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UTILIZATION OF RIVER SILT AND POND ASH FOR SUSTAINABLE GROUND IMPROVEMENT APPLICATIONS

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Abstract

This study investigates the effectiveness of river silt and pond ash as sustainable stabilizing materials for improving the engineering properties of black cotton soil. The experimental program was carried out by incorporating river silt and pond ash in varying proportions of 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% each, resulting in total additive contents of 0%, 5%, 10%, 15%, 20%, 25%, and 30% by dry weight of soil. Laboratory investigations were conducted to evaluate the changes in the plasticity characteristics and overall engineering behavior of the stabilized soil. The results of the plasticity index test indicate that the untreated black cotton soil has a high plasticity index of 35.51%. With increasing proportions of river silt and pond ash, the plasticity index generally decreases, reaching 21.22% at 30% total additive content. A significant reduction in plasticity is observed particularly at 25% and 30% replacement, indicating a reduction in the plastic and expansive characteristics of the soil. The improvement is attributed to the incorporation of relatively non-plastic materials, which modifies the soil particle interaction and reduces its moisture sensitivity. The findings demonstrate that the combined utilization of river silt and pond ash can effectively reduce the plasticity of black cotton soil and improve its suitability for ground improvement applications. The study also highlights the potential of utilizing locally available waste and marginal materials as sustainable alternatives to conventional soil stabilization practices.

Keywords: Black Cotton Soil; River Silt; Pond Ash; Soil Stabilization; Plasticity Index; Expansive Soil; Ground Improvement; Sustainable Construction.

Introduction

Ground improvement is a vital aspect of geotechnical engineering, adopted to enhance the engineering properties of weak or problematic soils so that they can safely support foundations, embankments, pavements, and other structures. Conventional ground improvement techniques such as excavation and replacement, deep foundation systems, stone columns, and soil stabilization with cement or lime are effective but often expensive, energy-intensive, and associated with considerable environmental footprints. In the current era of sustainable development and circular economy, there is a growing need to explore the use of locally available, low-cost, and environmentally benign materials for soil improvement.

In this context, the utilization of industrial and natural by-products has gained significant attention. River silt is a naturally occurring fine-grained sediment deposited in large quantities along riverbeds and floodplains as a result of erosion and water flow. It is usually considered a waste material and often remains underutilized despite its abundance. On the other hand, pond ash is a by-product of thermal power plants, collected from the bottom of ash settling ponds. Large quantities of pond ash are generated annually, creating challenges related to disposal and potentially causing environmental problems such as land degradation and contamination of surrounding areas.

Both river silt and pond ash possess characteristics that can be utilized for improving soil properties. When used individually or in combination, these materials have the potential to modify the engineering behaviour of soil by improving its strength, reducing compressibility, controlling plasticity, and enhancing its compaction characteristics. Their utilization can simultaneously address waste-disposal problems and reduce dependence on conventional stabilizing materials, thereby promoting economical and sustainable construction practices.

Pond ash contains significant quantities of silica and alumina, which can contribute to pozzolanic reactions in the presence of suitable calcium sources. Its relatively lightweight nature and granular characteristics can also be advantageous in selected ground improvement and embankment applications. Similarly, river silt, because of its fine particle size and mineral composition, can influence particle packing, moisture-density relationships, and the strength characteristics of soil when appropriately proportioned with other stabilizing materials. The combined use of these materials may therefore provide an opportunity to develop an alternative ground improvement technique based on locally available waste and natural resources.

Therefore, the present study aims to investigate the feasibility and effectiveness of utilizing river silt and pond ash, individually and in combination, for sustainable ground improvement applications. The research focuses on evaluating important geotechnical parameters such as optimum moisture content, maximum dry density, unconfined compressive strength, California Bearing Ratio (CBR), and swelling characteristics. The study is expected to provide a sustainable, economical, and environmentally friendly alternative for improving weak soils while promoting the beneficial utilization of naturally occurring sediments and industrial by-products in infrastructure development.

Literature Survey

Recent investigations have demonstrated that activated or modified river sediments can contribute to strength enhancement and microstructural densification of soil systems. Mechanical grinding, thermal activation, and chemical stabilization improve the pozzolanic activity of river silt and enhance bonding among soil particles. Moderate replacement and blending strategies have shown improvements in compressive strength, durability, and permeability characteristics while reducing dependence on natural aggregates.

Pond ash, a by-product of coal-based thermal power plants generated through slurry disposal of Pond ashand bottom ash, has emerged as another promising sustainable geomaterial. Large-scale disposal of pond ash occupies substantial land areas and creates environmental concerns. However, its low density, silt-sized particles, and compatibility with other binders make it suitable for geotechnical applications including embankment fills, subgrade stabilization, backfill material, and foundation improvement.

The integration of river silt and pond ash represents an emerging sustainable approach for ground improvement. River silt can contribute finer particles and silica-rich content, whereas pond ash improves particle packing, drainage, and strength development. The combined utilization of these materials offers environmental advantages through waste valorization, reduced extraction of natural borrow materials, and lower carbon footprints compared with traditional stabilization methods. Such combinations are particularly attractive for embankment construction, pavement subgrades, and low-cost foundation systems in regions with abundant river sediment and thermal power residues.

Aamir ahsan et al (2024) the long-term performance and service life of pavement structures largely depend on the strength, stability, and load-bearing capacity of the sub-base and base layers. These layers act as the foundation of the pavement and are responsible for distributing traffic loads safely to the underlying soil. If the supporting soil is weak or unstable, the pavement may develop defects such as cracking, rutting, settlement, and premature failure. Therefore, improving the engineering properties of soil through stabilization becomes an essential step in pavement construction.

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Soil stabilization is a process in which the physical and mechanical properties of soil are modified to increase its strength, reduce compressibility, control volume changes, and improve durability. Stabilization can be achieved through mechanical methods or by adding stabilizing agents such as lime, cement, fly ash, industrial by-products, or recycled construction materials. The primary objective is to make weak soils suitable for engineering applications while reducing maintenance requirements and increasing pavement lifespan. In India, black cotton soil is one of the most challenging soil types used in civil engineering projects and represents the fourth largest soil group in the country. It is predominantly found in states such as Maharashtra, Madhya Pradesh, Gujarat, Karnataka, Andhra Pradesh, and parts of Tamil Nadu. Black cotton soil contains a high percentage of expansive clay minerals, particularly montmorillonite, which causes the soil to undergo significant volume changes with variations in moisture content. The major problem associated with black cotton soil is its high swelling and shrinkage characteristics. During the rainy season, the soil absorbs water and expands, while in dry conditions, it loses moisture and shrinks. These repeated expansion–contraction cycles create cracks and uneven settlement in pavement structures. Black cotton soil also possesses relatively low bearing capacity, high plasticity, low shear strength, and poor drainage characteristics, making it unsuitable for direct use in road subgrades without treatment. To overcome these limitations, stabilization of black cotton soil becomes necessary. One sustainable and economical approach is the utilization of construction and demolition (C&D) waste as a stabilizing material. Construction and demolition waste consists of discarded materials generated from building construction, renovation, maintenance, and demolition activities. These materials commonly include crushed concrete, bricks, mortar, ceramic tiles, stone aggregates, and other mineral-based debris.

When processed and mixed with black cotton soil, construction and demolition waste improves the soil structure by filling void spaces and creating a denser and more stable matrix. The granular particles present in C&D waste increase interlocking between soil particles, which enhances compaction characteristics and reduces excessive swelling and shrinkage behavior. This modification leads to improved strength and deformation resistance of the stabilized soil.

Methodology

The materials used in this study consist of river silt and pond ash, selected for their potential application in sustainable ground improvement. River silt is a naturally deposited fine-grained soil collected from riverbeds or riverbanks. It generally contains varying proportions of silt, clay, and fine sand particles and often exhibits low bearing capacity, high compressibility, and poor drainage characteristics, making stabilization necessary for engineering applications. Before use, the collected river silt is air-dried, pulverized, and passed through a suitable sieve to remove oversized particles and obtain uniformity.

Pond ash is an industrial by-product obtained from thermal power plants, where ash particles are mixed with water and stored in ash ponds. Pond ash mainly consists of silica, alumina, and small amounts of iron oxide and calcium compounds. Due to its lightweight nature and pozzolanic characteristics, pond ash can improve the engineering behavior of weak soils by reducing plasticity, increasing strength, and enhancing compaction characteristics. The collected pond ash is dried and sieved prior to mixing.

For stabilization studies, different proportions of pond ash are mixed with river silt to evaluate changes in geotechnical properties. Laboratory tests such as moisture content, specific gravity, grain size distribution, Atterberg limits, compaction test, California Bearing Ratio (CBR), and Unconfined Compressive Strength (UCS) are generally carried out to assess the effectiveness of stabilization. The combination of river silt and pond ash offers an environmentally sustainable solution by utilizing naturally available and industrial waste materials for ground improvement applications.

Result and Discussion

In this chapter, the experimental results are presented and discussed to effectively communicate the outcomes of the research and their implications for sustainable ground improvement applications. The primary objective of the study was to evaluate the effectiveness of stabilizing black cotton soil using river silt and pond ash in different proportions and to determine their influence on the engineering properties of the soil. The study was conducted to address the research objective of improving the strength and compaction characteristics of expansive soil through the utilization of sustainable and locally available materials.

The results are presented systematically according to the type of laboratory tests conducted and the engineering parameters measured. The experimental program included varying the percentages of river silt and pond ash as stabilizing materials. Each material was added at proportions of 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15%, resulting in total additive contents of 0%, 5%, 10%, 15%, 20%, 25%, and 30% by weight of dry soil. The obtained results are illustrated using tables, graphs, and figures to ensure clear interpretation and comparison of data.

Table 1 Result of Plasticity index

S.N	Percentage of Soil Mix	PI = LL-PL in %
1	0	35.51
2	5	32.81

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3	10	33.71
4	15	29.48
5	20	28.79
6	25	21.41
7	30	21.22

The Plasticity Index (PI), calculated as PI = Liquid Limit (LL) − Plastic Limit (PL)**,** represents the range of water content over which soil remains plastic and indicates the degree of soil compressibility, cohesion, and swelling behavior. Based on the test results, the virgin soil (0% soil mix) shows the highest PI value of **35.51%**, indicating high plasticity and greater susceptibility to volume change and deformation under moisture variation. With the addition of pond ash and river silt in increasing proportions, the PI generally decreases, showing improvement in soil behavior. At 5% replacement, PI decreases to 32.81%**,** indicating a reduction in plasticity due to the introduction of non-plastic fine particles. A slight increase to 33.71% at 10% replacement suggests minor variation in particle interaction and moisture retention characteristics. Beyond this level, a consistent reduction is observed, with PI decreasing to 29.48% at 15%**,** 28.79% at 20%**,** 21.41% at 25%**,** and reaching the minimum value of 21.22% at 30% replacement**.** This overall decline demonstrates that the combined addition of river silt and pond ash reduces the clay activity and plastic nature of the soil, resulting in lower compressibility, reduced shrink–swell potential, improved workability, and enhanced suitability for geotechnical and ground improvement applications. The optimum improvement is observed near 25–30% replacement, where the soil exhibits significantly lower plasticity and better engineering performance compared with virgin soil.

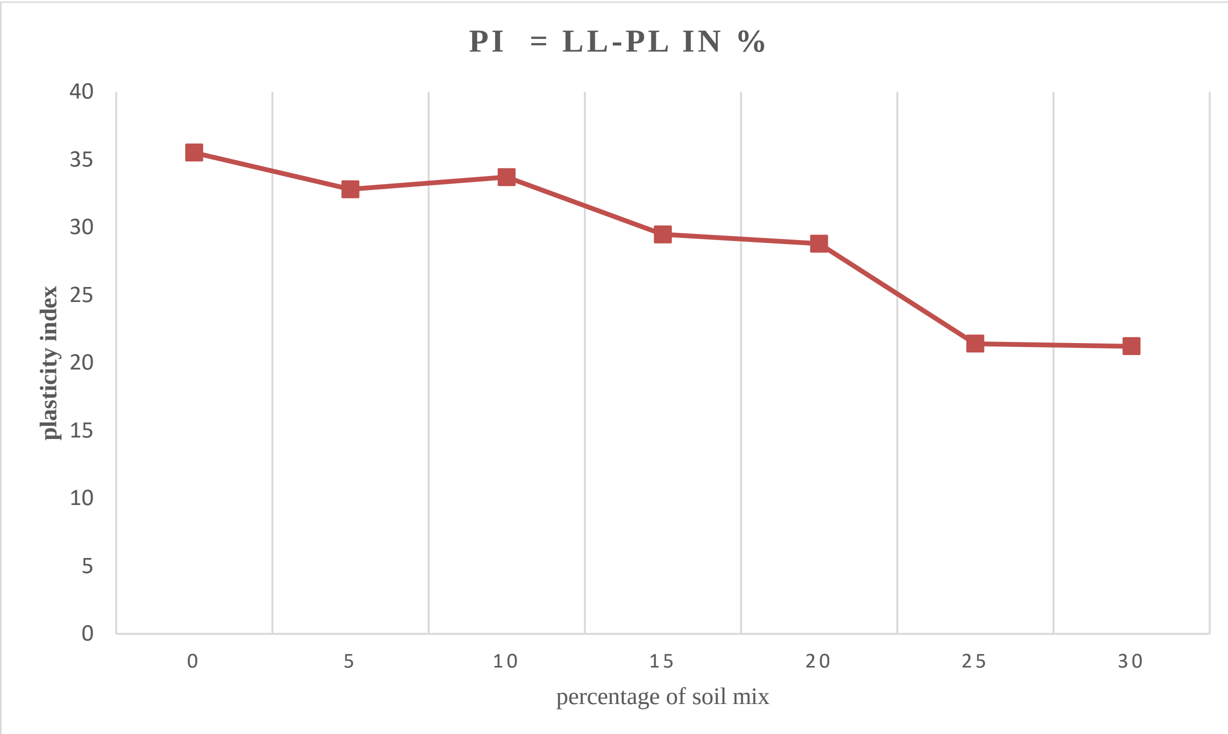

Figure 1 showing the value of plasticity index virgin soil and stabilized soil

Conclusion

The experimental investigation demonstrates that the combined utilization of river silt and pond ash can effectively improve the plasticity characteristics of black cotton soil and can serve as a sustainable ground improvement material. The Plasticity Index of the untreated black cotton soil was found to be 35.51%, indicating a highly plastic soil with considerable potential for swelling, shrinkage, and volume change.

With the incorporation of river silt and pond ash, the Plasticity Index generally decreased with increasing replacement content. The PI reduced from 35.51% for untreated soil to 32.81%, 33.71%, 29.48%, 28.79%, 21.41%, and 21.22% at 5%, 10%, 15%, 20%, 25%, and 30% replacement, respectively. Although a slight increase was observed at 10% replacement, the overall trend clearly indicates a reduction in soil plasticity with increasing stabilizer content.

The reduction in PI indicates a decrease in the active clay fraction and moisture sensitivity of the black cotton soil. Consequently, the treated soil is expected to exhibit reduced shrink–swell potential, lower compressibility, improved workability, and better dimensional stability. The most significant improvement was observed at 25–30% total replacement, where the PI was reduced by approximately 40% compared with the untreated soil.

Therefore, the study concludes that the combined application of river silt and pond ash, particularly at higher replacement levels of about 25–30%, has considerable potential for sustainable ground improvement of expansive black cotton soil. The use of these locally available waste materials not only improves the engineering characteristics of problematic soil but also provides an environmentally beneficial approach by promoting the productive utilization of waste materials and reducing the dependence on conventional soil stabilization resources. Further evaluation of compaction, strength, swelling, and durability properties is recommended to establish the optimum proportion for practical field applications.

References

[1] Aamir ahsana, Sapana madan “soil stabilization using demolished concrete waste and Pond ashin highway construction” 2024, IRJEdT Volume: 06 Issue: 05 | May -2024

[2] H. Paul and S. Cyrus, "stabilization of weak subgrade soil using demolished concrete aggregate," in Indian Geotechnical Conference, IIT Madras, Madras, Dec 2016.

[3] Akshata. R and Bharat. H M, "Improvement in CBR of black cotton soil using Brick powder (Demolition Brick masonry waste) and lime," International Journal of Innovative science research, Engineering and Technology, vol. 5, Sept 2016.

[4] R. M. Brooks and M. Cetin, "Application of construction and demolition waste for improving the performance of subgrade and subbase layers," IJRRAS, vol. 12, Sept 2012.

[5] Yadu (2013) evaluated the potential of granulated blast furnace slag (GBS) with Pond ashto stabilize clay. Study shows that clay can be effectively stabilized with the addition of a fly ash-GBS mixture.

[6] Kumar (2015) conducted a study on the use of construction and demolition waste. The study concludes that construction and demolition waste like bricks, concrete, tiles, etc. may be used for mechanical stabilization of very poor soils, by adding extra cementitious materials or commercial stabilizers accredited by IRC as per IRC: SP:89. The C&D waste material shall have gradation as per IRC: SP: 89

[7] V. Ramesh Babu, K. Niveditha, Dr. B. Ramesh Babu 2016 “Stabilization of black cotton soil with sand and cement as a subgrade pavement” International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 2, 2016.

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[8] Ashkan GHolipoor Norozi, Siavash Kouravand, Mohammad Boveiri#3 “A review of using the waste in soil stabilization” International Journal of Engineering Trends and Technology (IJETT) – Volume 21 Number 1 – March 2015.

[9] Maninder Singh, Rubel Sharma, Abhishek “Soil stabilization using industrial waste (wheat husk and sugarcane straw ash) “International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 09 | Sep - 2017

[10] Stabilization of expansive soils using construction and demolition waste Vivek S1, Parimal Kumar2, Vivek Shukla3, Kiran Markal4, Mallikarjun5 Department of Civil Engineering, JSSATE, Bangalore, Karnataka, India.