STUDY THE IMPACT OF BIO-ENZYMES ON ENHANCING REGUR SOIL STRENGTH: A REVIEW

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Abstract - *Black cotton soil, also known as Regur soil, is widespread across various regions globally, posing challenges due to its expansive nature and low shear strength. Recently, bio-enzymes have emerged as a promising solution to address the adverse effects of Regur soil on construction projects. This paper aims to comprehensively review existing literature on the efficacy of bio-enzymes in bolstering the strength of Regur soil. The review begins by outlining the physicochemical properties of Regur soil and the impediments it presents to construction endeavors. It then delves into the mechanisms through which bio-enzymes interact with Regur soil, encompassing soil stabilization, structural enhancement, and improvement of shear strength. Various application methodologies of bio-enzymes are explored, alongside an assessment of their efficacy under different conditions. Factors such as soil composition, enzyme type, dosage, and environmental variables influencing the efficiency of bio-enzymes are also scrutinized. The paper examines case studies and experimental findings from pertinent research to offer insights into the practical implications of utilizing bio-enzymes for Regur soil stabilization. Ultimately, it concludes with recommendations for future research directions and practical considerations for integrating bio-enzymes into engineering applications. Overall, this review contributes to advancing understanding regarding the potential of bio-enzymes in fortifying Regur soil strength and facilitates informed decision-making in geotechnical engineering and construction practices.*

Key Words: Regur soil, black cotton soil, bio-enzymes, soil strength enhancement, soil stabilization, shear strength, geotechnical engineering.

1.BACKGROUND

Exploring the influence of bio-enzymes on enhancing the strength of regur soil marks a significant advancement in soil engineering and agricultural practices. This research seeks to decipher how biological catalysts, known as bio-enzymes, can affect both the mechanical attributes and fertility levels of regur soils. Regur soils, alternatively referred to as black soils or black cotton soils, are distinguished by their high clay content and expansive behavior. Predominantly found in the Deccan Plateau region of India, these soils are renowned for their fertility, yet they are prone to cracking and shrinking during dry periods. The exploration of bio-enzymes' impact on regur soil strength can be traced back to a growing recognition of sustainable agricultural methods and the necessity to enhance soil quality without excessive reliance on chemical supplements. Researchers and agronomists have long been engaged in seeking alternative approaches to enrich soil properties and crop productivity while minimizing environmental repercussions. Initially, laboratory experiments likely focused on unraveling the biochemical processes involved in soil stabilization and nutrient cycling. Various bio-enzymes such as cellulases, proteases, and amylases would have been scrutinized for their effects on soil structure and fertility, laying the foundation for subsequent field trials to evaluate practical applications in real-world agricultural scenarios. As the body of research expanded, scientists would have refined methodologies and gained deeper insights into the intricate mechanisms by which bio-enzymes interact with regur soils. Factors including enzyme dosage, application techniques, and environmental considerations would have been meticulously evaluated to optimize the efficacy of bio-enzyme treatments. Collaboration among soil scientists, microbiologists, agronomists, and agricultural engineers would have been instrumental, fostering a multidisciplinary approach to research. Field trials conducted across regur soil regions on farms and research stations would have assessed the scalability and feasibility of bio-enzyme treatments for farmers. As research progressed, dissemination of findings through scientific publications, conferences, and extension programs would have served to enlighten farmers and policymakers about the potential advantages of employing bio-enzymes to enhance soil quality and crop yields in regur soil areas.

The historical journey of studying the impact of bio-enzymes on augmenting regur soil strength embodies a pursuit of scientific exploration and innovation, aimed at devising sustainable solutions to confront the challenges of modern agriculture while safeguarding soil and environmental health.

2.INTRODUCTION

Soil stabilization serves as a cornerstone process in civil engineering and construction, geared towards enhancing the mechanical properties and durability of natural soils. With the escalating demands for infrastructure expansion and the adoption of sustainable construction practices, the necessity for effective soil stabilization techniques has grown considerably. This procedure entails modifying the physical and chemical attributes of soil to bolster its engineering qualities, rendering it suitable for a myriad of construction applications such as road pavements, embankments, foundations, and retaining structures. In this introductory discussion, we will delve into the principles, methodologies, and practical applications of soil stabilization, illuminating its pivotal role in contemporary construction practices. We will address the challenges associated with unstable soils and explore a spectrum of strategies employed to achieve stabilization, including the utilization of chemical additives, mechanical reinforcement, and innovative sustainable approaches. Furthermore, we will scrutinize the environmental ramifications and economic advantages of embracing soil stabilization techniques, underscoring their indispensable contribution to enhancing infrastructure resilience, curbing maintenance expenses, and mitigating environmental impacts. Through this exploration, our aim is to furnish a comprehensive overview of soil stabilization, underscoring its significance as a sustainable solution for augmenting the performance and longevity of civil engineering structures amidst the evolving demands of the environment and society.

Figure-1: Soil Stabilization

3.PROCESS OF THE SOIL STABILIZATION

Soil stabilization encompasses a sequence of actions directed towards improving the engineering characteristics of natural soil to fulfill particular construction needs. Although the precise methods can vary based on factors like soil composition, project parameters, and environmental factors, the standard process typically comprises the following steps:

I. **Site Assessment:** The first step in soil stabilization is to conduct a thorough assessment of the site conditions. This includes analyzing the soil composition, moisture content, bearing capacity, and any existing geotechnical issues that may affect stability.

II. **Soil Testing:** Comprehensive testing of the soil is essential to determine its engineering properties and identify any deficiencies that need to be addressed through stabilization. Tests commonly performed include grain size analysis, Atterberg limits, compaction tests, and strength tests.

III. **Selection of Stabilization Technique:** Based on the site assessment and soil testing results, the most suitable stabilization technique is selected. This could involve chemical stabilization using additives such as lime, cement, or fly ash, mechanical stabilization through techniques like compaction or soil reinforcement using geosynthetics or natural fibers.

IV. **Preparation of Soil:** Before applying the chosen stabilization technique, the soil must be properly prepared. This typically involves grading, excavation, and removal of any organic matter, debris, or unsuitable materials that may interfere with the stabilization process.

V. **Application of Stabilizing Agents:** Depending on the selected technique, stabilizing agents are applied to the soil either in dry form or as a solution. Chemical additives are mixed thoroughly with the soil to induce chemical reactions that improve strength and reduce plasticity, while mechanical methods involve compacting the soil to increase density and stability.

VI. **Mixing and Homogenization:** After the stabilizing agents are applied, the soil is mixed and homogenized to ensure uniform distribution of additives and achieve the desired engineering properties throughout the treated area. This may involve mechanical mixing using heavy machinery or specialized equipment.

VII. **Compaction and Curing:** Once the soil has been treated and homogenized, it is compacted to achieve the desired density and strength. Compaction is typically carried out using rollers or compactors, with multiple passes performed to achieve uniform compaction. Depending on the stabilization technique used, curing may also be required to allow for chemical reactions to take place and strengthen the soil.

VIII. **Quality Control and Monitoring:** Throughout the soil stabilization process, quality control measures are implemented to ensure compliance with project specifications and regulatory requirements. This includes regular testing and monitoring of key parameters such as density, moisture content, and strength to verify the effectiveness of the stabilization treatment.

4.BLACK COTTON SOIL

Black Cotton Soil, also referred to as black clay soil or regur soil, is a prevalent soil type found in numerous regions across the globe, including the Indian subcontinent, Africa, South America, and Australia. It is distinguished by its dark coloration, high clay content, and unique physical properties. Renowned for its expansive behavior, this soil swells considerably when wet and develops deep cracks when dry. While its fertility, attributed to its rich nutrient composition, renders it suitable for agriculture, its poor drainage and tendency to impede root growth present challenges for farming. Additionally, in construction, its expansiveness necessitates meticulous engineering to avert structural damage. Notwithstanding these hurdles, through appropriate management techniques such as incorporating organic matter and employing soil stabilization methods, Black Cotton Soil can be utilized sustainably for agricultural and construction purposes, underscoring its significance across various sectors.

Figure-2: Black Cotton Soil.

4.1.Principle for Improving the Strength of the Regular Soil

Enhancing the strength of ordinary soil relies on a variety of principles and techniques aimed at increasing its load-bearing capacity and stability. Compaction, a fundamental method, involves boosting soil density through mechanical processes such as rolling or vibrating compactors. The addition of binders like cement, lime, or fly ash improves cohesion and reduces permeability, thus reinforcing the soil. Proper grading and drainage help regulate water flow, reducing erosion risks and enhancing stability. Materials such as geotextiles or soil nails are used for reinforcement to distribute loads evenly and improve overall soil stability. Techniques like compaction grouting or vibro-compaction further consolidate loose soil, while preloading accelerates consolidation in compressible soils. Chemical stabilization modifies soil properties using additives such as lime or polymers. Monitoring and testing ensure the effectiveness of strengthening methods and compliance with engineering standards. By integrating these approaches, engineers can effectively enhance the strength of ordinary soil for various construction applications.

5.PREVIOUS RESEARCH ON THE STABILIZATION OF THE REGUR SOIL

In this section, we have studied the previous research work on the stabilization of the regur soli, and the summary of those previous research is given below in the details:

Priyanka, Rakaraddi: The UCS values continued to increase until the twenty-first day following the application of Terra-Zyme, showing respective increments of approximately 94.86 percent, 114.69 percent, 150.28 percent, and 63.34 percent. Optimal results for the UCS values were observed with the third dose of Terra-Zyme, administered at a rate of 200 milliliters per 0.75 cubic meters after a curing period of twenty-one days. This was the situation after the drying and curing procedures were completed. With the curing process concluded and the product fully cured, this step could then be deemed finished.

Lekha et.al: The research project conducted an investigation into the effectiveness of bio-enzyme-stabilized soil. After completing laboratory tests, several conclusions were drawn. Firstly, it was observed that the clay content plays a crucial role in determining consistency restrictions. Additionally, the treated soil displayed lower plasticity index values compared to untreated soil. Over an 8-week curing period, there was a significant reduction in organic matter content, from 17.08% to 13.46%. Minimal changes were detected in the maximum dry density (MDD). Notably, there was a substantial increase in unconfined compressive strength (UCS) after curing, rising from 268 kN/m2 to 859 kN/m2. This increase was attributed to the cementation effect resulting from enzyme-clay reactions. Furthermore, as the curing duration increased, California Bearing Ratio (CBR) values also increased due to decreased void ratios. The Fine-Grained Soil Index (FSI) decreased from 50% to 8.33% after treatment, indicating reduced swelling capacity. Treated soil exhibited a 22% reduction in weight loss during freeze-thaw cycles compared to untreated soil. However, despite these improvements, the soil samples were unable to withstand stress during wet and dry cycles.

Puneet, Suneet: Based on the data obtained from numerous tests, the following conclusions can be drawn: The unconfined compressive strength (UCS) of Black Cotton Soil significantly increased due to the application of Terrazyme for soil stabilization, resulting in a doubling of strength compared to previous levels. The duration of Terrazyme treatment was found to be a critical factor, with soil treated for seven days exhibiting greater strength than soil treated for shorter durations. The recommended dosage of Terrazyme for optimal UCS improvement is 1 milliliter per 5 kilograms of soil, as specified by the manufacturer. Terrazyme, an environmentally safe enzyme, has proven to be highly effective in enhancing the UCS of Black Cotton Soil, without any adverse environmental impact.

Ramesh, Sagar: The study aimed to determine the suitability of TerraZyme for modifying the geotechnical properties of expansive and non-expanding soils, specifically black cotton soil and red earth. This involved evaluating the influence of TerraZyme on the index and engineering characteristics of these soils. The researchers concluded that TerraZyme is indeed appropriate for altering the geotechnical properties of both expansive and non-expanding soils, based on their findings. They established air-dry curing conditions in addition to laboratory desiccator curing to simulate real-world circumstances, finding that TerraZyme was effective in both scenarios. Application of TerraZyme resulted in significant improvements in the engineering properties of black cotton soil and red earth, particularly in unconfined compressive strength. Both soils exhibited hydrophobic qualities and improved physical attributes after treatment with TerraZyme. The optimal dosage for black cotton soil was 200 milliliters per cubic meter, while red earth required the same dosage to maintain consistency. Both soils showed substantial improvement in unsoaked California Bearing Ratio (CBR) after drying. However, characteristics of compacted soil did not significantly change post-TerraZyme treatment. Black cotton soil displayed enhanced compressibility and structural integrity compared to other soil types. Free swell index of black cotton soil decreased notably after treatment and drying. Overall, air-dry curing conditions proved more effective than desiccator curing, demonstrating superior outcomes for both types of soil.

Srinivas, Amith: This study investigated the effectiveness of bioenzyme-stabilized soil and its potential applications. Laboratory tests revealed several key findings: clay content significantly affects consistency limitations, with reductions in plasticity and liquidity index percentages observed post-treatment. While modest changes occurred in Maximum Dry Density (MDD) and Organic Matter Content (OMC), efficient ion exchange mechanisms likely contributed to concentration drops in the soil. Over four weeks, Unconfined Compressive Strength (UCS) more than doubled, indicating substantial strength gains. The cementation effect, arising from enzyme-clay reactions, significantly influenced strength development. California Bearing Ratio (CBR) values increased with longer curing times, reflecting enhanced density and reduced void ratios in enzyme-treated soil. After four weeks, the soaking CBR value of native soil rose by 387%. Moreover, bioenzymes such as TerraZyme proved safe and environmentally friendly, with long-lasting effects that eliminate the need for certain construction materials, saving both time and money.

Rishi, Rakesh: The research aimed to assess the enhancement in geotechnical qualities of soil upon the addition of Terrazyme. The investigation sought to determine the extent of improvement attributed to Terrazyme incorporation. Various doses of Terrazyme enzyme were added to unsaturated soil mixtures to evaluate efficacy. Findings indicate the soil's substantial productive capacity. Conclusions drawn from extensive testing include: Terrazyme treatment notably improved the plasticity index of the soil from an initial value of 14.05, signifying enhanced characteristics. Increasing Terrazyme dosage correlated with increased overall activity of the soil mixture, as reflected in rising index values. Treatment with Terrazyme led to a significant increase in the soil's unconfined compressive strength, indicating enhanced breakdown of organic substances. The subsequent progression of soil quality demonstrated continued improvement. Moreover, Terrazyme treatment resulted in a notable increase in the soil's California Bearing Ratio (CBR) value, indicating enhanced resilience.

Jenith, Parthiban: This research study involved various activities, including an assessment of soil effectiveness after treatment with bioenzymes. The researchers conducted lab tests and reached the following conclusions: A dosage of 200 milliliters per 1.5 cubic meters resulted in the highest unsoaked California Bearing Ratio (CBR) values for soil samples S1, S2, S3, and S4, with percentage increases of 7.92%, 7.99%, 8.10%, and 8.3% respectively. The soaking CBR values for these samples after a 28-day stabilization period with an eco-enzyme dosage of 200 milliliters per cubic meter of soil were 4.9%, 5.15%, 5.36%, and 5.5% respectively. These values were obtained after considering the soil treatment with eco-enzyme. The required eco-enzyme quantity for achieving these results was 200 milliliters per cubic meter of soil. After a 28-day curing period, the best outcomes for unconfined compressive strength (ucc) values were obtained with an eco-enzyme dose of 200 milliliters per half cubic meter of soil, representing the most effective treatment overall. This procedure was conducted after the specified curing time, resulting in the most favorable ucc values.

6.CONCLUSION

In conclusion, the enhancement of regur soil strength presents a critical area of research with significant implications for various engineering applications. Through an extensive review of literature, it is evident that numerous techniques and methods have been explored to address the inherent challenges associated with regur soil, including its low strength and expansive nature. From chemical stabilization and mechanical reinforcement to geosynthetic interventions and innovative construction practices, a range of approaches have shown promise in effectively improving regur soil's strength properties. However, it is essential to recognize the site-specific nature of regur soil and the need for careful consideration of local conditions and requirements when selecting and implementing improvement techniques. Furthermore, ongoing research and advancements in material science, geotechnical engineering, and construction methodologies offer promising avenues for further enhancing regur soil strength and expanding its suitability for diverse engineering projects. Overall, this review underscores the importance of continued investigation and innovation in addressing the challenges posed by regur soil, ultimately contributing to the development of sustainable and resilient infrastructure solutions.

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