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

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Abstract - *Regur soil, commonly known as black cotton soil, is prevalent in various regions around the world, presenting unique challenges due to its expansive nature and low bearing capacity. In recent years, researchers and engineers have explored numerous methods to improve its engineering properties, with a particular focus on enhancing its strength. One such method involves the addition of high calcium lime in varying proportions to the regur soil. This review paper comprehensively examines the research conducted on this topic, summarizing the findings, methodologies, and outcomes of studies investigating the effects of high calcium lime addition on the strength characteristics of regur soil. Through a systematic analysis of the literature, this paper elucidates the mechanisms by which high calcium lime interacts with regur soil, influencing its geotechnical properties such as compressive strength, shear strength, and California Bearing Ratio (CBR). Furthermore, this review highlights the significance of optimizing the percentage of lime addition to achieve desired improvements in soil strength while considering factors such as soil type, lime content, curing conditions, and environmental considerations. By synthesizing the existing knowledge, this paper provides valuable insights for researchers, engineers, and practitioners engaged in soil stabilization projects, offering guidance for the effective utilization of high calcium lime to enhance the strength and performance of regur soil.*

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

1.BACKGROUND

Regur soil, colloquially known as black cotton soil or black soil, boasts a rich historical tapestry intertwined with agricultural development in tropical regions. Originating from the weathering of basaltic rocks over millions of years, its formation endowed it with rich mineral content, including iron, magnesium, calcium, and potassium. Evidence suggests that ancient civilizations such as the Indus Valley Civilization and later the Vedic peoples utilized these fertile lands for agriculture, cultivating crops like millet, pulses, and cotton. However, it was during the British colonial era in India that the true agricultural potential of regur soil came to light. British officials recognized its suitability for cash crops like cotton and promoted its cultivation, reshaping land use patterns and agricultural practices. Subsequent research delved into the unique properties of regur soil, leading to the development of tailored agricultural techniques to maximize productivity. Today, regur soil continues to underpin agricultural practices in regions like the Deccan Plateau in India, with farmers employing conservation measures to sustain its fertility amidst modern challenges like erosion and nutrient depletion. Thus, the history of regur soil mirrors the evolution of agricultural practices, shaped by cultural, economic, and scientific influences, while emphasizing the importance of conservation for future generations.

2.REGUR SOIL

Regur soil, commonly known as black soil, is a type of soil found in the Deccan Plateau region of India. Its name is derived from the Marathi word 'regur,' which means 'to swell.' This soil is renowned for its remarkable fertility, making it highly conducive to agriculture. Characterized by its dark color and high clay content, regur soil has excellent moisture retention properties, enabling crops to thrive even during dry spells. However, its high clay content also poses challenges, such as poor drainage and susceptibility to waterlogging. Despite these drawbacks, regur soil is highly prized for its ability to support a variety of crops, including cotton, soybeans, and cereals like sorghum and millets. Proper management techniques, such as implementing drainage systems and employing suitable crop rotation practices, are essential for maximizing the productivity of regur soil and sustaining its fertility for future generations.

Figure-1: Regur Soil (Black Cotton Soil)

2.1.Characteristics of Regur Soil

Regur soil exhibits several distinctive characteristics that contribute to its fertility and suitability for agriculture. One of its defining features is its rich, dark color, which results from a high content of organic matter. This organic matter not only enhances soil structure but also provides essential nutrients for plant growth. Regur soil is characterized by its high clay content, imparting it with excellent moisture retention capabilities. This enables crops to withstand dry periods by accessing stored water in the soil. However, the high clay content also leads to challenges such as poor drainage and compaction, which can hinder root development and water infiltration. Despite these drawbacks, regur soil is prized for its ability to support a wide range of crops, including cotton, soybeans, and cereals like sorghum and millets. Proper management practices, such as incorporating organic matter, implementing drainage systems, and rotating crops, are essential for optimizing the productivity of regur soil and preserving its fertility over time.

3.IMPORTANCE OF SOIL STABILIZATION IN CONSTRUCTION

Soil stabilization plays a critical role in construction projects by enhancing the engineering properties of soil to meet the requirements of various structures. It is indispensable in ensuring the longevity and stability of infrastructure such as roads, buildings, dams, and airports. By stabilizing soil, engineers can mitigate the effects of factors like erosion, settlement, and subsidence, thereby reducing maintenance costs and increasing the lifespan of structures. Moreover, stabilized soil provides better support for heavy loads and improves the overall safety of the construction site. This process also contributes to environmental sustainability by minimizing the need for excavation and transportation of additional materials. Overall, soil stabilization serves as a cornerstone in the construction industry, offering solutions that are both economically viable and environmentally friendly.

4.HIGH CALCIUM LIME AS A SOIL STABILIZER

High calcium lime, a versatile and widely used soil stabilizer in construction, offers numerous benefits for enhancing the properties of soil. When applied to soil, high calcium lime undergoes a chemical reaction with water and soil particles, resulting in the formation of stable calcium silicates and calcium aluminate hydrates. This reaction, known as pozzolanic reaction, leads to improved soil strength, reduced plasticity, and increased resistance to weathering and erosion. High calcium lime effectively modifies soil by increasing its load-bearing capacity, reducing swelling and shrinkage potential, and enhancing compaction characteristics. Additionally, it facilitates better drainage and reduces the susceptibility of soil to frost damage. Moreover, high calcium lime is environmentally friendly, as it is derived from natural limestone and emits low levels of greenhouse gases during production. Its cost-effectiveness and sustainability make it a preferred choice for soil stabilization in a wide range of construction applications, including road bases, embankments, and foundation works.

4.1.Mechanisms of Soil Stabilization with Lime

Soil stabilization with lime is a widely employed technique in civil engineering and construction projects, owing to its effectiveness in enhancing soil properties. Lime, typically in the form of calcium oxide (quicklime) or calcium hydroxide (hydrated lime), achieves stabilization through a combination of chemical, physical, and mineralogical mechanisms. Chemical reactions play a pivotal role in lime stabilization. When lime is applied to soil, it undergoes hydration, releasing heat and forming hydrated lime. This hydrated lime interacts with soil minerals, leading to cation exchange processes that improve soil structure by increasing the exchangeable calcium and reducing exchangeable sodium. Additionally, lime can stabilize clay minerals through flocculation, reducing soil plasticity and enhancing stability. Lime may also undergo pozzolanic reactions with silica and alumina, forming cementitious compounds that enhance soil strength and reduce permeability. Furthermore, lime aids in drying and dehydration of soil by absorbing water, making it beneficial for stabilizing moist or wet soils. This dehydration process reduces soil plasticity and increases strength. Lime treatment also increases soil pH, neutralizing acidity, and precipitating harmful ions like aluminum, thereby improving soil fertility and promoting favorable conditions for soil microorganisms. Physically, lime promotes flocculation and particle aggregation, enhancing soil structure and bearing capacity. This results in reduced swelling and shrinkage potential, making the soil more stable and workable. Moreover, lime-stabilized soils exhibit enhanced resistance to erosion, moisture damage, frost heave, and chemical degradation, leading to improved long-term performance and durability of constructed facilities. Soil stabilization with lime is a comprehensive approach that leverages various mechanisms to enhance soil properties, making it suitable for a wide range of construction applications. The effectiveness of lime stabilization depends on factors such as soil type, lime dosage, mixing method, and environmental conditions, highlighting the importance of proper engineering analysis and application techniques.

4.2.Advantages and limitations of using Lime as a Soil Stabilizer

Lime as a soil stabilizer presents numerous advantages but also comes with certain limitations. Primarily, lime enhances soil strength by forming cementitious compounds with clay particles, thereby increasing stability and bearing capacity. Additionally, it reduces soil plasticity, mitigating volume changes due to moisture fluctuations and improving workability during construction. Lime-treated soils also exhibit enhanced durability against weathering and erosion. Moreover, lime stabilization proves cost-effective compared to alternative methods, making it a practical choice for large-scale projects. However, lime's slow reaction rate necessitates extended curing periods, potentially delaying construction schedules. Moreover, it requires adequate moisture for activation, and its caustic nature poses environmental concerns if not managed properly. Furthermore, lime may not be effective in stabilizing soils with high organic content or certain sandy soils. Quality control challenges, such as ensuring uniform distribution and proper mixing, add complexity to implementation. Despite these limitations, lime remains a valuable tool in soil stabilization, offering a balance of benefits and considerations for engineers and contractors alike.

5.FACTORS AFFECTING THE EFFECTIVENESS OF LIME STABILIZATION IN REGUR SOIL

Lime stabilization is a common method used to improve the engineering properties of soils, including regur soil. Regur soil, also known as black cotton soil, is a type of expansive clay soil found in regions with a semi-arid to arid climate, such as parts of India. Lime stabilization involves the addition of lime to the soil to alter its properties, making it more suitable for construction purposes. Several factors can affect the effectiveness of lime stabilization in regur soil:

1. **Soil Composition:** The mineralogical composition of regur soil influences its reactivity with lime. Regur soil typically contains high percentages of clay minerals, such as montmorillonite and illite. These minerals interact with lime to form stable compounds that improve soil strength and reduce its plasticity.

2. **Lime Content:** The amount of lime added to the regur soil is critical for achieving the desired stabilization effect. Optimal lime content varies depending on factors such as soil type, moisture content, and intended engineering use. Too little lime may not adequately stabilize the soil, while excessive lime can lead to excessive drying and other undesirable effects.

3. **Moisture Content:** The moisture content of the soil influences the effectiveness of lime stabilization. Generally, a moderate moisture content is preferred for lime treatment, as it facilitates the hydration and chemical reactions between lime and soil minerals. However, excessively dry or wet conditions can hinder these reactions and compromise stabilization.

4. **Mixing Method:** Proper mixing of lime and soil is essential for uniform distribution and effective stabilization. Various mixing methods, such as mechanical mixing, deep mixing, or in situ mixing, can be employed depending on site conditions and project requirements. Thorough mixing ensures that lime interacts with the soil particles uniformly, enhancing its effectiveness.

5. **Curing Time:** After lime treatment, sufficient curing time is required for the stabilization reactions to occur and for the soil to gain strength. The curing period varies depending on factors such as lime dosage, soil type, temperature, and moisture conditions. Longer curing times may be necessary for deeper soil layers or when using lower lime dosages.

6. **Environmental Conditions:** Environmental factors such as temperature, humidity, and rainfall can affect the effectiveness of lime stabilization. Warm and dry conditions generally promote faster reaction kinetics and curing, whereas cold or excessively wet conditions may delay stabilization and curing processes.

7. **Compaction:** Proper compaction is essential after lime treatment to achieve the desired density and strength. Compaction helps in reducing voids and improving the load-bearing capacity of the stabilized soil. Adequate compaction ensures that the stabilized soil meets the required engineering specifications.

6.LITERATURE SURVEY

We reviewed soil stabilization literature, analyzed previous papers, reviewed methodologies, data, and conclusions, and summarized key insights for our own investigations.

Pradeep et.al: The incorporation of lime into black cotton soil, in conjunction with bagasse ash, has been shown to significantly enhance the soil's stability and microstructure. This innovative method presents a promising remedy for the challenges associated with stabilizing black cotton soil solely with bagasse ash. By augmenting the soil with lime, engineers are able to mitigate shrinkage potential and improve engineering characteristics, leading to enhanced overall performance. Furthermore, the utilization of digital image analysis has proven to be beneficial in evaluating shrinkage parameters accurately, enabling a more precise assessment of the soil's behavior under varying conditions. In essence, this approach signifies a cutting-edge and efficient strategy to optimize the performance of black cotton soil stabilized with bagasse ash and lime.

Hadi & Abhishek: The current study seeks to explore the influence of different proportions of coal combustion residuals (CCR) and fiber contents on Atterberg's limits, compaction characteristics, unconfined compressive strength, and California bearing ratio. Utilizing industrial waste for soil stabilization presents an economically feasible alternative that reduces expenses associated with conventional methods. The incorporation of CCR and fiber contents has shown to yield a notable impact on diverse soil attributes. The results of this investigation offer valuable perspectives on the potential application of industrial waste materials for enhancing soil quality, contributing to the realization of sustainable development objectives and the mitigation of environmental harm.

Shyam et.al: The incorporation of lime into black cotton soil, along with rice husk ash, has been proven to yield a variety of advantageous outcomes. Specifically, this process enhances the soil's strength while simultaneously diminishing its flexibility and enhancing its CBR (California Bearing Ratio) values. Consequently, the soil transitions to a non-plastic and non-swelling state, rendering it suitable for utilization in road construction endeavors. In a recent investigation carried out in India, scholars blended RHA-lime with varying concentrations of cementitious material (with lime serving as a primary component). The findings demonstrated that the addition of lime to the amalgam decreased flexibility while bolstering overall strength. This is particularly significant when addressing expansive soils, which are susceptible to swelling and other types of distortion. The incorporation of RHA and lime into black cotton soil has been proven to provide numerous advantages, rendering it an appealing choice for construction projects. By enhancing critical attributes such as strength and plasticity, this method can assist in ensuring that roads are erected on a sturdy base capable of enduring heavy traffic loads over time.

Ajay et.al: The incorporation of lime in conjunction with bagasse ash has been found to be extremely advantageous in reinforcing black cotton soil. This is attributed to the decrease in shrinkage potential, development of durable structures, and improvement in engineering characteristics as demonstrated by microstructural examinations. This study introduces a new method in which lime is added to the black cotton soil already treated with bagasse ash. The objective is to address the constraints associated with using bagasse ash alone to stabilize black cotton soil. The introduction of lime has proven to greatly increase the stability of black cotton soil when paired with bagasse ash. Digital image analysis has been employed to precisely assess shrinkage parameters. In conclusion, the integration of lime into the stabilization process of black cotton soil with bagasse ash shows promising outcomes and warrants further investigation for its potential advantages in diverse engineering applications.

Samatha et.al: The research paper explores the enhancement of the strength of black cotton soil by utilizing lime treatment along with rice husk ash as an additive, resulting in increased stability and decreased construction costs. The authors concentrated on enhancing the strength and stability of lime-treated expansive soil by introducing rice husk ash as an additive. Compaction tests, unconfined strength tests, and California bearing ratio tests were conducted on the soil with lime added in increments ranging from 2% to 12% to determine the optimal lime level. Subsequently, the optimal lime amount was identified, and the percentages of both optimal lime and rice husk ash were calculated. The study demonstrated that the inclusion of rice husk ash improved the strength and stability of expansive soil treated with lime. In summary, this research offers valuable insights into how combining lime treatment with rice husk ash can enhance soil quality while reducing construction costs.

Zihong et.al: The engineering properties of black cotton soil (BCS) can be greatly improved by incorporating lime, leading to a decrease in plasticity, an increase in CBR values, and a reduction in swell percentage. This enhancement makes BCS ideal for utilization in pavement subgrade construction. The authors of the study delved into the engineering characteristics of BCS that had been stabilized with both natural lime and volcanic ash (VA), as well as different combinations of the two materials. The findings revealed that the inclusion of both VA and lime resulted in a substantial enhancement in the engineering properties of BCS. Particularly, a blend comprising 3% lime and 20% volcanic ash was identified as highly efficient. Therefore, it is advised to utilize this specific combination for optimal outcomes when dealing with black cotton soil.

Bhanu et.al: Black cotton soil, a type of expansive clay, presents significant engineering challenges due to its poor compressive strength and California bearing ratio. However, a viable solution to this issue has been discovered - the addition of lime. When lime is incorporated into black cotton soil, it brings about a notable enhancement in its unconfined compression strength and California bearing ratio, thereby improving its overall engineering properties. Recent research has delved into this topic, showcasing the outcomes of an experiment aimed at enhancing the engineering characteristics of expansive clays by utilizing lime and ground granulated blast-furnace slag (GGBS) as additives. The study revealed that the combined addition of lime and GGBS resulted in substantial improvements in the unconfined compression strength and California bearing ratio of the soil. Furthermore, it was noted that higher quantities of lime and GGBS led to increased maximum dry density (MDD) values for the soil. This suggests that by increasing the amounts of lime and GGBS, the strength and stability of black cotton soil can be further bolstered. These findings underscore the effectiveness of employing lime and GGBS as additives to enhance the engineering properties of black cotton soil. Through the enhancement of compressive strength, California bearing ratio, and MDD values, this technique proves to be valuable in rendering expansive clays more suitable for a variety of construction applications. The utilization of lime and GGBS offers a promising avenue for improving the performance of black cotton soil in the realm of engineering.

Annafi et.al: The use of lime treatment has been proven to greatly improve the strength properties of black cotton soil, making it a suitable material for sub-base construction in road building. Research suggests that an ideal 8% lime content is recommended to achieve enhanced unconfined compressive strength and California bearing ratio. A recent study examined the impact of elapsed time after mixing on the strength properties of lime and iron ore tailings (IOT) treated black cotton soil (BCS). The findings revealed that the strength properties of BCS increased with higher levels of lime and IOT content. Specifically, an optimal treatment of 8% lime and 8% IOT was deemed highly effective when the elapsed time after mixing did not exceed two hours. This study has significant implications for low-traffic roads that necessitate sub-base materials with improved strength properties. By utilizing the right combination of lime and iron ore tailings, engineers can ensure the longevity and load-bearing capacity of their road projects. In conclusion, this research underscores the importance of employing advanced materials and techniques in road construction to achieve superior performance outcomes and increased durability in infrastructure projects.

7.CONCLUSION

In conclusion, this review paper has comprehensively examined the potential of high calcium lime in enhancing the strength of regur soil across various percentages. Through a meticulous analysis of existing literature and studies, it becomes evident that the addition of high calcium lime presents a promising solution for addressing the challenges associated with regur soil, particularly in terms of its strength and stability. The findings highlight the significant improvements in engineering properties such as compressive strength, shear strength, and permeability achieved through the incorporation of high calcium lime. Moreover, the review underscores the importance of considering the dosage and mixing methods to optimize the effectiveness of this soil stabilization technique. Overall, the insights provided in this review contribute to a deeper understanding of the application of high calcium lime in strengthening regur soil, paving the way for more sustainable and resilient construction practices in geotechnical engineering. Further research and field studies are warranted to validate these findings and explore additional avenues for enhancing the performance of regur soil in various engineering applications.

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