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Enhancing Soil Stability With Lime And Chebula

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Abstract:

The present study focuses on the impact of conventional ground improvement techniques on the environment, supporting the argument with documentary evidence and alternatives to these techniques. The study aims at testing the effectiveness of natural materials such as CHEBULA in powder form as soil Stabilizer. Chebula is also known as Terminalia, the process involves mixing lime and chebula with clay soil to improve the soil's engineering properties, such as Strength, Plasticity, and Bearing capacity. Either in part or whole in the process of soil stabilization index properties, UCS and California bearing ratio test be analysed. The combination of lime and chebula powder has been adopted for use in soil stabilization, the material has been adopted for its capacity in soil stabilization by testing the index and engineering properties of the soil after the addition of material. The addition of lime and chebula powder to the soil (1:1, 2:1 & 3:1) results in a decrease in liquid limit indicating improved soil properties while adding 15% of chebula and Lime to decrease in plasticity indicates improved stability of the soil, The combination of lime & chebula produces high compaction density will indicates the most effective stabilizing agent and optimal dosage, the L: C increases the study of soil in UCS and Bearing capacity that increases the soil stabilizing characteristics of the clay soil.

Keywords: Lime and Chebula , Soil Stabilization , Clayey Soils

INTRODUCTION:

While constructing on expansive soils, which are frequently weak and lack sufficient stability under strong loading, geotechnical engineers face numerous challenges. To increase the soil's engineering properties, stabilizing the soil is important. Little resources are available for network planning and development in under developed nations like India. To enhance road surfaces, it is possible to use soil stabilization to increase the weight-bearing capacity and performance of in situ sub soils, sands, and other waste materials. The main goals of soil stabilization are to increase the in situ soils' California Bearing Ratio, to enhance the on-site materials to produce solid and durable sub-base and base courses and to replace valuable and scarce virgin construction materials that are not renewable. A variety of techniques could be utilized to enhance the performance of sub grade soils. The type of soil to be improved, its features, and the kind and level of improvement needed in a given application all play a role in the decision of which method to use. The quality of soil can be improved through stabilization of soils. Expansive soil is one whose volume alters in response to variations in the amount of water present. The Deccan trap, which comprises Maharashtra, Andhra Pradesh, Madhya Pradesh, and a few isolated locations in Odessa, is where the majority of the expansive soils on the Indian subcontinent are located. These soils may be found in the Narmada, Tapti, Godavari, and Krishna river valleys. In the higher portions of the Godavari and Krishna rivers as well as the north western portion of the Deccan

Plateau, expansive soil is quite deep. This soil ranges in colour from black to brown and contains a significant concentration of clay minerals. On average, expansive soils cover 20% of the country's total geographical area. Due to the high moisture retentive capacity of expansive solids, these soils are ideal for dry farming and the growth of crops like cotton, rice, jowar, wheat, cereal, tobacco, sugarcane, oilseeds, citrus fruit, and vegetables. However, in recent decades, damage from the swelling-shrinking action of expansive soils has been prominently observed in the form of cracking and break-up of roads, channel and reservoir linings, pave slab-on-grade members, irrigation systems, water and sewage lines, and building foundations. Many types of soils may be found across India. These soils are distinct from one another. Because soil mineral content varies depending on location, there are several types of soil accessible. The following map illustrates the vast soils that are present both in India and around the world.

OBJECTIVE OF THE STUDY:

The primary objective of this study is to achieve ground improvement of poor soils with no or minimum impact on the environment and to achieve sustainable development by utilizing unusable land without harming the environment. The objective can be disaggregated into the following stages.

i. To document and evaluate environmental consequences of recent methods of ground improvement methods.

ii. To adopt natural materials in part or whole in ground improvement techniques, after validating their positive results in the improvement of properties of the clays.

MATERIAL DESCRIPTION:

BLACK COTTON SOIL:

A typical black soil has a high clay factor of 62 per cent or more, is extremely argillaceous (geology (of rocks or sediment) consisting of or containing clay), and is very argillaceous in general. Black soils are often less fruitful in uplands than they are in valleys, and vice versa. A lot of moisture is retained by the dark soil. As moisture gathers, it swells considerably. The soil becomes extremely sticky during the rainy season, necessitating arduous labour to work on it. As a result of soil shrinkage and moisture evaporation in the summer, the ground develops wide, deep fractures. Still capable of holding moisture are the bottom layers. The soil has unusual fertility because the fissures allow oxygenation to reach adequate depths.

LIME:

Lime is a chemical substance, often in the form of quicklime or hydrated lime, that is added to soil. Lime stabilizes soil by promoting pozzolanic reactions, forming durable compounds and It helps control soil moisture content, reducing susceptibility to swelling and shrinkage. It is mixed with soil to improve its properties, such as stability and strength and it stabilizes the soil by increasing its PH level and reducing its plasticity, making it more suitable for the construction works.

TERMINALIA CHEBULA IN POWDER FORM:

Chebula also known as TERMINALIA CHEBULA or BLACK MYROBALAN, is sometimes used as a natural additive for lime stabilization of clay soils. The bioactive compounds in chebula powder, such as tannis and polyphenols, interact with clay particles promoting flocculation and reducing the plasticity of soils.

WATER:

The water used for mixing was potable water that had no oils, acids, alkalis, sugar, salts, organic compounds, or other things that may be harmful to soil.

Lime Chebula powder

Table: 1 PHYSCIAL PROPERTIES OF BLACK COTTON SOIL:

Soil property	Results
Specific gravity of soil (%)	2.71
Liquid limit (%)	52
Plastic limit (%)	29.8
Plasticity Index (%)	22.2
MDD(g/cc)	26
OMC (%)	1.44
CBR Test (%)	4.35
UCC Strength(kg/cm2)	q= 3.6 & c= 1.6

METHODOLOGY:

Here we outline the tests that will be performed with Line and Terminalia chebula powder in various ratios as 1:1, 2:1 & 3:1 by weight of dry soil, several laboratory experiments were carried out. According to the applicable IS Code, the following tests were carried out on BC soil and Lime & Chebula powder mixtures. The Lime and Chebula powder is applied to the soil in the next stage of the project at a rate of 5-15% Lime and 5% Chebula powder by weight of the soil. Standard proctor tests, UCC tests, and CBR ratio tests should be carried out on natural soil after partial replacement, while soil mixed with Lime and Chebula powder is compared by experimental work, with the results being analysed for an increase in effective strength.

1. LIQUID LIMIT BY CASEGRANDEE METHOD:

It is the water content of the soil that lies between its liquid state and plastic state, and it may be described as the water content below which, although being in a liquid form, the soil exhibits a negligible resistance to flow. The Casegrandee Operator and Grooving tool is used to measure it, and LL is used to indicate it.

2. PLASTIC LIMIT:

This boundary separates the plastic condition of the sod from its semi-solid state. Rolling out a thread of dirt on a flat, non-porous surface yields the answer. The dirt simply starts to crumble and roll into a thread about 3 mm in diameter at the lowest water concentration. PL stands for plastic limit.

3. SPECIFIC GRAVITY OF SOIL:

The specific gravity of black cotton soils serves as a crucial indicator of their engineering properties. This property measures the ratio of the soil's density to the density of water, providing insights into its compactness and composition. Understanding the specific gravity aids in assessing the soil's bearing capacity, permeability, and potential for swelling or shrinkage. Consequently, the main aim of determining the specific gravity is to enhance the overall geotechnical analysis and engineering design associated with these soils.

4. X- RAY DIFFRACTION (XRD):

X-ray diffraction (XRD) analysis of black cotton soils provides valuable insights into their mineral composition and structure. In XRD analysis of black cotton soils, prominent mineral phases such as smectite, illite, kaolinite, and quartz are typically identified. Smectite clay minerals dominate these soils, contributing to their high plasticity and swelling behaviour. Illite and kaolinite are also commonly present, influencing soil properties such as permeability and shear strength. Quartz, a non-

clay mineral, often occurs in smaller proportions but can significantly impact soil stability and erosion resistance.

5. SCANNING ELECTRON MICROSCOPY (SEM):

Scanning Electron Microscopy (SEM) offers a powerful tool for investigating the microstructure and morphology of black cotton soils, shedding light on their intricate features at a microscopic level.SEM analysis of black cotton soils reveals the fine-scale arrangement of clay particles, pore structure, and the distribution of organic and inorganic constituents. The high-resolution imaging capabilities of SEM allow for detailed examination of soil aggregates, clay mineral assemblages, and soil fabric characteristics, providing valuable insights into their mechanical properties, hydraulic behaviour, and fertility.

6. STANDARD PROCTOR TEST:

An experimental approach for establishing the ideal moisture level at which a certain soil type will become most dense and reach its maximum dry density is the Proctor compaction test. The test is named after R. R. Proctor, who demonstrated in 1933 that the quantity of water present in the soil at the time of soil compaction affects the dry density of soil for a given compaction effort.

7. UNCONFINED COMPRESSION STRENGTH TEST

Black cotton soils, known for their expansive nature, pose unique challenges in construction. The UCS test helps characterize their strength under unconfined conditions, simulating real-world scenarios. Understanding the UCS is essential for foundation design and construction projects in regions with black cotton soils. The results guide engineers in determining the soil's load-bearing capacity, aiding in the design of structures that can with stand the expansive nature of these soils.

8. CALIFORNIA BEARING RATIO:

The California Bearing Ratio (CBR) test is a crucial geotechnical evaluation method used to assess the load-bearing capacity of sub grade soils, particularly black cotton soils prevalent in regions like California. This test provides valuable insights into soil strength, aiding in the design of road pavements and foundations.. For black cotton soils, notorious for their expansive nature, the CBR test becomes pivotal due to their susceptibility to swelling and shrinkage. Understanding the CBR of black cotton soils is instrumental in designing robust foundations and pavements that can withstand the unique challenges posed by these expansive soils.

RESULTS AND DISCUSSIONS:

1. LIQUID LIMIT BY CASEGRANDEE METHOD:

The minimum water content at which a standard grove made by a ASTM tool which will flow together for a distance of 12mm under impact of 25 number of blows is called Liquid limit. The test used to determine the water content of the soil. For the normal Black cotton soil as 52% And for (1:1) 5% Lime & 5% chebula powder as 45%, for (2:1) 10% Lime& 5% chebula powder as 40%, for (3:1) 15% Lime & 5% chebula powder as 36%. So that we conclude that water content be decreased up to 15% of adding admixture.

LIQUID LIMIT	RESULTS
FOR NORMAL SOIL	52%
5% L & 5% C	45%
10% L & 5% C	40%
15% L 7 5% C	36%

2. PLASTIC LIMIT:

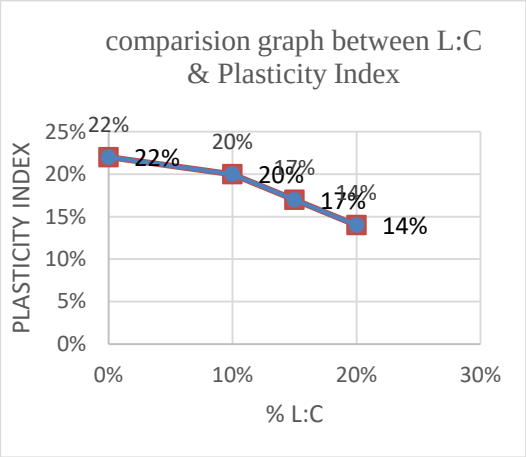
The minimum water content at which a soil can made into a thread of 3mm dia with crumbling as For the normal Black cotton soil as 29.8% And for (1:1) 5% Lime & 5% chebula powder as 25% , for (2:1) 10% Lime& 5% chebula powder as 23%, for (3:1) 15% Lime & 5% chebula powder as 22%.So that we conclude that water content be decreased up to 15% of adding admixture.

3. PLASTICITY INDEX:

It indicates the fineness of the soil and its capacity to change shape without altering its volume. The test used to determine the water content of the soil. For the normal Black cotton soil as 22% And for (1:1) 5% Lime & 5% chebula powder as 20%, for (2:1) 10% Lime & 5% chebula powder as 17%, for (3:1) 15% Lime & 5% chebula powder as 14%. So that we conclude that water content be decreased up to 15% of adding admixture.

Plasticity index (PI) = LL – PL

PLASTICITY INDEX	RESULTS
FOR NORMAL SOIL	22%
5% L & 5% C	20%
10% L & 5% C	17%
15% L 7 5% C	14%

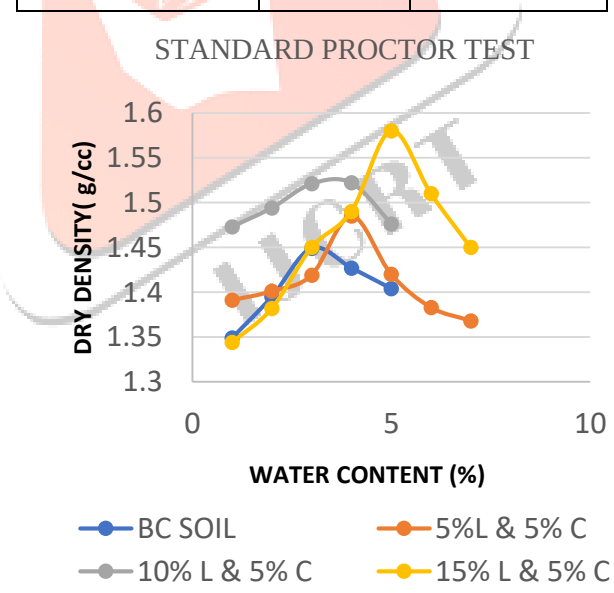


5 .STANDARD PROCTOR TEST:

In this only the soil sample is tested to determine the naturally Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) at site .This soil indicates that variation of Dry Density with varying percentages of water in natural BLACK COTTON soil using without Lime and Chebula powder as stabilizers. For the obtained values, the graph is drawn and shows the Optimum Moisture Content is 25% and Maximum Dry Density is 1.44g/cc, And for (1:1) 5% Lime & 5% chebula powder OMC as 34% and MDD as 1.48g/cc, for (2:1) 10% Lime & 5% chebula powder OMC as 45% and MDD as 1.54g/cc, for (3:1) 15% Lime & 5% chebula powder OMC as 53% and MDD as 1.58g/cc. So that we conclude that OMC be increased up to 15% of adding admixture and MDD be increased up to 15% of adding admixture.

PLASTIC LIMIT	RESULTS
BC SOIL	29.8%
5% L & 5% C	25%
10% L & 5% C	23%
15% L & 5% C	22%

SPT	OMC (%)	MDD (g/cc)
BC SOIL	25%	1.44
5% L & 5% C	34%	1.48
10% L & 5% C	45%	1.54
15% L & 5% C	53%	1.58

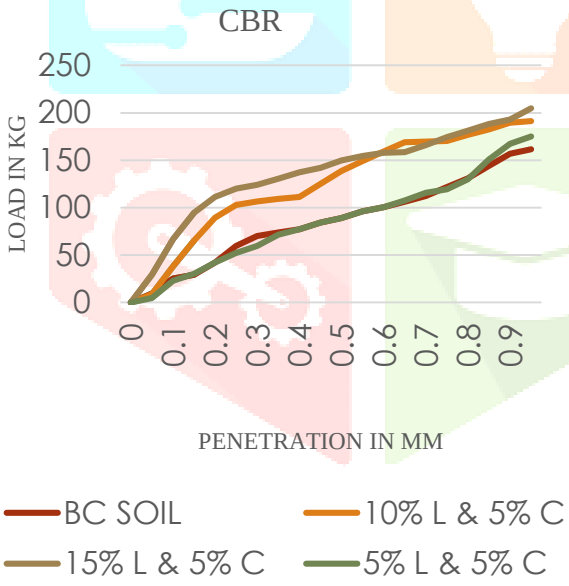


6. CALIFORNIA BEARING RATIO TEST:

This indicates that variation of soil strength for varying percentages of optimum moisture content with natural BLACK COTTON soil using without Lime and chebula powder as stabilizer. From the obtained values, the graph is drawn and shows the penetration @ 2.5 mm as 4.35mm and penetration @ 5.0 mm as 4.325mm. And for (1:1) 5% Lime & 5%

chebula powder @ penetration 2.5mm as 4.52mm and @ penetration 5.0mm as 4.328mm for (2:1) 10% Lime& 5% chebula powder @ penetration 2.5mm as 7.52mm and @penetration 5.0mm as 6.74mm for (3:1) 15% Lime & 5% chebula powder @ penetration 2.5mm as 8.75mm and @ penetration 5.0 mm as 7.28mm. So that we conclude that laod penetration be increased up to 15% of adding admixture. And to determine the load bearing capacity for the addition of 15% of lime chebula gives high load bearing capacity

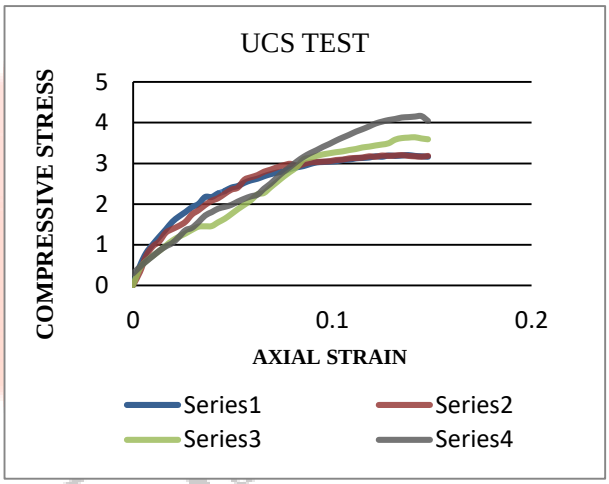
CBR TEST	2.5MM	5.0MM
BC SOIL	4.35	4.325
5% L & 5% C	4.52	4.328
10% L & 5% C	7.52	6.74
15% L & 5% C	8.75	7.28



7. UNCONFINED COMPRESSION STRENGTH TEST:

The unconfined compressive strength (UCS) is the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions—the confining stress is zero. From the obtained values, the graph is drawn and shows the maximum stress values for normal black cotton soil as 3.2 kg/cm^2, for 5% lime and 5% chebula powder as 3.8 kg/cm^2, for 10% lime and 5% chebula powder as 4.2 kg/cm^2, for1 5% lime and 5% chebula powder as 4.4 kg/cm^2. So that we conclude that shear strength be increased up to 15% of adding admixture. And to determine the shear strength for the addition of 15% of lime chebula gives high strength.

UCS TEST	qu=(kg/cm^2)	c=(kg/cm^2)
BC SOIL	3.2	1.6
5% L & 5% C	3.6	1.8
10% L & 5% C	3.9	1.81
15% L & 5% C	4.2	2.1



CONCLUSION:

1. The moisture content of Liquid limit be decreased from 52% to 36% and plastic limit be decreased from 29.8% to 22% of adding Lime and Chebula powder in Black cotton soil.
2. Plasticity index be decreased from 22% to 14% of adding Lime and Chebula powder in Black cotton soil.
3. Due to the presence of biactive compounds in chebula powder as tannis and polyphenols & promoting pozzolanic reactions forming durable compounds – plasticity index be decreased.
4. The Optimum Moisture content of Standard proctor test be increased from 26% to 53% and the Maximum dry density be increased from 1.44g/cc to 1.583g/cc

of adding Lime and Chebula powder in Black cotton soil.

6. The Bearing capacity of soil be increased from 4.35% to 8.75% @ 2.5mm and from 4.32% to 7.28% @ 5.0mm of adding Lime and Chebula powder in Black cotton soil The unconfined compreesive strength of soil be increases from

   UCS VALUE(q) increased from 3.2 kg/sq.cm to 4.4 kg/sq.cm

   COHESION(c) increases from 1.6 kg/sq.cm to 2.32 kg/sq.cm

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