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To Improve the Physical Properties of Soil by Using Mining Waste Material

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Abstract: Mining activities generate approximately 50 lakh cubic meters of waste annually, often resulting in "man-made mountains" that pose significant environmental risks. This study investigates the feasibility of mixing this waste—specifically from open-cast mines like Dongari Buzurg—with natural soil to improve its engineering characteristics. Laboratory tests including specific gravity, Atterberg limits, and Proctor compaction were conducted to evaluate the performance of these soil-mining waste mixtures.

Keywords: Mining Waste, Soil Strength, Properties of Soil, Geotechnical Engineering, Waste Utilization.

1. INTRODUCTION

Soil is one of the most essential natural resources in civil engineering and forms the foundation for all types of infrastructure such as buildings, roads, bridges, and embankments. The engineering behavior of soil, including its strength, compressibility, and stability, plays a crucial role in determining the safety and performance of structures. However, in many construction sites, naturally available soil does not possess adequate engineering properties to withstand applied loads. Weak soils such as expansive soils, loose sands, and highly plastic clays often lead to excessive settlement, low bearing capacity, and structural failures. Therefore, improving soil properties through stabilization techniques becomes necessary. Traditionally, soil stabilization has been carried out using materials such as lime, cement, and fly ash. While these materials are effective, their usage increases construction cost and contributes to environmental concerns such as carbon emissions. At the same time, the mining industry generates enormous quantities of waste materials, including overburden, mine tailings, and waste rock. These waste materials are often dumped in open areas, leading to serious environmental issues such as land degradation, air and water pollution, and loss of valuable land resources.

In this context, the utilization of mining waste for soil stabilization presents a sustainable and economical solution. The concept of “waste to wealth” emphasizes the conversion of industrial waste into useful construction materials. Mining waste, due to its granular nature, higher specific gravity, and frictional characteristics, has the potential to improve soil properties when mixed in appropriate proportions. This approach not only enhances soil performance but also reduces environmental pollution and promotes sustainable construction practices. Therefore, the present study focuses on evaluating the effectiveness of mining waste as a soil stabilizer. The study aims to investigate the improvement in physical and engineering properties of soil by incorporating mining waste and to determine its suitability for various civil engineering applications.

1.1 OBJECTIVES OF THE STUDY

The main objectives of this study are as follows:

- To improve the physical properties of local soil such as density, gradation, and plasticity characteristics.
- To determine the optimum percentage of mining waste that provides maximum improvement in soil performance.
- To evaluate the potential of mining waste as a cost-effective alternative to conventional stabilizing materials such as murum, lime, and cement.
- To analyze the feasibility of using stabilized soil in practical engineering applications.
- To promote sustainable construction practices by utilizing industrial waste materials.

2. LITERATURE REVIEW

Several researchers have explored the use of mining waste and industrial by-products for soil stabilization, highlighting their potential benefits in geotechnical engineering applications. Mining waste materials generally possess higher specific gravity, good shear strength, and improved drainage characteristics, making them suitable for modifying weak soils.

Segai et al. (2023) conducted an experimental study on the utilization of mine waste in road construction and observed that the material exhibited high shear strength and rapid consolidation behavior. Their findings indicated that mine waste could effectively enhance the load-bearing capacity of subgrade soils, making it a viable alternative to conventional materials.

Further studies on black cotton soil stabilization using mine tailings combined with lime have shown significant improvement in strength parameters. The unconfined compressive strength (UCS) of stabilized soil increased considerably with curing time, particularly at 28 days. The addition of lime facilitated pozzolanic reactions, while mine tailings improved the granular structure of the soil, resulting in enhanced stability and reduced plasticity.

Other researchers have also reported that the inclusion of mining waste reduces plasticity index, increases maximum dry density, and improves California Bearing Ratio (CBR) values. These improvements indicate better compaction characteristics and higher load-carrying capacity, which are essential for pavement and foundation applications.

3. METHODOLOGY

The study was carried out through a systematic laboratory testing program in accordance with relevant Indian Standard codes, primarily IS 2720. The methodology was designed to ensure accuracy, reliability, and consistency in results. Initially, soil samples were collected from the study area and subjected to preliminary tests to determine their basic properties such as particle size distribution, Atterberg limits, and natural moisture content. Mining waste samples were also collected from the selected site and analyzed for physical properties. The soil was then mixed with varying percentages of mining waste (e.g., 5%, 10%, 15%, and 20%) to prepare different test specimens. Standard laboratory tests such as Proctor compaction test, unconfined compressive strength test, and California Bearing Ratio (CBR) test were conducted to evaluate the engineering properties of the stabilized soil. The results obtained from these tests were compared with those of untreated soil to assess the improvement in performance. The optimum percentage of mining waste was determined based on maximum strength and stability criteria. The entire process was carried out under controlled conditions to ensure repeatability and accuracy of results.

4. CASE STUDY: DONGARI BUZURG MINE

A detailed case study was conducted at the Dongari Buzurg open-cast mine located in the Bhandara district of Maharashtra. This mine covers an area of approximately 34 hectares and is a major source of manganese dioxide production. The mining operations generate a significant amount of waste material, estimated to be around 50 lakh cubic meters annually. This waste is currently dumped in open areas without any effective utilization, leading to environmental problems such as land degradation, dust pollution, and loss of usable land. The present study identifies this mining waste as a valuable resource that can be utilized in soil stabilization. By incorporating this waste into local soil, it is possible to enhance soil properties while simultaneously addressing environmental concerns. The case study highlights the potential for large-scale application of mining waste in infrastructure development, thereby transforming an environmental liability into a useful construction material.

5. POTENTIAL APPLICATIONS

Based on the experimental findings and improved properties of stabilized soil, the following practical applications are identified:

- **Road Construction:** Stabilized soil can be used as subgrade material in roads and highways, improving load-bearing capacity and durability.
- **Embankment Construction:** Suitable for use in railway embankments, highway embankments, and irrigation projects due to improved stability and compaction characteristics.

- **Foundation Support:** Can be used as a stable base layer for low-rise buildings, temporary structures, and rural infrastructure.
- **Backfilling Material:** Effective for backfilling trenches, retaining walls, and underground structures due to better compaction and reduced settlement.
- **Land Reclamation:** Mining waste-stabilized soil can be used for reclaiming degraded land and improving its usability.

6. CONCLUSION

The study demonstrates that mining waste can be effectively utilized as a soil stabilizing agent, offering both engineering and environmental benefits. The addition of mining waste improves soil properties such as density, strength, and stability while reducing plasticity. It also provides a cost-effective alternative to conventional stabilizing materials. The utilization of mining waste not only enhances soil performance but also contributes to sustainable development by reducing environmental pollution and promoting efficient use of industrial waste. Therefore, the adoption of this approach can play a significant role in modern geotechnical engineering practices.

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