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Sustainable Geotechnics: Harnessing Bagasse Ash and E-Waste for Improving Soil Performance

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Abstract

This study addresses the prevalent issue of expanding soils in India, which exhibit a propensity to shrink and swell in response to changes in moisture content. Because of their high porosity and poor permeability, expansive soils can seriously jeopardize a structure's ability to support its weight. This study was aimed to use industrial waste like Bagasse ash and processed E-waste in a different ratio. Locally available soil from Sultanpur, Uttar Pradesh, was considered for experimental investigation. First optimum Bagasse ash content from different ratio (10%, 20%, 30% and 40%) by weight of soil is determined and then E-waste in different ratios (2.5%, 5% and 7.5%) was blended in soil. To determine enhancement in soil strength various test like California Bearing Ratio, Unconfined Compressive Strength was done. Optimum Bagasse ash content was determined as 15% and E-waste was 7.5%. Results from the experimental test indicate that the addition of E-waste combined with Bagasse ash improves soil strength in terms of CBR and UCS values. These test results will be helpful in the development and design of pavements and road construction in rural areas.

Keywords: *E-waste, Bagasse Ash, California Bearing Ratio, Unconfined Compressive Strength, Expensive Soil.*

1. Introduction

The importance of a strong foundation for any land-based structure cannot be overstated, with the soil playing a pivotal role in determining its stability. Knowledge of soil properties and factors influencing its behavior is essential, and soil stabilization emerges as a critical process to achieve the desired characteristics for construction purposes. Recognizing the diverse nature of soil properties, the practice of soil stabilization addresses the need to predict and enhance the load-bearing capacity of the soil [1]. This approach Proves economical, Energy-efficient and environmentally sustainable compared to alternatives like deep foundations. The advantages of soil stabilization encompass improved soil strength, enhanced bearing capacity, stability in slopes, erosion prevention, dust control in arid conditions, water-proofing, and mitigation of soil volume changes due to environmental variations. Soil stabilization is a crucial aspect of civil engineering, particularly in regions with diverse soil compositions that impact the performance of infrastructure like pavements. This holds true for many parts of India, including the state of Uttar Pradesh, where the prevalent clayey soil presents unique challenges for pavement construction [2]. The need for effective soil stabilization methods becomes paramount to enhance the engineering properties of the soil, ensuring the longevity and performance of pavements. The increasing demand for sustainable construction practices has led to the exploration of alternative materials for soil stabilization [3]. Bagasse ash, a byproduct of sugarcane processing, and processed fine grain electronic waste present promising opportunities for enhancing soil properties. Bagasse ash, a byproduct derived from the combustion of sugarcane bagasse in sugar mills, has garnered increasing attention as a valuable and sustainable material in various industries. Sugarcane bagasse, is a stem fibrous part, it is the residue remaining after juice extraction from sugarcane, which is traditionally considered waste [4]. However, through controlled incineration, bagasse ash is produced, presenting unique properties that make it an environmentally friendly and economically viable resource. As concerns for sustainable practices continue to grow, researchers and industries are exploring the diverse applications of bagasse ash, ranging from construction materials to agriculture [5]. Electronic waste, commonly known as E-waste, has become a pressing global issue in the wake of rapid technological advancements and widespread adoption of electronic devices [6]. E-waste encompasses as many discarded electrical and electronic devices like, computers, smartphones, televisions, and household appliances, which have reached the end of their life cycles. The proliferation of technology, coupled with shortened product lifespans and rapid obsolescence, has led to a surge in E-waste generation [7-8], posing significant challenges to environmental sustainability and resource management. As a complex mixture of metals, plastics, and other materials, E-waste not only presents disposal challenges but also represents a potential reservoir of valuable resources. This introduction explores the growing concerns surrounding E-waste, its composition, environmental implications, and the increasing importance of adopting responsible and innovative approaches to manage and recycle electronic waste for a sustainable future [9].

2. Literature review

The potential of E-waste in soil stabilization is an underexplored area that demands further investigation, emphasizing the necessity for more comprehensive research. Study conducted by [10], Black Cotton Soil (BCS) and E-waste were combined in varying ratios (3%, 6%, 9%, and 12% by dry weight of the soil) to enhance soil qualities sourced from Badanavalu city in Karnataka, India. The findings indicated that incorporating 6% more E-waste improved the soil's engineering characteristics. Another study [11] demonstrated the successful use of E-waste in stabilizing black cotton soil by employing ratios of 2%, 5%, and 8%, addressing waste disposal challenges. From the Pune District in Maharashtra, India, the study concluded that adding 5% of E-waste to soil could be a cost-effective and efficient soil stabilization method. Exploring the impact of various percentages of E-waste (6%, 8%, 12%, and 15%) on the geotechnical qualities of sensitive clayey soil [12], the study collected soil samples identified as CL soil from Chembarambakkam city in Tamil Nadu, India. Proposing the use of E-waste for soil stabilization, they conducted tests such as Direct Shear, CBR, and UCS to determine the optimal E-waste dosages. The results showed a noticeable improvement in UCS and CBR values, particularly at the 6% E-waste mixture. In a broader perspective [13], a review compared the utilization of three modern waste materials, including E-waste, in soil stabilization. Various laboratory tests such as UCS, CBR, and Proctor were conducted, concluding that the addition of E-waste to soil enhances its engineering properties, reinforcing its potential as a valuable resource in soil stabilization practices. Addressing the challenges posed by clayey soil in Uttar Pradesh requires a focused approach to soil stabilization for pavement construction. Effective soil stabilization methods will not only enhance the performance of pavements but also contribute to sustainable and resilient infrastructure in the region. As the demand for robust transportation networks continues to grow, investing in research and solutions for soil stabilization becomes instrumental in ensuring the longevity and quality of pavement structures in rural areas of Uttar Pradesh.

3. Material

For this experimental Investigation, clayey soil was tested. An examination is done to determine the effect and change in soil strength properties with the inclusion of bagasse ash and E-waste.

3.1. Soil

The initial soil sample was shown in Figure 1 obtained from Dhanpatganj, situated in the Sultanpur district of Uttar Pradesh. The soil undergoes a preparation process involving drying and crushing before being sieved with a 4.75 mm mesh size to create the sample. Subsequently, a series of laboratory tests are conducted on the pure soil to gather relevant data. To classify soil various tests are performed as per IS classification code IS 2720. All the test results are given in the following Table 1

Figure 1 Sample of Soil

Table 1 Soil Properties

Properties		Values
Specific Gravity (G)		2.73
Grain Size Analysis	Gravel	0
	Sand	3.2
	Silt & Clay	96.8
Plastic Limit (%)		19.22
Liquid Limit (%)		35.56
Plasticity Index (%)		16.34
OMC (%)		18.97
MDD (gm/cc)		1.65
CBR (%)		3.5
UCS (kg/cm^2)		1.82
Classification of soil		CL

3.2. Bagasse ash

Uttar Pradesh has many sugar mills which produce sugar for the state. Sultanpur and nearby area are hub for it. Upon extraction of juice from cane the left bagasse is burned to produce heat for the boilers. After burning the ash remaining is called bagasse ash. The raw material was obtained from Kishan Sahakari Chini mill, Ltd. Sultanpur, Avadh, Uttar Pradesh. Bagasse ash Properties are shown in Table 2.

Table 2 Bagasse Ash Properties

Properties	Values
Specific gravity (G)	2.1
Plasticity	Non-plastic
MDD (gm/cc)	1.22
OMC (%)	14.4
Plastic Limit (%)	12.1
Liquid Limit (%)	22.3
Plasticity Index (P.I.) (%)	10.2

3.3. Processed E-Waste

Processed E-waste used in this study was mainly obtained from shredded and grinded E-waste obtained from waste electronic equipment’s like the printed circuit boards, For this experimental investigation, Processed E-waste powder was procured from Haryana, Gurugram based Industry. The following properties of E-waste are tabulated in Table 3.

4. Methodology

Table 3 Properties of E-waste

Properties	Values
Specific gravity(G)	1.26
Colour	Black
Physical appearance	Flaky Powder
Density	596.30 kg/m^3
Crushing Value	< 2
Impact value	< 2
Fineness modulus	7.7

To assess the impact of induction materials such as Bagasse ash and E-waste on clayey soil, various tests in accordance with IS 2720 standards, including compaction, CBR, and UCS, are conducted. Initially, different proportions of Bagasse ash (5%, 10%, 15%,

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and 20% by dry weight of soil) are randomly hand-mixed into the soil sample. After determining the optimum dosage, E-waste is introduced at varying ratios (2.5%, 5%, and 7.5%), blended with the Bagasse ash content in the soil, and the overall optimal dosage is identified to enhance soil conditions. The research methodology is depicted in the Figure 2 above, classified into three main blocks. The first block involves soil classification and testing techniques. The second block illustrates the utilization of Bagasse ash, where the ash is classified based on its properties. Subsequently, varying ratios of fly ash, relative to the soil weight, are incorporated into the soil sample, followed by testing for compaction, CBR, and UCS. After analyzing the test results, the optimal Bagasse ash content is determined. Subsequently, with the optimal Bagasse ash content in the soil, E-waste is introduced into soil samples at different ratios (2.5%, 5%, 7.5% by weight of soil), and the optimal combination of Bagasse ash and E-waste content in the soil is determined to achieve the optimum value.

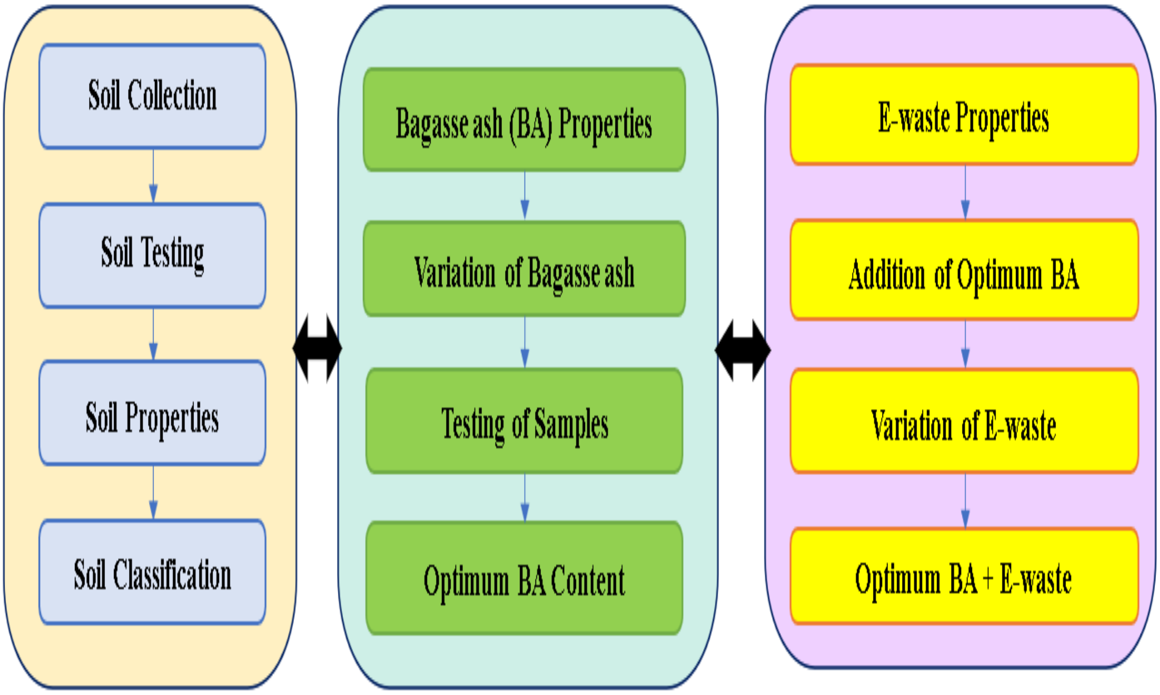

Figure 2 Methodology

5. Results and Discussion

Upon conducting experimental tests shown in the above procedure, various test results are obtained which are shown below

5.1 CBR Values

CBR value is predominant for testing the thickness of the pavement. CBR test were conducted to evaluate the combined effect of Bagasse ash and E-waste when randomly hand mixed in soil. All the test was conducted on soaked condition, soil samples were soaked for 72 hours in water and then it was tested. The CBR values for different Soils samples are given in the above Figure 3, Bagasse ash (BA) and processed E-waste are blended in soil. It is clear that with addition of BA and E-waste CBR value increases. The most suitable content of BA in soil is 15%. With E-waste combined with BA the optimum dosage for E-waste is (15% BA + 7.5% E-waste) the highest increase in CBR value. The percentage increase numbers for these combinations reveal how successful they are in increasing load-bearing capability.

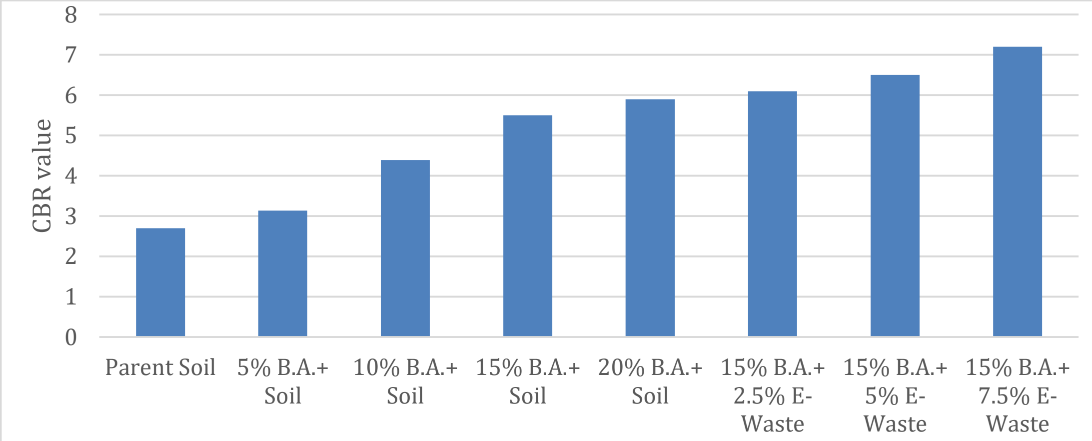

Figure 3 **CBR Values for Soaked Condition**

5.2 UCS Values

The inclusion of BA and E-waste in soil affects the compressive strength of the soil. The rise in UCS values due to E-waste implies that it has a beneficial Impact on strength. The combination of 7.5% E-waste and 15% RBD appears to relate to a higher UCS, which can be termed as optimum content for this experimental study.

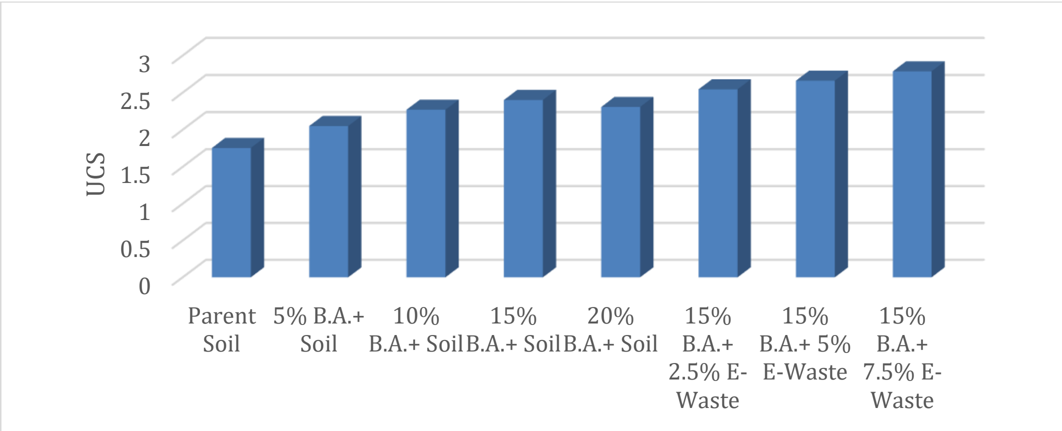

Figure 4 **UCS values**

Conclusions

The experimental investigation focused on utilizing locally available soil for real-time applications, like developing pavement for rural areas which has expansive soil. Incorporating waste products such as E-waste (in proportions of 2.5%, 5%, and 7.5%) And BA (in proportions of 5%, 10%, 15%, and 20%) by weight of the soil, with the objective to improve the engineering properties of the soil. The experimentation was conducted in two phases: first, examining the individual effects of waste materials on the soil and determining the optimum ratio, and second, optimizing the best-suited combination ratio of E-waste and BA.The results of the experiment work, shows a positive enhancement in the engineering properties of the soil. Analysis of CBR values provides insights into the impact of different proportions of E-waste and BA on the soil's CBR. The most optimal combination, constituting 4% E-waste and 15% RBD, showcases an CBR increase of 153% compared to the unaltered soil. The UCS values demonstrate a substantial variation, the optimal blend, comprising 7.5% E-waste and 15% BA, exhibits a remarkable 79% increase in UCS values are shown in Figure 4.While the combination of E-waste and BA in soil stabilization proves to be efficient, future research can be determining the optimal ratios for different soil types and conditions. Cost-benefit analyses can be done for economic feasibility of this approach compared to traditional soil stabilization methods.

References

[1] Majeed, M., & Tangri, A. P. "Stabilization of soil using industrial wastes." In IOP Conference Series: Earth and Environmental Science. IOP Publishing Ltd. 2021. https://doi.org/10.1088/1755-1315/889/1/012018.

[2] Mohd Khaidir Abu Talib and Yasufuku Noriyuki. "Highly organic soil stabilization by using sugarcane bagasse ash (SCBA)." In MATEC Web of Conferences, vol. 103, pp. 07013. 2017. https://doi.org/10.1051/matecconf/201710307013.

[3] Shivam Banchchhas, D.K. Soni. "Stabilization of clayey soil using sugarcane bagasse ash and rice husk ash." In IJSTM, ISSN(P)2394-1529, Vol. No. 6, Issue No. 01. 2017.

[4] A. Bahurudeen, Manu Santhanam. "Influence of different processing methods on the pozzolanic performance of sugarcane bagasse ash." In Cement & Composites, vol. 56, pp. 32-45. 2015. https://dx.doi.org/10.1016/j.cemconcomp.2014.11.002.

[5] Humphrey Dnso, D. Brett Martinson, Muhammad Ali, John B. Williams. "Effect of sugarcane bagasse fibre on the strength properties of soil blocks." In First International Conference on Bio-based Building Materials. 2015.

[6] Arya, S., & Kumar, S. "E-waste in India at a glance: Current trends, regulations, challenges and management strategies." In Journal of Cleaner Production, vol. 271. 2020. https://doi.org/10.1016/j.jclepro.2020.122707.

[7] He, Y., Kiehbadroudinezhad, M., Hosseinzadeh-Bandbafha, H., Gupta, V. K., Peng, W., Lam, S. S., Tabatabaei, M., & Aghbashlo, M. "Driving sustainable circular economy in electronics: A comprehensive review on environmental life cycle assessment of E-waste recycling." In Environmental Pollution, vol. 342, p. 123081. 2024. https://doi.org/10.1016/j.envpol.2023.123081.

[8] Schneider, A. F., & Zeng, X. "Investigations into the transition toward an established E-waste management system in China: Empirical evidence from Guangdong and Shaanxi." In Current Research in Environmental Sustainability, vol. 4, p. 100195. 2022. https://doi.org/10.1016/j.crsust.2022.100195.

[9] Dias, P., Bernardes, A. M., & Huda, N. "Ensuring best E-waste recycling practices in developed countries: An Australian example." In Journal of Cleaner Production, vol. 209, pp. 846-854. 2019. https://doi.org/10.1016/j.jclepro.2018.10.306

[10] 10. Gupta, R., & Raghuwanshi, A. K. (2016). Utilization of E-waste in strength enhancement of black cotton soil. Journal of Environmental Science and Engineering, 1(3), 9–19.

[11] Chaugule, M., Deore, S., Gawade, K., Tijare, A., & Banne, S. (2017). Improvement of black cotton soil properties using E-waste. IOSR Journal of Mechanical and Civil Engineering, 14, 76–81. https://doi.org/10.9790/1684-1403017681

[12] Kumar, J. K., & Kumar, V. P. (2020). Experimental analysis of soil stabilization using E-waste. In Materials Today: Proceedings (pp. 456–459). Elsevier Ltd. https://doi.org/10.1016/j.matpr.2019.07.716

[13] Rai, A. K., Singh, G., & Tiwari, A. K. (2020). Comparative study of soil stabilization with glass powder, plastic and E-waste: A review. Materials Today: Proceedings, 32(4), 771–776. https://doi.org/10.1016/j.matpr.2020.03.570.