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ENHANCING THE STRENGTH OF REGUR SOIL BY ADDING THE HIGH CALCIUM LIME IN DIFFERENT PERCENTAGE

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Abstract - *Expansive soil exhibits a remarkable capacity for absorbing substantial quantities of water, resulting in significant volume fluctuations that lead to seasonal expansion and contraction based on water availability. This phenomenon can result in structural damage and failure for any buildings constructed on such soil. Various strategies have been implemented to tackle the swelling problem associated with this type of soil, including preloading for moisture control, replacing affected soil, and incorporating additives such as lime, cement, fly ash, or other industrial by-products. Numerous research endeavors have explored the modification of expansive soil behavior through these additives. The primary aim of the present study is to ascertain the most effective application of lime as a soil modifier when necessary. To accomplish this objective, we introduced varying proportions (3%, 4%, 5%, and 6%) of lime to black cotton soil prior to conducting geotechnical tests to evaluate its impact on properties such as plasticity, compaction, consolidation, swelling potential, and strength. Our investigation revealed that higher lime concentrations significantly influenced specific properties, such as plasticity and strength, in comparison to lower levels. In our research paper on the impact of lime treatment on geotechnical parameters' strength measurements in black cotton soil, we conducted liquid limit tests, plastic limit assessments, and examined factors like plasticity index values through compaction tests, as well as California Bearing Ratio assessments.*

Key Words: Regur Soil, Strength, Lime, Improvement of Regur soil, Compressive strength, Shear Strength.

1.BACKGROUND

Ebony-hued cotton soil, commonly referred to as regur soil, holds a prominent position in the agricultural annals of India. Spanning vast expanses of the Deccan Plateau, notably in regions such as Maharashtra, Gujarat, Karnataka, and sections of Madhya Pradesh, this soil variant has been instrumental in sculpting the agricultural topography of the subcontinent. The historical lineage of ebony-hued cotton soil in India traces back numerous centuries, wherein its distinctive attributes have both conferred advantages and posed challenges to farmers. Its inky hue and elevated clay composition render it exceptionally fecund, capable of nurturing a variety of crops such as cotton, sorghum, millets, and pulses. Nonetheless, its pronounced expansiveness during rainy seasons presents hurdles, giving rise to issues like waterlogging and crop fatalities. Over time, farmers have devised an array of methodologies to alleviate these obstacles, encompassing contour farming, bunding, and the employment of deep plowing. Despite its intricacies, ebony-hued cotton soil endures as an indispensable facet of India's agricultural legacy, epitomizing the perseverance and resourcefulness of its agriculturalists in harnessing the land's potential for sustenance and prosperity.

2.REGUR SOIL

Ebony hued cotton soil, also referred to as regur soil, stands as a distinctive element within India's agricultural terrain. Its profound black hue and elevated clay composition present both a blessing and a hurdle for agricultural practitioners. Predominantly located in the Deccan Plateau, notably in regions like Maharashtra, Gujarat, and Karnataka, this soil variant boasts a storied past intricately woven into the agricultural evolution of the area. Renowned for its fertility, it sustains a diverse array of crops, encompassing cotton, sorghum, and pulses. Nevertheless, its pronounced expansiveness during the monsoon season may give rise to challenges such as waterlogging and crop failures, thereby posing formidable obstacles for farmers. Throughout the years, farmers have devised innovative strategies to navigate these obstacles, exemplified by practices like deep plowing and contour farming. Despite its intricate nature, black cotton soil stands as a pivotal component of India's agricultural legacy, epitomizing the resilience and ingenuity of its farming communities in harnessing the land's potential for nourishment and advancement.

Figure-1: Regur Soil (Black Cotton Soil)

2.1.Behaviours of Black Soil

Black cotton soil, also known as regur soil, possesses distinctive qualities that characterize its fertility and pose challenges to agriculture. Its most notable feature is its deep black hue, resulting from its high iron oxide content. This dark color indicates its richness in organic matter and nutrients, making it exceptionally fertile for cultivation. Furthermore, black cotton soil is recognized for its high clay content, often surpassing 30% in composition. This clay content imparts the soil with its sticky consistency when wet and hard, clod-like texture when dry. While this clay content enhances the soil's fertility, it also presents difficulties during farming, particularly in wet seasons. Black cotton soil exhibits significant expansiveness, expanding considerably when wet and contracting when dry. This characteristic can lead to soil fissures and the development of deep cracks, which can impact crop growth and irrigation efficiency. Despite these challenges, farmers have devised innovative methods to manage black cotton soil, ensuring its continued use for agriculture. In essence, the unique attributes of black cotton soil highlight its significance in India's agricultural sector, embodying both its fertility and the resourcefulness necessary for effective cultivation.

3.HIGH CALCIUM LIME

Calcium oxide, commonly referred to as high calcium lime or quicklime, is a vital industrial compound with a diverse array of uses. Its production entails heating limestone (calcium carbonate) to elevated temperatures, leading to its decomposition into calcium oxide and carbon dioxide. High calcium lime is highly esteemed for its versatility across multiple sectors, including construction, agriculture, and environmental restoration. In the realm of construction, it acts as a fundamental component in mortar and plaster, imparting strength and longevity to structures. In agriculture, it serves to neutralize acidic soils, enhance soil composition, and provide essential calcium for plant development. Furthermore, it plays a crucial role in environmental remediation activities, such as wastewater treatment and flue gas desulfurization processes. Despite its utility, the handling of high calcium lime demands caution due to its corrosive properties, necessitating the implementation of appropriate safety measures during its production, transportation, and application. High calcium lime possesses numerous noteworthy characteristics that render it a valuable substance in diverse industrial and commercial settings. Firstly, it showcases exceptional reactivity, allowing it to swiftly interact with water to generate calcium hydroxide, a phenomenon known as slaking. This reactivity proves beneficial in scenarios where quick hydration is essential, as observed in the production of mortar and plaster. Secondly, high calcium lime boasts a high calcium concentration, typically exceeding 90%, making it a potent source of calcium for soil enhancement in agricultural contexts. Its alkaline properties enable it to counterbalance acidic soils, optimize soil pH levels, and bolster soil structure, thereby fostering robust plant growth. Additionally, high calcium lime exhibits desiccating attributes, enabling it to absorb moisture from its environment, a trait advantageous in specific industrial processes and environmental applications. Nonetheless, handling high calcium lime with care is imperative due to its caustic nature, which can lead to burns and irritation upon skin or eye contact. Overall, the distinctive characteristics of high calcium lime render it indispensable in various sectors, spanning from construction to agriculture and environmental restoration.

3.1.Mechanisms of soil stabilization with High Calcium Lime

High Calcium Lime (HCL) is a potent agent for soil stabilization, offering several mechanisms that enhance the structural integrity and durability of soil. One primary mechanism involves the chemical reaction between HCL and soil particles, resulting in the formation of stable compounds such as calcium silicates and calcium aluminates. This reaction alters the soil's mineral composition, promoting cohesion and reducing its susceptibility to erosion and weathering. HCL acts as a binding agent, effectively cementing soil particles together. As it hydrates, it forms a matrix within the soil, creating a dense and robust network that enhances load-bearing capacity and reduces settlement. This binding action significantly improves the soil's mechanical properties, making it suitable for various engineering applications such as road construction, embankment stabilization, and foundation support. Additionally, HCL exhibits pozzolanic properties, which further contribute to soil stabilization. Pozzolanic reactions occur between lime and certain silica and alumina-containing materials present in the soil or added as supplements. These reactions produce additional binding compounds, enhancing the overall strength and durability of the stabilized soil. HCL treatment can modify the soil's pH, creating conditions unfavorable for the growth of harmful organisms such as bacteria, fungi, and pests. By altering the soil's chemical environment, HCL helps mitigate issues related to soil degradation and contamination.

3.2.Improving the Strength of Black Cotton Soil with High Calcium Lime

Enhancing black cotton soil with High Calcium Lime (HCL) improves its strength by reacting with clay minerals to form stable compounds like calcium silicates and aluminates. This alters the soil's composition, reducing plasticity and enhancing cohesion. HCL binds soil particles, creating a stronger, more compact structure that resists swelling, shrinkage, erosion, and shear forces. Its pozzolanic properties further enhance soil stability and durability, reducing maintenance needs. HCL is an effective solution for construction projects in areas with black cotton soil, enabling infrastructure development and economic growth.

4.METHODOLOGY

In this segment of the methodology, we will explore the practical steps required to thoroughly assess the influence of soils utilizing different proportions of high calcium lime. The objective of this research is to enhance our comprehension of how diverse lime levels can impact soil structure and excellence, consequently guiding more judicious decision-making in agricultural and land management strategies. By delving deeply into these principles, our goal is to provide readers with the expertise and resources necessary to effectively navigate this crucial field of study.

5.RESULT AND ANALYSIS

In this specific section of the report, we will explore the findings and analysis resulting from the conducted calculations. The parameters considered in geotechnical engineering are outlined below, forming the foundation for the achieved outcomes. The liquid limit (LL) of the swelling soil was determined by employing different concentrations of high calcium lime. The Plastic Limit (PL) of the expansive soil can be modified by varying quantities of High Calcium lime. The Plasticity Index (PI) of the swelling soil was evaluated through the use of different proportions of High Calcium lime. Compaction testing of swelling soil was carried out using various percentages of high calcium lime.

5.1.The Value of Liquid Limit of the Regur Soil with High Calcium Lime

To determine the liquid limit of regur soil, a series of experiments were conducted using varying concentrations of high calcium lime. The aim was to assess the impact of lime addition on the soil's consistency and behavior across different scenarios. Through precise incorporation of lime in different ratios, a substantial amount of data was gathered, meticulously organized into tables and graphs for easy comprehension and analysis. The outcomes from these experiments are expected to offer significant insights into the behavior of regur soil in diverse conditions. They can also serve as crucial decision-making aids when considering the use of this soil type in various applications. This study yields valuable information on how regur soil responds to different environmental factors, highlighting both its strengths and weaknesses, thereby facilitating the optimization of its utilization.

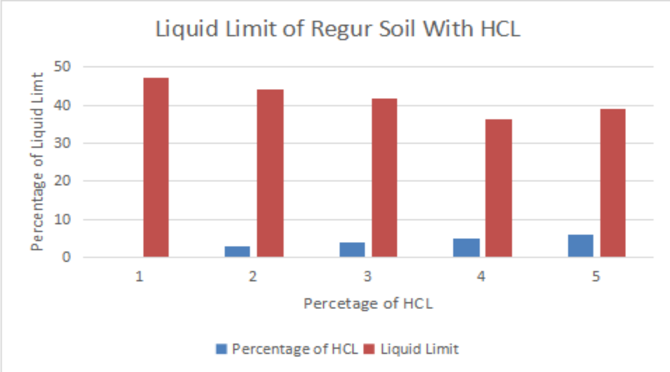

Figure-2: Liquid Limit.

5.2.The Value of Plastic Limit of The Regur Soil with High Calcium Lime

The plasticity limit of soil is crucial in geotechnical engineering, showing when soil goes from semi-solid to plastic due to moisture. The ASTM D4318 test method is used to determine this limit by forming a soil sample into a thread without breaking. This helps classify soils and understand their properties for construction and foundation planning. Knowing the plasticity limit ensures stability and security in engineering projects by providing accurate data on soil behavior. Geotechnical engineers must understand this limit for construction projects.

Table-1: Plastic Limit of BCS with Lime

S.No	RS with various percentage of the HCL	Plastic limit(PL)
1	RS with Zero Percent of HCL	032.00%
2	RS with Three Percent of HCL	NP
3	RS with Four Percent of HCL	NP
4	RS with Five Percent of HCL	NP
5	RS with Six Percent of HCL	NP

5.3.Plasticity Index of Regur Soil

Soil plasticity is determined by the plasticity index (PI), calculated as the difference between liquid limit (LL) and plastic limit (PL). Higher PI values indicate greater plasticity and deformation capacity. PI is crucial in soil classification systems like USCS for evaluating soil suitability in engineering projects.

Table-2: Plasticity Index of BCS through Lime

S.No	RS with various percentage of the HCL	Plasticity index = Liquid limit-plastic imit
1	RS with Zero Percent of HCL	15.40
2	RS with Three Percent of HCL	NON PLASTIC
3	RS with Four Percent of HCL	NON PLASTIC
4	RS with Five Percent of HCL	NON PLASTIC
5	RS with Six Percent of HCL	NON PLASTIC

5.4.Compaction Test For Regur Soil with Different Percentage of High Calcium Lime

The Proctor compaction test determines max dry density and optimal moisture content of soil by compacting samples at various moisture levels using standardized energy. Testing follows ASTM D698 or AASHTO T99. Results help calculate key parameters for soil compaction in construction projects.

Table-3: Compaction Test of BCS with Lime

S.no	Calculation	RS without HCL	RS with Three Percent of HCL	RS with Four Percent of HCL	RS with Five Percent of HCL	RS with Six Percent of HCL
1	Mass of mould + compacted soil „W"(gms)	6993.00	7256.00	7263.00	7215.00	7202.00
2	Mass of compacted soil W3 = W2-W1 (gms)	1807.00	1746.00	1743.00	1705.00	1682.00
3	Wet density v wt	01.81	1.75	1.74	1.70.00	1.68.00
4	Moisture content (%)	014.0	14.5	14	12.5	12
5	Dry density (gm/cm3)	01.580	1.52	1.53	1.51	1.50

5.CONCLUSION

This study has illustrated the effective alteration of black cotton soil properties through the incorporation of lime in varying proportions. Soil stabilization was accomplished by blending different quantities of lime, resulting in several noteworthy findings. The liquid limit value exhibited an increase of 6.695%, 12.095%, 21.382%, and 17.71% respectively when 3%, 4%, 5%, and 6% lime were added to the black cotton soil, with a subsequent decline observed at concentrations exceeding 6%. Therefore, it is advisable not to exceed a maximum of 5% lime addition to achieve optimal liquid limit levels. The plastic limit value for black cotton soil without any lime addition is approximately 30.9%. However, upon incorporating 3%, 4%, 5%, or 6% lime into the black cotton soil, it becomes non-plastic. Similarly, the plasticity index value for black cotton soils without lime addition is 15.4%. After introducing varying amounts of lime into these soils, they also become non-plastic. In compaction tests conducted on different lime mixtures within black cotton soils, dry density values ranged from 1.58 g/cm^3 with no additional materials to an increase between 3.797% and 5.06% when mixed with 6% lime content levels.

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