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Stabilization of Expansive Soil Using Waste Ceramic

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Abstract – *The foundation of any construction heavily depends on the characteristics of the soil beneath it. In India, a significant portion of land comprises clayey soil, with a notable portion being expansion soil, notably black cotton soil. This kind of soil tends to expand and contract with variations in moisture content, primarily due to the presence of the clay mineral montmorillonite. While beneficial for agriculture, these soils pose a significant risk to structures due to their unpredictable behavior. Soil stabilization is the process of enhancing the shear strength parameters of soil, thereby increasing its bearing capacity. Over time, numerous studies have been conducted to tackle this issue and enhance the properties of black cotton soils.*

Soil stabilization has emerged as a viable solution to mitigate the problems associated with the swelling and shrinking behavior of black cotton soil. Among various methods explored, the utilization of waste materials has shown promise. In this paper, the study on stabilization of black cotton soil using waste ceramic, along with fly ash was discussed. The material was mixed with different proportion, and the results ware compared to analyzed the most effective combination. The utilization of waste ceramic 10% shows, the maximum MDD, CBR and UCS of this sample was increased by 15% and 19.63 % respectively. The soil mixed with waste ceramic and fly ash, with 10% and 20% proportion respectively gives maximum MDD. The CBR value and UCS value of black cotton soil with 10% waste ceramic and 20% fly ash, was increased by 82.72 % and 208.4 % respectively. This approach offers a sustainable solution to enhance the properties of black cotton soil and ensure the stability of structures built upon it.

Keywords - ***Stabilization of black cotton soil, ceramic, fly ash, lime***

I- INTRODUCTION

Soil stabilization refers to the modification of soil engineering properties through either chemical or mechanical means. Within civil engineering, it serves as a method to refine and enhance various soil characteristics such as mechanical strength, permeability, compressibility, durability, and plasticity. Widely applied in road construction, soil stabilization techniques are broadly categorized into mechanical and chemical methods. Mechanical stabilization entails adjusting soil grading by mixing it with different soil types to achieve desired compactness. On the other hand, chemical stabilization involves altering soil properties by introducing active substances. It is crucial to understand the properties of the materials involved, as well as to assess the outcomes and impacts on nearby structures and surroundings post-mixing. Decisions regarding material selection and dosages are guided by such assessments. Moreover, beyond material choice and dosage determination, several other factors influence the effectiveness of soil stabilization.

II - LITERATURE REVIEW

Sabat (2012) shows that addition of ceramic dust results in a consistent decrease in liquid limit, plastic limit, and plasticity index, regardless of the amount added. At 30% addition, the soil transitions from the CH group to the CL group. Moreover, as the percentage of ceramic dust increases, the maximum dry density (MDD) increases while the optimum moisture content (OMC) decreases. The unconfined compressive strength (UCS) and soaked California bearing ratio (CBR) both increase with the addition of ceramic dust.

Mehta, and Parate (2013) conducted the study on stabilization of black cotton soil by Fly Ash. The utilization of 20% fly ash leads to a notable increase in unsoaked CBR values compared to other mixtures, suggesting its promising potential for geotechnical applications. Additionally, the dry density associated with the 20% fly ash mixture exceeds that of other fly ash percentages, further highlighting its suitability. Consequently, fly ash demonstrates favorable characteristics for construction purposes, including its relatively low unit weight, which makes it suitable for placement on soft or low bearing strength soils.

Negi., *et al.* (2013) stabilizedthe soil with lime. The study investigates that lime serves as a highly effective soil stabilizer, particularly for soils to frequent expansion and shrinkage. Its action was rapid, leading to immediate improvements in various soil properties. These enhancements include increasing the soil's load-bearing capacity, minimizing shrinkage during moist conditions, reducing the plasticity index, and elevating the California bearing ratio (CBR) value. Moreover, over time, lime-treated soil demonstrates increased resistance to compression. The reaction between lime and soil initiates swiftly, with soil stabilization commencing within a few hours of application.

Arya and Soorya (2020) studied the effect of ceramic dust on geotechnical properties of clayey soil. The Atterberg limits exhibit a continuous decrease with increasing percentages of ceramic dust addition. The optimum moisture content similarly decreases with the rise in ceramic dust percentage up to 20%, beyond which further additions do not result in significant alterations in the optimum moisture content.

Priya and Singh (2021) carried out the stabilization of black cotton soil using fly ash. Based on the findings of the compaction test, it was evident that the maximum dry density (MDD) was achieved at a 20% fly ash content, indicating optimal compaction parameters. Conversely, the optimum moisture content (OMC) was minimized at this fly ash content level. Regarding the California bearing ratio (CBR) test results, the addition of fly ash as a stabilizing agent for clayey soils demonstrates a substantial increase in CBR values, indicating enhanced soil strength.

Rathore and Tiwari (2023) described the soil stabilization using Ceramic Waste (CW). The increase in the proportion of ceramic waste led to a decrease in the Liquid Limit (LL) and Plastic Limit (PL) of clay-CW composites. This reduction in LL and PL was attributed to the non-expansive nature of ceramic particles. Additionally, the compaction parameters of clayey soil showed notable improvement upon the inclusion of CW. The maximum dry unit weight (γ max) of the clay-CW composite increased with the percentage of CW, while the optimum moisture content decreased with the increasing CW content. Incorporating CW in clayey soil significantly enhanced the California bearing ratio (CBR) performance under both soaked and unsoaked conditions.

Deboucha*etal.* (2023) explored the impact of incorporating ceramic waste (CW) and lime into the road sub-base layer. It aims to optimize mixtures of CW-soil-lime and CW-soil-lime-cement by assessing their performance through maximum dry density (MDD), California bearing ratio (CBR), and unconfined compressive strength (UCS) tests across various compositions. Analysis of the test results indicates that CBR values notably rise with increased proportions of CW and lime, particularly when subjected to submerged conditions. Additionally, the UCS tests reveal that the highest UCS values are achieved by incorporating CW and lime independently, as well as by using CW with 2% lime and 2% Ordinary Portland Cement (OPC). This research suggests that integrating CW with a limited amount of lime and OPC presents a promising alternative for stabilizing soil in pavement sub-base layers.

III – MATERIAL USED

Expansive Soil

In the current study, a sample of expansive soil was collected from sitein proximity to college campus. The soil underwent a comprehensive analysis covering several key engineering properties. These analyses included sieve analysis, specific gravity, liquid limit and plastic limit, maximum dry density (MDD), optimum moisture content (OMC), as well as evaluation of California bearing ratio (CBR). Each of these properties provides valuable insights into the behavior and characteristics of the soil under various conditions.

Ceramic Dust

The ceramic waste, sourced from a local hardware shop, underwent fragmentation into smaller pieces using a hammer. Subsequently, the fragmented ceramic waste was sieved using a 4.75mm IS sieve.Ceramic waste encompasses discarded materials or by-products stemming from the production, utilization, or disposal of ceramics. Ceramics, composed of inorganic, non-metallic compounds like clay, silica, and other minerals, find diverse applications including pottery, construction materials, tiles, bricks, and industrial components.

Fly ash

The fly ash was collected from the Koradi thermal power plant, globally recognized as a soil ameliorator, fly ash boasts a chemical composition primarily comprising silica, alumina, iron oxide, calcium, and variable carbon content.

This residue presents a multitude of advantages including cost-effectiveness, heightened durability, and enhanced stability. Its versatile applications span various industries such as land stabilization, road construction, and the production of bricks and blocks.

Table 1. Mix proportion of soil, ceramic waste and fly ash

Sr No.	Sample No.	Soil (%)	Ceramic (%)	Fly ash (%)
1	S 1	100	0	
2	S 2	95	5	
3	S 3	90	10	
4	S 4	85	15	
5	S 5	80	20	
6	S 6	70	30	
7	S 7	60	40	
8	S 8	70	5	25
9	S 9	70	10	20
10	S 10	70	20	10
11	S 11	70	25	5
13	S 13	70	0	30

IV-METHOLOGY

The engineering properties of soil, including sieve analysis, specific gravity, liquid limit, plastic limit, unconfined compressive strength (UCS), and California bearing ratio (CBR), were determined according to the guidelines specified in Code SP 36. The process involved preparing various blends of ceramic, fly ash, and lime, as illustrated in Table 1.

A series of tests, including standard proctor test, were conducted on these samples. The blend demonstrating the highest maximum dry density (MDD) was subsequently chosen for further testing, which included assessments of unconfined compressive strength (UCS) and unsoaked California bearing ratio (CBR). All tests were performed in accordance with relevant Indian Standard (IS) Codes to ensure comprehensive and accurate evaluation of the samples' properties and performance characteristics.

V–MATERIAL MIX

The soil utilized in our project was gathered from the local area near the campus. Ceramic waste was collected and broken into small fragments, passing through 4.5 mm sieve, for testing purposes. Similarly, fly ash obtained from a nearby thermal power plant was utilized for our project. The detailed proportions of the mixture are outlined in Table 1.

VI - ANALYSIS OF TEST RESULT

A series of tests were performed on a soil sample, including sieve analysis, liquid limit, plastic limit, specific gravity, standard proctor compaction test, California Bearing Ratio (CBR) test, and Unconfined Compressive Strength (UCS) test. The engineering properties of black cotton soil in Table.

Table 2. Engineering Properties of Black cotton soil.

Sr. No.	Test On Soil	Parameter	Value
1	Sieve analysis (Passed from 75 µ)	%	59
2	Liquid limit	%	64
	Plastic limit	%	20
3	Plasticity Index	%	44
4	Specific gravity	-	2.7
5	MDD	kN/m^3	20.2
	OMC	%	15.25
6	CBR	%	11
7	UCS	kN/m^2	107

The soil tested 59% finer than 75 microns also the plasticity index is 44% which is vary high. The present soil is classified as CH as per IS classification system. The CBR value was found to be 11 % and unconfined compressive strength as 107 kN/m^2. The soil was mixed with different proportion with waste ceramic and fly ash as shown in table 2

The maximum dry density (MDD) and optimum moisture content (OMC) was calculated for all mix proportion. It was observed that MDD of stabilized soil increased than soil alone while OMC was found less than only soil. The mix proportion of soil and ceramic waste in proportion of 90:10 shows the maximum dry density in all various proportion. Similarly, the mix proportion of a soil, ceramic waste and fly ash in proportion of 70:10:20 gives maximum dry density among all mix proportions, for there two proportion, California bearing ratio (CBR) and unconfined compression strength (UCS) was determined. The MDD, OMC, CBR value and UCS of soil and stabilized soil are shown in Table 3.

Table 3. MDD, OMC, CBR and UCS of stabilized soil

Sr No.	Samples	MDD (KN/m 3)	OMC (%)	CBR (%)	UCS (KN/m 2)
1	S1	20.2	15.25	11	107
2	S2	19	12.3		
3	S3	20.6	12	12.65	128
4	S4	19.30	12		
5	S5	20	14.5		
6	S6	18.5	15.5		
7	S7	20.09	19.5		
8	S8	19.9	14.2		
9	S9	21.1	12.5	20.10	330
10	S10	20	13.3		
11	S11	20.1	9		
13	S13	19.2	9.8		

The MDD of soil with ceramic waste 10% alone shows maximum increaseby 1.98 % while soil stabilized with ceramic waste 10% and fly ash 20% shows maximum increase in MDD by 4.45%. The CBR and UCS test conducted on the proportions giving maximum MDD, shows that strength parameters of stabilized soil increased. The CBR for soil + 10% ceramic waste was increased by 15% while for soil + 10 % ceramic waste and 20 % fly ash, the CBR value increased by 82.47%. The UCS for soil + 10% ceramic waste was increased by 19.63% +while for soil + 10% ceramic waste + 20% fly ash , the UCS was increased by 208.4%. It shows that the engineering properties of stabilized soil improved to great extent. The soil mixed with 10% ceramic waste and 20% fly ash proves to be best proportion as a sustainably soil mix.

VII - CONCLUSION

1. Incorporating ceramic and fly ash contents into soil mixtures leads to significant improvements in engineering properties, notably in California bearing ratio (CBR) and unconfined compressive strength (UCS).
2. It indicates that a ceramic content of 10% in the mixture resulted in the highest maximum dry density, leading to notable increases in both CBR and UCS values compared to the original soil.
3. The mix strengthens the positive impact of additives on soil properties, with mixtures containing 10% and 20% ceramic and fly ash contents exhibiting the highest maximum dry density. These compositions demonstrated substantial increases in both CBR and UCS values compared to the original soil, indicating their effectiveness in improving soil stability and strength.
4. Overall, the findings suggest that incorporating ceramic and fly ash contents into soil mixtures can significantly enhance their engineering properties, rendering them more suitable for various construction and infrastructure applications.

REFERENCES

[1] *Aashish Ashwin Mehta (2022) "Stabilization of black cotton soil by Fly Ash," International Journal of Application or Innovation in Engineering & Management Application or Innovation in Engineering & Management (IJAIEM)* www.ijaiem.org *, ISSN 2319 – 4847.*

[2] *Akshaya Kumar sabat, (2012) "Stabilization of expansive soil using waste ceramic dust," Vol. 17 [2012], Bund. Z.36-1 (1987): Compendium of Indian Standards on Soil Engineering.*

[3] *Arya Sankar M. and Soorya S (2020) "Effect of ceramic dust on geotechnical properties of clayey soil," e-ISSN: 2395-0056 , Volume: 07 Issue: 02 | Feb 2020* www.irjet.net *p-ISSN: 2395-0072*

[4] *Er. Sumit Shringi', Er. Nidhi Gautam' Dr. Biswajit Acharya, (2018) "stabilizing the black cotton soil with rice husk ash and lime," International Journal of Advance Research in Science and Engineering, Volume No.07, Special Issue No.03.*

[5] *Ganga Bhavani and Dr.D.S.V.Prasad, (2015) "Strength Properties of Expansive Soil Treated With Lime, Gypsum and Coir Fibre," December 2015 | IJIRT | Volume 2 Issue 7 | ISSN: 2349-6002*

[6] *K.S Gandhi., .(2012) "Expansive soil stabilization using Bagasse Ash" IJERT, Issue 5.*

[7] *T. Geeta Rani and Ch. Shivnarayana, (2014), "Strength Behaviour of Expansive Soil Treated with Tile Waste" International Journal of Engineering Research and Development, e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com Volume 10, Issue 12, PP.52-57.*

[8] *Ganga Bhavani and Dr.D.S.V.Prasad, (2015) "Strength Properties of Expansive Soil Treated With Lime, Gypsum and Coir Fibre," December 2015 | IJIRT | Volume 2 Issue 7 | ISSN: 2349-6002.*

[9] *Shailendra Singh, Hemant B. Vasaikar, (2015) "Stabilization of Black Cotton Soil using Lime," Volume 4 Issue 5, May 2015 www.ijsr.net 2090, Paper ID: SUB154736.*

[10] *Subash K. et al. (2016) "Stabilization of Black Cotton Soil using Glass and Plastic Granules," International Journal of Engineering Research & Technology (IJERT) http://www.ijert.org ISSN: 2278-0181, Vol. 5 Issue 04.*