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Soil Stabilization Using Cement

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ABSTRACT

Soil stabilization using cement is a widely employed technique in civil engineering and construction projects aimed at improving the engineering properties of soil. This paper provides a comprehensive review of the various methods and mechanisms involved in cement stabilization of soil. It explores the fundamental principles behind cement-soil interactions, discussing factors such as cement dosage, curing methods, and environmental conditions that influence the effectiveness of stabilization. Furthermore, this review examines the mechanical, physical, and chemical changes induced in soil by cement stabilization, elucidating how these alterations contribute to enhanced strength, durability, and load-bearing capacity. Case studies and experimental findings from literature are analyzed to highlight the practical applications and performance of cement-stabilized soils in different geotechnical contexts. Additionally, this review addresses considerations related to sustainability, cost-effectiveness, and environmental impacts associated with cement stabilization techniques. By synthesizing current knowledge and identifying research gaps, this paper aims to provide insights for engineers, researchers, and practitioners seeking to optimize the use of cement for soil stabilization purposes in construction projects.

INTRODUCTION

In the domain of civil engineering and construction, the foundation upon which infrastructure stands holds paramount importance. Yet, the inherent variability and inadequacies of natural soil often pose significant challenges to the stability and longevity of structures. Enter soil stabilization with cement—a venerable technique that harnesses the binding prowess of cement to fortify soil, rendering it robust and resilient against the forces of nature.

Cement, esteemed for its intrinsic binding and strengthening qualities, takes center stage in this narrative as a fundamental building material. When carefully integrated with soil, it catalyzes a transformative journey, enriching the substrate with amplified load-bearing capacity, heightened resistance to erosion, and elevated durability. This harmonious fusion between cement and soil sets in motion a process that fortifies the ground beneath, laying a resilient foundation for infrastructure that withstands the test of time and environmental challenges.

Need for the study

The study of soil stabilization using cement is essential due to the increasing need for resilient infrastructure in the face of urbanization and environmental challenges. Cement stabilization offers an effective means to improve soil properties, enhancing its strength and durability for various construction applications. By addressing geotechnical issues such as erosion, settlement, and instability, cement stabilization ensures the longevity and performance of infrastructure projects. Moreover, it promotes sustainable construction practices by reducing material consumption, construction time, and maintenance costs. The economic, environmental, and social benefits of cement stabilization underscore its significance in modern construction practices, highlighting the necessity for further research and innovation to meet the demands of sustainable development and infrastructure resilience.

Objectives of Present Study

- Substituting poor-quality soils with aggregates with better engineering properties.
- To encourage the use of waste geomaterials in building construction.

RESEARCH METHODOLOGY

Research methodology refers to the systematic approach employed by researchers to gather and analyse data, with the objective of addressing a research question or testing a hypothesis. It serves as the framework that guides the entire research process, ensuring the validity and reliability of the research findings.

RESULT & DISCUSSION

This chapter presents the test results for soil and its stabilization, encompassing a series of experiments conducted with various mix designs. Through systematic analysis and interpretation of the test results, valuable insights are provided into the performance and characteristics of the soil, as well as the efficacy of different stabilization techniques and mix formulations. These detailed findings serve as a foundation for informed decision-making in engineering and construction practices, facilitating the optimization of soil stabilization strategies and the design of resilient infrastructure solutions. The result of the test on soil sample is detailed below:

Test	**Result**	**Limit**	**Remarks**
Free Swell Index	41.67%	Maximum 50%	Result Satisfactory
Grain Size Analysis	Gravel content : 4.20%		Result Satisfactory
	Sand content : 53.60%		
	Silt & clay : 42.20%		
Atterberg Limit	Liquid Limit : 40.50%	Maximum 50%	Result Satisfactory
	Plastic Limit: 22.95%		
	Plasticity Index: 17.55%	Maximum 25%	
Maximum Dry Density	1.575 gm/cc	Minimum 1.75 gm/cc for Subgrade	Result Unsatisfactory
California Bearing Ratio	4.56%	Minimum 8%	Result Unsatisfactory

The obtained MDD & CBR result falls below the minimum requirement typicaly needed for subgrade construction, indicating insufficient load-bearing capacity. Consequently, the material is deemed unsuitable for both embankment and subgrade applications. Although the soil sample met most criteria, it failed both the Maximum Dry Density (MDD) and CBR tests, highlighting significant deficiencies in its compaction and strength characteristics.

Therefore, stabilization using cement was conducted to enhance its properties and prepare it for road construction, aiming to improve its strength, stability, and load-bearing capacity to meet the required standards for successful project execution.

MIX Design using cement & soil

Based on the laboratory test results, a mix design was conducted to determine the optimal proportions of cement and soil for the soil stabilization mixture. This crucial step ensures that the stabilized soil meets the required engineering properties, including strength, stability, and durability, necessary for its intended application in road construction. This systematic approach to mix design plays a vital role in the successful execution of soil stabilization projects, facilitating the attainment of desired performance standards and long-term structural integrity.

The initial MIX design comprised 98% soil and 2% cement content. Subsequent mix designs involved incrementally increasing the cement content by 2% in each iteration. This systematic approach aimed to achieve the required criteria for subgrade and embankment construction. The objective was to blend these components in a manner that enhances the mixture's strength, durability, and other desired characteristics compared to untreated soil. The test result of the stabilized soil sample with different cement content is detailed below:

Cement Content	**MDD**	**CBR**
2%	1.67 gm/cc	5.91%
4%	1.765 gm/cc	7.67%
6%	1.862 gm/cc	8.87%

With a CBR value of 8.87% & MDD value of 1.862gm/cc, the material has successfully passed the California Bearing Ratio & Maximum Dry Density test. As the result suggests, Increasing the cement content in a stabilized mix leads to higher Maximum Dry Density (MDD) and California Bearing Ratio (CBR) values. Cement acts as a binding agent in the soil-cement mixture. As the cement content increases, more binding occurs between soil particles. This increased binding leads to better compaction, allowing for more soil particles to come into close contact with each other, resulting in a higher MDD. Essentially, higher cement content enhances the inter-particle friction and cohesion within the mix, enabling it to achieve greater density when compacted. The CBR test measures the bearing capacity of a soil or aggregate material when compacted under specific conditions. With increased cement content, the soil-cement mixture becomes more homogeneous and stable. The cement binds the soil particles together more effectively, resulting in improved strength and stiffness properties. This increased strength leads to higher CBR values, indicating better resistance to deformation under load

It is necessary to evaluate other criteria of stabilized soil sample having cement content 6% to determine its suitability for embankment & subgrade construction.

Test	**Result**	**Limit**	**Remarks**
Unconfined Compressive Test	4.56 MPa	Minimum 1.75 MPa	Result Satisfactory
Durability Test	1.575 gm/cc	Maximum 14	Result Satisfactory

Analysis of Results:

After conducting various tests, it has been established that soil stabilization using 6% cement content is suitable for embankment and subgrade construction in road projects. This conclusion stems from the satisfactory performance of the stabilized soil in key tests, including Maximum Dry Density (MDD), California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), and Durability tests.

The utilization of 6% cement content has proven effective in enhancing the soil's strength, stability, and load-bearing capacity. This improvement is crucial for ensuring the stabilized soil can adequately support the anticipated traffic loads and endure the various environmental conditions encountered in embankment and subgrade construction for roads.

By meeting the requirements set forth in these tests, the stabilized soil demonstrates its reliability and suitability for use in infrastructure projects. This validation reinforces the confidence in the effectiveness of the stabilization process and underscores its role in enhancing the performance and longevity of road construction projects. Ultimately, the use of stabilized soil with 6% cement content contributes to the development of durable, resilient, and sustainable transportation infrastructure.

CONCLUSION

In conclusion, soil stabilization using cement offers a reliable and effective method for enhancing the engineering properties of soils, making them suitable for various construction applications. Through a series of tests and analyses, it has been demonstrated that the addition of cement to soil can significantly improve its strength, stability, and durability. This enhanced performance makes cement-stabilized soil a viable option for embankment construction, subgrade stabilization, and other infrastructure projects requiring load-bearing capacity and resistance to environmental factors.

The successful implementation of soil stabilization using cement relies on careful mix design, quality control measures, and adherence to established standards and specifications. By optimizing the cement content and mix proportions, engineers can tailor the stabilized soil to meet specific project requirements and performance criteria. Additionally, ongoing monitoring and testing ensure that the stabilized soil maintains its desired properties over time and under varying conditions. The benefits of soil stabilization with cement and fly ash include improved soil strength, reduced plasticity, increased durability, and enhanced workability. The cost-effectiveness of this method, along with its environmental sustainability by recycling existing materials, makes it an attractive option in many construction scenarios.

Overall, soil stabilization using cement offers numerous advantages, including improved strength, reduced construction time, and enhanced long-term performance. As a cost-effective and sustainable solution, it plays a crucial role in modern construction practices, providing stable and durable foundations for infrastructure development while minimizing environmental impact.

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