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Comparative Study of Soil Stabilization by Using Steel slag, Fly Ash and Coconut Shell

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ABSTRACT: Due to the rapid increase in urbanization, there's a growing need to safeguard the environment and the soil. To address this, we're utilizing industrial and agro – waste. For example, steel slag has already proven effective in stabilizing soil. Along similar lines, research shows that fly ash and coconut shells can also be valuable. Based on a specific research paper, we've decided to combine all three materials in varying proportion for soil stabilization. Steel slag will be used at 5%, 10% and 15%, while coconut shell present in all samples at 5%. Additionally fly ash will be incorporated at 12%, 15% and 16%, by conducting a series of tests including CBR, MDD, OMC, Plastic limit, Liquid limit and Plasticity index, we aim to assess the outcomes of the approach.

KEYWORDS: stabilization, fly ash, steel slag, coconut shell, black cotton soil, MDD, CBR, OMC, Liquid limit, Plastic limit, Plasticity index.

I. INTRODUCTION

Soil stabilization generally refers to the process of enhancing and improving the engineering properties of a soil to enhance its durability, load-bearing capacity, and deformation resistance. Soil stabilization is commonly applied to building foundations, pavement, railways, road construction, industrial sites, etc. The main objective here is to increase the strength and stability of the soil with reduced construction costs and making the best use of locally available materials. For the purpose of soil stabilization, we are using industrial waste material and locally available waste materials such as steel slag, fly ash, and coconut shell. Property of steel slag is to enhance the load bearing capacity of soil. Fly ash can increase density and compaction of soil, making it more stable and able to support heavier loads. Coconut shell helps to reduce the plasticity of clay soil, making them less susceptible to shrink and swell during wet and dry period.



Fig.1 Testing of Soil

II. OBJECTIVE OF THE STUDY

The Experimental work Aim on

1. To assess soil strength using the CBR test
2. To check the compressibility of soil
3. To check the shear strength of the soil.
4. To enhance the stabilization of black cotton soil.
5. To decrease the plasticity of black cotton soil.
6. To increase the load-bearing capacity of black cotton soil.
7. To study the provision of IRC SP 121 for steel slag, IRC 1984 Recommended Practice for Lime Fly Ash Stabilization of Soil Base/Subbase in Pavement Concrete

III. LITRATURE REVIEW

3.1 Stabilization of Soil Using Steel Slag:

Magdi Mahamed Etayeb Zumrawi, Alaa Abdel-Aziz Ali Babikir, (2017): The effectiveness of adding 5%, 10%, 15%, 20%, and 30% steel slag to the soil was studied. Comparing the results obtained for the natural and stabilized soils revealed that steel slag has a significant effect on strength parameters and a considerable improvement in plasticity and swelling properties. The addition of steel slag to the soil increased dry density, decreased optimum moisture content, and improved compressive strength.

Hindawi (2017): The steel slag is often dumped randomly in open areas, causing numerous environmental hazards. Most of the steel slag production in hazardous areas is utilized in the cement industry and has never been used in any other field due to a lack of research in the field. Steel slag is used in the soil up to 0 to 25% to improve consistency limits, compaction, free swell, and unconfined compression strength.

Shubham More, Apeksha Lokhande, shaik Sabir, Pooja Aade, Nilambarika Bansod, Omkar Joshi (2018): Different percentages of 5%, 10%, 15%, and 20% steel slag have been used to stabilize the black cotton soil to verify its suitability for use as a construction material for roads.

3.2 Stabilization of Soil Using Fly Ash

J. Karthick, S. rajesh, M. Saravana Kumar, M. Thinakaranraj, M. Vijayaram, T. ramkumar (2019): In this paper, it is proven that adding fly ash can increase clay soil stability through various tests. The effect and addition of 2-40% of fly ash to the clay soil were investigated with the help of Atterberg's limit test, the Proctor compaction test, and the unconfined compression test. In Atterberg's limit test, it was found that by adding 15% fly ash, the liquid limit and PI of clay soil were decreased, but the plastic limit was found to be increased. As well as in the proctor compaction test and the unconfined compression test, the result These tests showed that the maximum dry density of the mixture decreased and the optimum water content increased, which ultimately resulted in the fact that the addition of fly ash to soil can be an effective treatment for improving its strength. Thus, the use of fly ash in stabilization was a very good way to go about the process of stabilization. It was concluded to have a very good environmental effect by avoiding the use of stabilization. It was concluded to have a very good environmental effect by avoiding the use of current admixtures like cement and therefore keeping them out of landfills.

Zala Yashwantsinh, (2013): In this research paper, different tests were carried out on natural soil with the help of fly ash. The paper describes the study carried out to check the properties of expansive soil with the help of fly ash. The mixing of fly ash was carried out manually, as per standard test procedures. With different percentages of fly ash, i.e., 15%, 20%, and 30%, added to the soil mixtures, tests like the liquid limit test, the plastic limit test, the proctor compaction test, and the unconfined compression test were carried out. Based on the results obtained from these tests, the liquid limit of the mixture decreases with an increase in the percentage of fly ash added up to 30%; similarly, the plastic limit was seen to be reduced with an increase in the fly ash percentage added up to 30%. Whereas the maximum

dry density was found to be increased with the addition of fly ash up to 30%, and the unconfined compressive stress of the soil was increased with the increased addition of more amounts of fly ash up to 20%.

Manuel Mateos: In this paper, fly ash is reacted with lime to form a cementitious material, which can help in the stabilization of soil. Five different fly ashes collected from different areas were used here, along with eight different types of soil materials and aggregates, to represent chemical and physical characteristics. Dried soils were mixed with dry fly ash in a laboratory mixer here to form a mixture. Test specimens of soil were moulded according to their physical preferences at severe moisture contents. After moulding, they were wrapped in wax paper, sealed with celotape, and stored for curing for 7, 28, and 90 days, then immersed in water for one day. A confined compression test was performed, and results were obtained according to which immersed compressive strength was found to be increased with the percentage of fly ash added. The fly ash added to the soils indicated that some fly ash can cement soil particles alone without the addition of lime. Some fly ashes are used to stabilize soils that are of either gravel, sand, or slag type.

3.3 Stabilization of Soil Using Coconut Shell:

Shweta Prasanna, Prasanna Kumar, (2020): The present work is aimed assessing the impact of coconut shell ash stabilization on poor soil. The increase in soil strength was found through different tests conducted on soil with varying percentages of coconut shell ash. From the obtained results, it was observed that the addition of 0.4% to 0.8% of coconut shell ash showed the maximum improvement in density, optimum moisture content, and angle of internal friction.

Arunave Chakraborty, Swapnaneel Roy, (2016): Cement and lime have been the two main materials for stabilizing soils over the years. These materials are highly expensive, which increases the cost of construction. So, we use agricultural materials like coconut husk ash, which not only reduces the cost of construction but also reduces the environmental hazards they cause.

Swaminathen, Jothishwar, Dinesh Kumar, Bevin Salo, Krishna Moorthi, (2018): Black cotton soil has greater compressibility, lower bearing capacity, and lower shearing strength. Stabilization of black cotton soil is achieved through the addition of substances such as lime powder, iron powder, and coconut shell ash. The objective of this research is to utilize coconut shell powder to enhance the engineering properties of expansive soil and increase the compressive strength of compacted expansive soil.

IV. MATERIAL TO BE USED

1. **Steel slag** is an industrial waste material that is formed as a byproduct of the steelmaking process. It is generated when iron is processed in a glare furnace to produce molten iron. It is composed of various oxides such as primary silicon dioxide (SiO₂), magnesium oxide (MgO), calcium oxide (CaO), iron oxide (FeO), etc. Currently, the daily estimated production of steel slag is 15 to 20 million tones. It improves the swelling potential of the clay soil, as the amount of added steel slag increases the swell pressure or free swell of the soil. Steel slag can enhance the load bearing capacity of soil. When mixed with soil, it can increase shear strength and reduce settlement.



Fig.2 Steel Slag

2. **Fly ash** forms when coal is burned in a power plant to generate electricity. To collect fly ash, electrostatic precipitators are used to filter it from the flue gases in the construction industry. Fly ash is employed as a material in making concrete. When mixed with cement and water, it enhances the workability, durability, and strength of the structure. Moreover, its use in production helps lessen the impact by reusing waste as a binder for soil stabilization. It can increase the density and compaction of soil, making it more stable and able to support heavier loads. It reduces the permeability of soil, which can be beneficial in preventing water infiltration and improving soil resistance to erosion.



Fig.3 Fly Ash

3. **Coconut shells** are natural and sustainable resources that can be used for soil stabilization. It's a waste product. The outermost layer is called the husk, which is hard and fibrous. There is a layer of coir, a tough and fibrous material used for making rope and mats. The actual hard shell protects the coconut meat and water. Using coconut shell and its byproducts, like coir, is often considered environmentally friendly. Coconut shells are light-weight and can be used as aggregate in soil. This reduces the overall density of the soil and can improve its load-bearing capacity. It helps to reduce the plasticity of clay soil, making it less susceptible to shrinking and swelling during wet and dry periods.



Fig.4 Coconut Shell

V. METHODOLOGY

Soil stabilization tests are important for assessing the suitability of soil for construction or other purposes. CBR is a test that measures the load-bearing capacity of a soil sample. It helps determine how well the soil can support road or pavement construction.

The plastic limit test identifies the moisture content at which the soil transitions from a plastic to a semi-solid state. This is essential to assess the plasticity of the soil.

The liquid limit test determines the moisture content at which the soil behaves as a liquid. It's essential for understanding the soil's consistency and its ability to retain moisture.

MDD is a test that determines the maximum density achievable for a given soil with a specific moisture content. It's essential for compaction and engineering purposes. OMC is the moisture content at which the soil reaches its maximum dry density. It helps in designing compaction efforts for construction.

These tests collectively provide critical information about the physical and mechanical properties of soil helping engineers and construction professionals make informed decisions regarding soil, stabilization and construction design.



Fig.5 Construction workers evaluating work at site for soil testing

VI. DESIRE OUTCOMES

- Improvements have been made to enhanced and upgraded soil's load-bearing capacity, making it suitable for infrastructure as well as construction projects.
- Reduced risk of erosion and subsidence as steel slag and fly ash can increase the bearing capacity of the soil.
- Reduced cost of construction or road maintenance compared to traditional methods.
- Reduced landfill waste: by repurposing steel slag and fly ash, you contribute to reducing landfill waste.
- Soil is more resistant to water infiltration and chemical degradation.

- Increased durability and longevity of constructed structures or roadways.

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