZATION ADMIXTURE: Lime stabilization is done by adding lime to soil. It is useful for stabilization of clayey soils. When lime reacts with soil, there is exchange of cations in the adsorbed water layer and a decrease in plasticity of the soil occurs. The resulting material is more friable than the original clay, and is, therefore, more suitable as sub grade.

Lime is produced by burning of lime stone in kilns. The quality of lime obtained depends upon the parent material and the production process. There are basically 5 types of limes.

i. High calcium, quick lime - CaO
ii. Hydrated high calcium lime – $Ca(OH)_2$
iii. Dolomite quick lime – CaO + MgO
iv. Normal hydrated dolomite lime – $Ca(OH)_2$ + MgO
v. Pressure hydrated dolomite lime–$Ca(OH)_2$ + $Mg(OH)_2$

The quick lime is more effective as stabilizer than the hydrated lime; but the latter is more safe and convenient to handle. Generally, the hydrated lime is used. It is also known as slaked lime. The higher the magnesium content of the lime, the less is the affinity for water and the less is the generated during mixing.

TESTS CONDUCTED: The series of Tests conducted for determination of Compaction Characteristics (Optimum Moisture Content & Maximum Dry Density) and California Bearing Ratio (Unsoaked) for different proportions of Lime, Lime with plastic Fibers mixed with soil as given below:

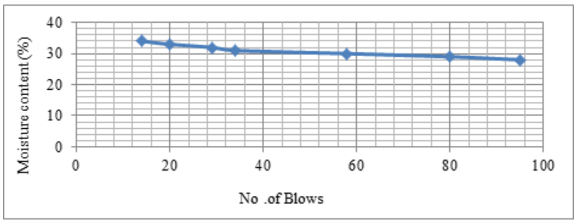
1) Soil Only
2) Soil + 5% Lime
3) Soil + 10% Lime
4) Soil + 20% Lime
5) Soil + 5% Lime + 1% fiber
6) Soil + 5% Lime + 1.5% fiber
7) Soil + 5% Lime + 2% fiber
8) Soil + 10% Lime + 1% fiber
9) Soil + 10% Lime + 1.5% fiber
10) Soil + 10% Lime + 2% fiber
11) Soil + 20% Lime + 1% fiber
12) Soil + 20% Lime + 1.5% fiber
13) Soil + 20% Lime + 2% fiber

RESULTS AND DISCUSSIONS

ATTERBERG LIMITS: The tests were conducted using saline water instead of normal tap water and the values of liquid limit, plastic limit and shrinkage limit are found to be 31.50,18 and 29.40 % respectively.

LIQUID LIMIT OBSERVATIONS:

S.NO	AMOUNT OF WATER ADDED (ML)	MOISTURE CONTENT (%)	NO. OF BLOWS
1	33.5	28	95
2	34.8	29	80
3	36	30	58
4	37.2	31	34
5	38.4	33	29
6	39.6	33	20
7	40.8	34	14



LIQUID LIMIT = 32.5 %

PLASTIC LIMIT OBSERVATIONS:

S.NO	CAN NO.	WT. OF CAN (W1) GM	WT. OF CAN+ WET SOIL (W2) GM	WT. OF CAN+ DRY SOIL(W3) GM	PLASTIC LIMIT MOISTURE CONTENT (%)
1	31	33.93	38.01	37.51	13.96

PLASTIC LIMIT =13.96 %

PLASTICITY INDEX = 18.54

STANDARD PROCTOR AND C.B.R TEST OBSERVATIONS

PROPORTIONS	MAXIMUM DRY DENSITY (gm/cm^3)	OPTIMUM MOISTURE CONTENT (%)	C.B.R VALUE (%)
Soil	1.95	12	10.331
Soil + 5% Lime	2.009	12	9.33
Soil + 10% Lime	2.015	10	41.66
Soil + 20% Lime	2.004	12	9.66
Soil + 5% Lime	1.852	13	18

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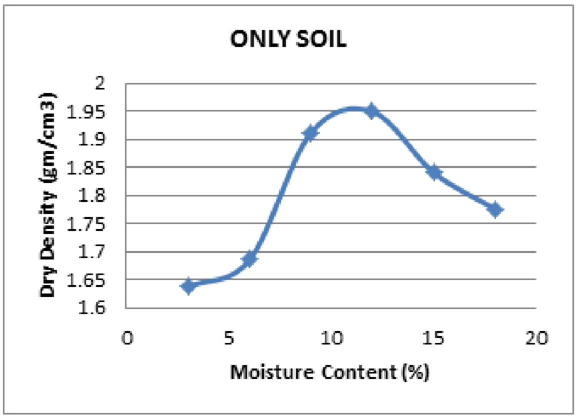
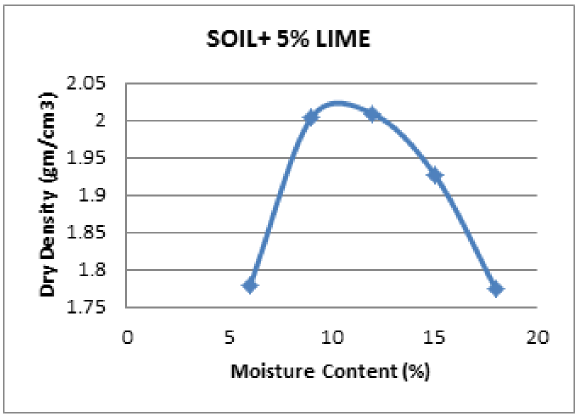
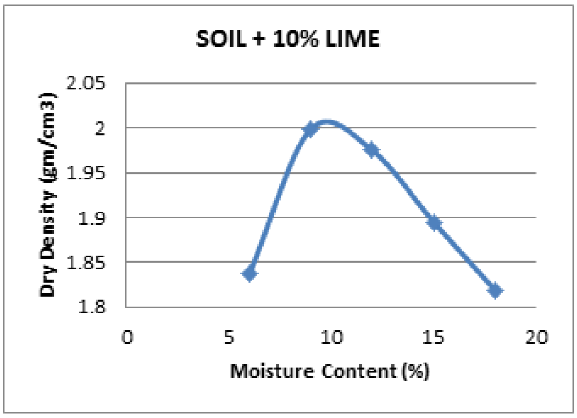
+ 1% Fiber			
Soil + 5% Lime + 1.5% Fiber	1.865	13	8
Soil + 5% Lime + 2% Fiber	1.75	15	13.33
Soil +10% Lime + 1% fiber	1.842	14.5	13.33
Soil +10% Lime + 1.5% fiber	1.837	15	14
Soil +10% Lime + 2% fiber	1.888	14.5	13
Soil + 20% Lime + 1% fiber	1.86	15	10.67
Soil + 20% Lime + 1.5% fiber	1.934	14.4	29.33
Soil + 20% Lime + 2% fiber	1.876	14.4	64.66

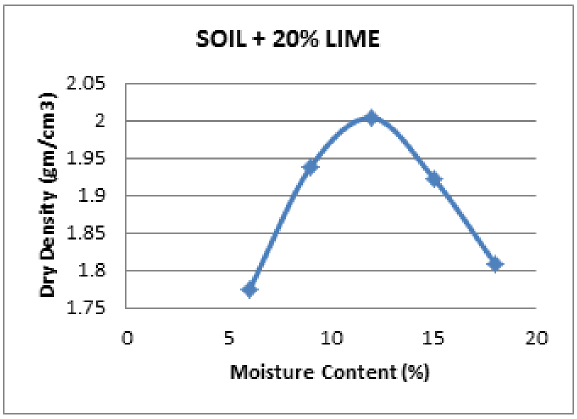
GRAPHS:

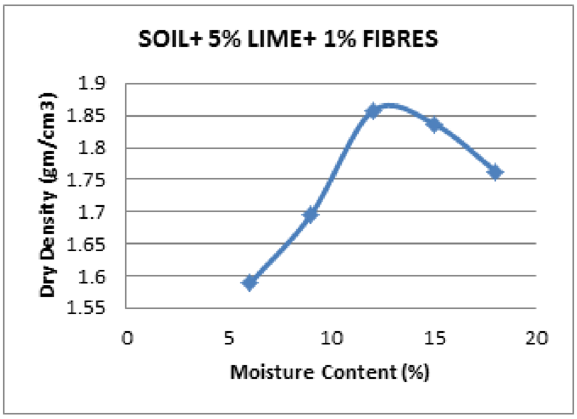
STANDARD PROCTOR TEST GRAPHS

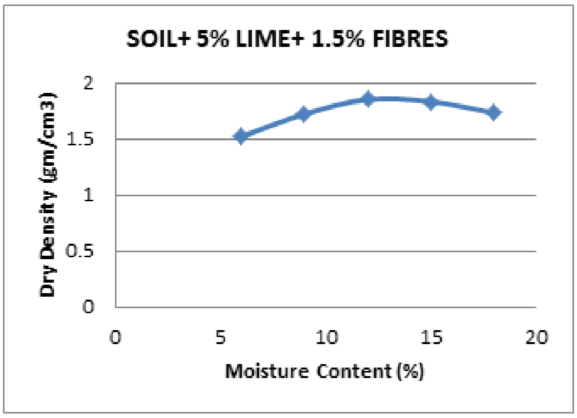


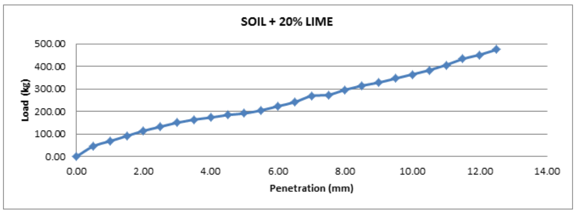


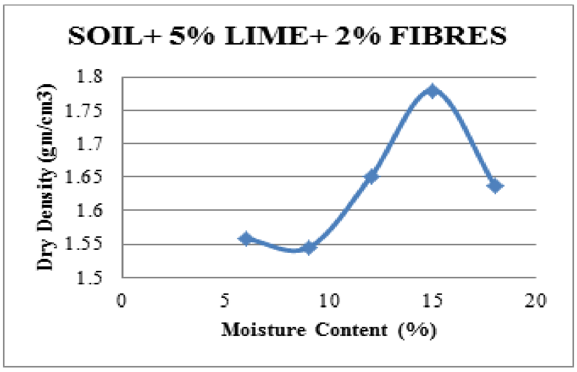


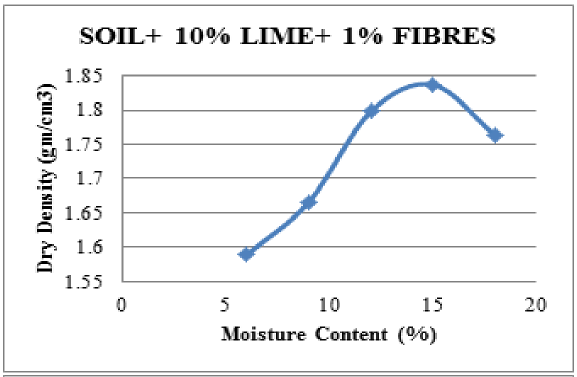


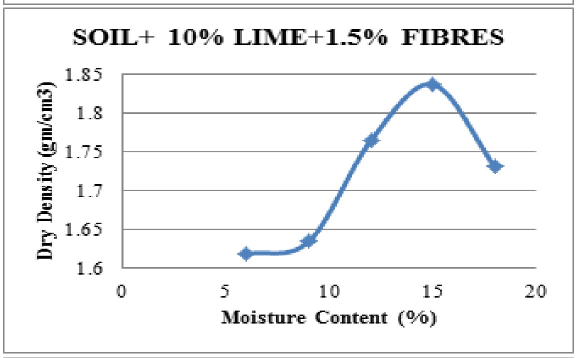


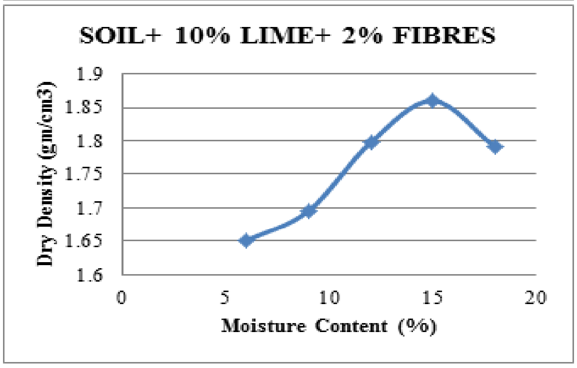


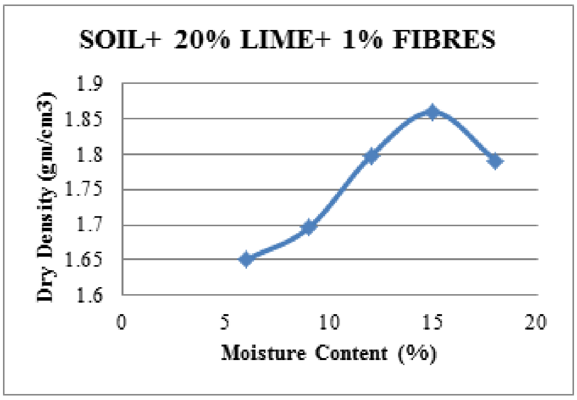


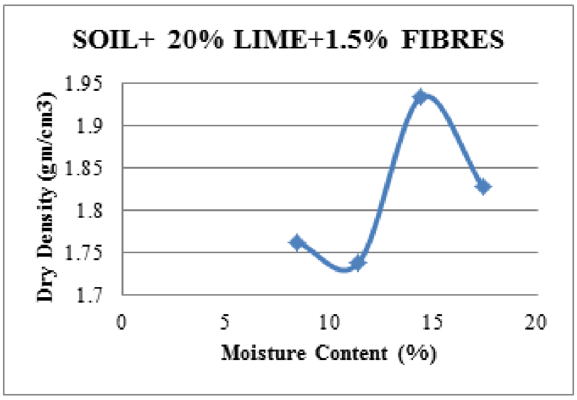


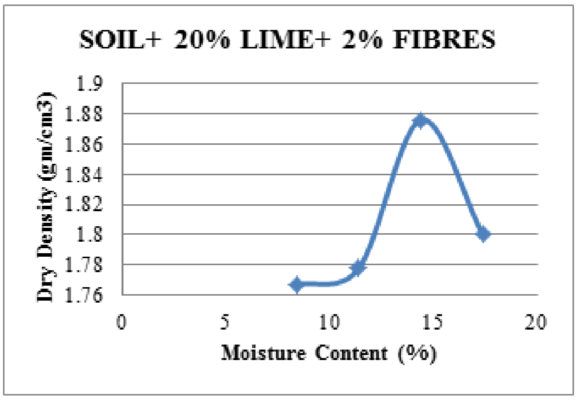




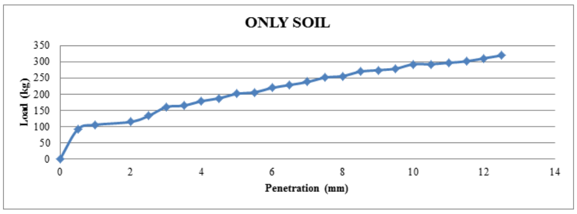


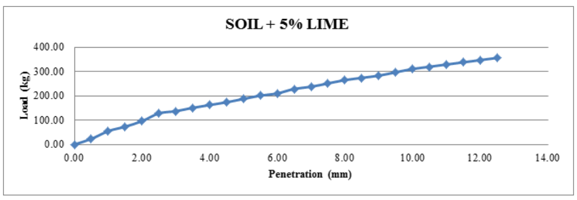


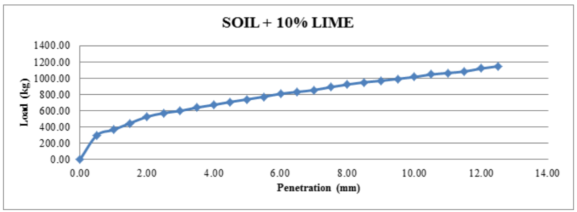


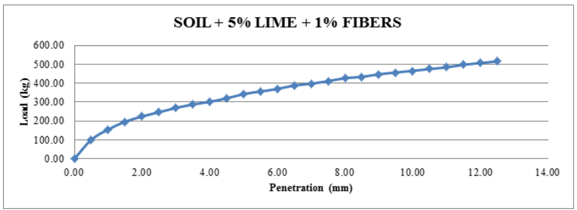


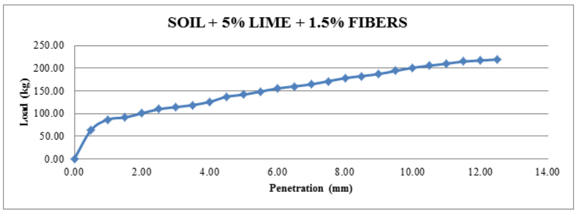
CBR TEST GRAPHS

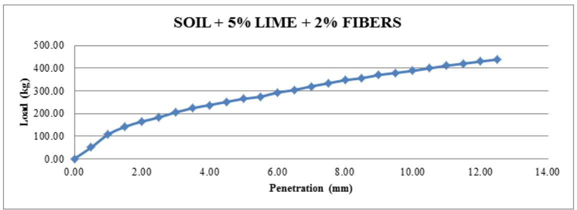


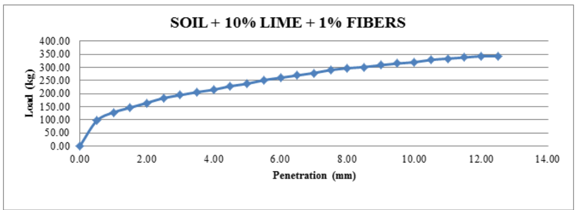


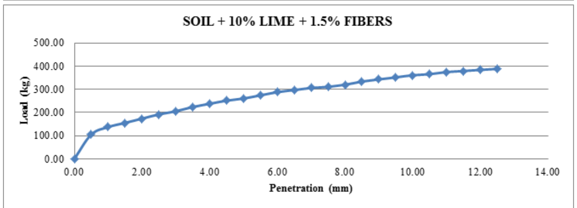


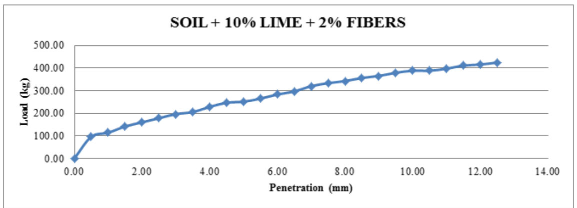


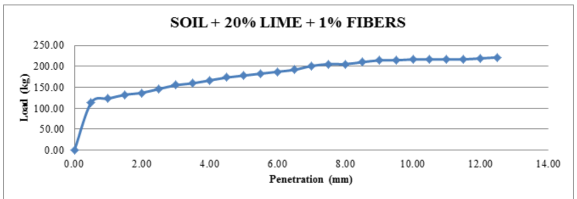


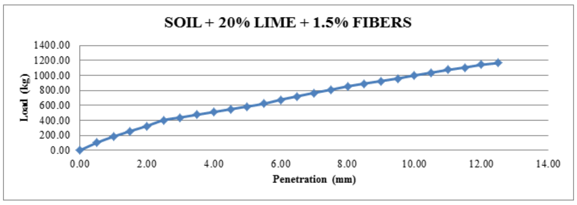


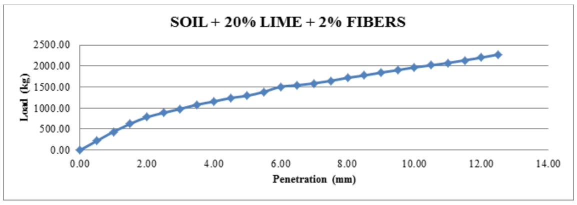












CONCLUSIONS

1. Optimum moisture content and maximum dry density decreases with increase in the lime content.
2. CBR value increases with increase in the quantity of plastic fibers.
3. CBR value is high at 10% lime.
4. Maximum dry density value high at 10% lime.
5. Maximum dry density value decreases with increasing fiber content.
6. CBR value high at 10%lime+2% fiber.
7. CBR gradually increases with increase in fibers upto 2% (soil + 20% lime).
8. CBR value increases up to 1.5% addition of fibers in and decreases in both 1% and 2%.
9. CBR value maximum at 10% lime+20% fibers.
10. From the observations, best ratio for both MDD & CBR values at 10% lime in addition with lime, 20% lime+1.5% fiber in case of both stabilizers.

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