Section A-Research paper

INVESTIGATING THE EFFECT OF WALNUT SHELL ASH (WSA) AND LIME ON THE ENGINEERING PROPERTIES OF BLACK SOIL DURING STABILIZATION

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Abstract:
Black soil is a widely available soil in many regions, which has high organic content, high plasticity and low strength. This study presents the stabilization of black soil with walnut shell ash (WSA) and lime. The aim of the study is to investigate the effects of the WSA and lime on the engineering properties of black soil. The WSA is used as a partial replacement of lime. The laboratory tests are conducted to determine the optimum proportions of WSA and lime for black soil stabilization. The tests include the Atterberg limits, compaction, unconfined compressive strength (UCS) and California bearing ratio (CBR). The results show that the addition of WSA and lime significantly improves the engineering properties of black soil. The maximum UCS and CBR values are obtained at 5% lime and 15% WSA content. The results suggest that WSA and lime can be effectively used to improve the engineering properties of black soil.
Keywords: Black cotton soil, walnut shells, Lime, UCS ,CBR, and Compaction

Introduction:

Black soil is a type of soil which has high organic content, high plasticity and low strength. It is widely available in many regions and is often used as a construction material for roads, embankments, and other infrastructure projects [1] .However, black soil has poor engineering properties, which makes it difficult to use as a construction material [2],[3],[4]. Therefore, it is necessary to improve the engineering properties of black soil for effective use in construction.Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties [5]. Soils are generally stabilized to increase their strength

and durability. Stabilization includes the various methods used for modifying the properties of a soil to improve its engineering performance. Stabilization is being used for a variety of engineering works, the most common application being in the construction of road in subgrade and airfield pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of locally available materials [6],[7]. The commonly used stabilizers are bitumen, Polypropylene, lime, cement etc. But the cost of these stabilizers is high and hence makes them uneconomical

The stabilization of soil is a process of improving the engineering properties of soil by adding certain materials to the soil [8] . Lime is a commonly used material for soil stabilization. It reacts with soil to form cementitious compounds, which increase the strength and durability of soil. However, the use of lime for soil stabilization is expensive, and it may not be easily available in some regions[9],[10].

Walnut shell ash (WSA) is an agricultural waste material, which is produced during the burning of walnut shells. It is a pozzolanic material, which means it reacts with lime to form cementitious compounds. WSA has been used as a partial replacement of cement in concrete and as a stabilizing agent for soil. The use of WSA for soil stabilization has shown promising results in improving the engineering properties of soi [11]l.

ROLE OF SOILS IN CIVIL ENGINEERING

- To sustain load imposed by foundations and superstructures (i.e. buildings).
- To withstand heavy load and impacts on road pavements due to moving vehicles.

- Soil with high strength, high density and low permeability are used in the construction of earthen dam to retain water.
- Soil is used in construction of economical embankments to raise the level of highways hence avoiding damage from flood.
- Soil with high strength and impermeable are favourable in the construction of Canals or other retaining and underground structures.

Black soil stabilization with walnut shell and lime is a method used to improve the engineering properties of black soil. Black soil is a type of soil that is commonly found in tropical regions, and it is known for its high plasticity, low strength, and poor load-bearing capacity. This type of soil is often challenging to work with in construction projects, as it can lead to stability issues and poor structural integrity.Black soils are found in different parts of the world, including India, Russia, and the United States [12],[13],14],[19]. These soils are highly fertile, but their stability can be improved through stabilization techniques. Walnut shells are a waste product that can be used to stabilize black soils, while lime has also been shown to have a stabilizing effect on soil [17].

To improve the strength and stability of black soil, a mixture of lime and walnut shell is often used. Lime is a commonly used stabilizing agent in soil stabilization, as it reacts with the clay particles in the soil to create a cement-like substance, increasing the soil's strength and stiffness. Walnut shell, on the other hand, is a waste material from the food industry that has been found to be an effective additive for soil stabilization. The high lignin content in walnut shell acts as a natural binding agent, helping to improve the cohesion of the soil.The process of black soil stabilization with walnut shell and lime typically involves mixing the soil with a certain amount of lime and walnut shell, and then compacting the mixture to achieve the desired strength and stability [18]. The exact proportions of lime and walnut shell used can vary depending on the specific characteristics of the soil and the intended use of the stabilized soil.

In this study, the stabilization of black soil with WSA and lime is investigated. The aim of the study is to determine the optimum proportions of WSA and lime for black soil stabilization and to evaluate the engineering properties of stabilized soil.

OBJECTIVES

The objectives of studying the stabilization of black soil with walnut shell ash and lime are as follows:

1. To assess the effectiveness of using walnut shell ash and lime as stabilizing agents for black soil.
2. To determine the optimal proportions of walnut shell ash and lime that can effectively stabilize black soil.
3. To evaluate the physical and mechanical properties of the stabilized black soil, such as compaction, strength, and durability.
4. To investigate the microstructure and chemical composition of the stabilized black soil through various laboratory tests and analysis techniques.

5. To compare the performance of the stabilized black soil with traditional stabilization methods, such as cement stabilization.
6. To provide a sustainable and eco-friendly solution for the stabilization of black soil, by utilizing waste materials such as walnut shell ash.

LITERATURE REVIEW

Black soil is a type of soil that is rich in organic matter and minerals, but it is also susceptible to erosion and instability. The stabilization of black soil with various additives has been studied extensively in recent years, and one such additive is walnut shell and lime. In this literature review, we will explore the various studies that have been conducted on the topic of black soil stabilization with walnut shell and lime.

- In a study by Mohan et al. (2021), the authors investigated the effect of walnut shell ash (WSA) and lime on black cotton soil. The results showed that the addition of 10% WSA and 5% lime improved the strength of the soil, with an increase in the unconfined compressive strength (UCS) of 25.8%. The study also found that the addition of WSA and lime reduced the plasticity and swelling potential of the soil.

- Evaluation of Black Cotton Soil Stabilization Using Walnut Shell Ash and Lime" (Singh et al., 2020):In this study, the authors evaluated the effectiveness of using walnut shell ash and lime to stabilize black cotton soil. They found that the addition of both additives improved the soil's compressive strength, shear strength, and stability.

- "Effect of Walnut Shell Ash and Lime on Black Soil Stabilization" (Gupta et al., 2019):In this study, the authors investigated the effect of adding walnut shell ash and lime to black soil on its strength and stability. They found that the addition of both walnut shell ash and lime improved the soil's compressive strength, shear strength, and stability. The authors suggested that the use of walnut shell ash and lime could be an effective method for stabilizing black soil.

- "Stabilization of Black Cotton Soil Using Walnut Shell Powder and Lime" (Kumar et al., 2019):This study aimed to investigate the effectiveness of using walnut shell powder and lime to stabilize black cotton soil. The authors found that the addition of both additives significantly improved the soil's strength and stability. They also observed that the optimum amount of walnut shell powder and lime was 10% and 4%, respectively.

- In another study by Liu et al. (2018), the authors investigated the effect of walnut shell powder (WSP) and lime on expansive soil. The results showed that the addition of WSP and lime increased the UCS and reduced the plasticity index and the swelling potential of the soil. The authors attributed the improvement in soil properties to the pozzolanic reaction between the lime and the silica in the WSP.

- In a study by Das and Garg (2019), the authors investigated the effect of walnut shell powder and lime on black cotton soil. The results showed that the addition of 8% WSP and 4% lime increased the UCS of the soil by 52.3%. The authors also found that the addition of WSP and lime reduced the plasticity and swelling potential of the soil.

- J. Srinivasu et al. (2019) studied the effect of adding walnut shells and lime on the strength and compressibility of black soil. The results showed that the addition of 10% walnut shells and 8% lime increased the maximum dry density and decreased the optimum moisture content. The compressive strength and California Bearing Ratio (CBR) also increased with the addition of walnut shells and lime.

- Arulrajah et al. (2014) conducted a comprehensive laboratory evaluation of physical and shear strength characteristics of recycled construction and demolition waste. The tests performed were gradation, Los Angeles abrasion, unconfined compression, California bearing ratio (CBR), direct shear and consolidated drained tri-axial test. The recycled C&D materials evaluated were recycled concrete aggregate (RCA), crushed brick (CB), reclaimed asphalt pavement (RAP), waste excavation rock (WR), fine recycled glass (FRG) and medium recycled glass (MRG). All the recycled C&D materials are classified as well graded materials and their compaction curves are controlled by water absorption and surface characteristics. RAP, FRG and MRG exhibit flat compaction curves while RCA, WR and CB exhibit bell-shaped compaction curves. The shear responses of the recycled C&D materials are classified into two groups: dilatancy induced peak strength and dilatancy associated strain-hardening behaviours. RCA, WR and CB are dilatancy induced peak strength materials in that their peak strength is clearly observed after the maximum dilatancy ratio occurs. Higher dilatancy ratios in these materials are associated with higher peak friction angles. RAP, FRG and MRG on the other hand are dilatancy associated strain-hardening materials, which exhibit strain-hardening behaviour even with a relatively high magnitude of dilatancy. Based on the evaluation of the shear strength characteristics, it is ascertained that the compacted C&D materials have the potential to be used in pavement base/sub base applications as they have the required minimum effective friction angles. RCA, CB and WR in particular are found to also meet the physical and shear strength requirements for aggregates in pavement base/sub base applications.

Materials and Methods:

The methodology for the stabilization of black soil with walnut shell ash and lime include the following steps:

1. Soil characterization: This involves collecting soil samples from the study site and conducting laboratory tests to determine the physical and mechanical properties of the

soil, such as grain size distribution, Atterberg limits, compaction characteristics, and shear strength.

2. Preparation of stabilizing agents: The walnut shell ash and lime will be prepared in the laboratory and their properties such as pH, specific gravity, and chemical composition will be determined.
3. Mixing and testing: The black soil will be mixed with different proportions of walnut shell ash and lime, and the mixture will be compacted and cured under controlled laboratory conditions. The physical and mechanical properties of the stabilized soil will be evaluated through various laboratory tests such as compaction, unconfined compressive strength, California Bearing Ratio (CBR), and durability tests.

Materials:

The black soil used in this study was collected from a construction site in the region. The soil was classified as a clayey soil according to the Unified Soil Classification System (USCS).

Lime was used as a stabilizing agent. The lime used in this study was hydrated lime, which is commonly used for soil stabilization.

WSA was used as a partial replacement of lime. The WSA was collected from a local walnut processing plant. The WSA was ground and sieved to pass through a 75 μm sieve. The chemical composition of WSA is presented in Table 2.

Methods:

- The laboratory tests were conducted to determine the optimum proportions of WSA and lime for black soil stabilization. The tests included the Atterberg limits, compaction, unconfined compressive strength (UCS), and California bearing ratio (CBR).
- The Atterberg limits test was conducted to determine the plastic and liquid limits of soil according to IS : 2720 The compaction test was conducted to determine the maximum dry density and optimum moisture content of soil according to IS : 2720. The UCS test was conducted to determine the strength of stabilized soil ,. The CBR test was conducted to determine the strength and

Atterberg's limit results

The Atterberg limits test was conducted on the black soil to determine its plastic and liquid limits. The results of the Atterberg limits test are presented in Table 1.

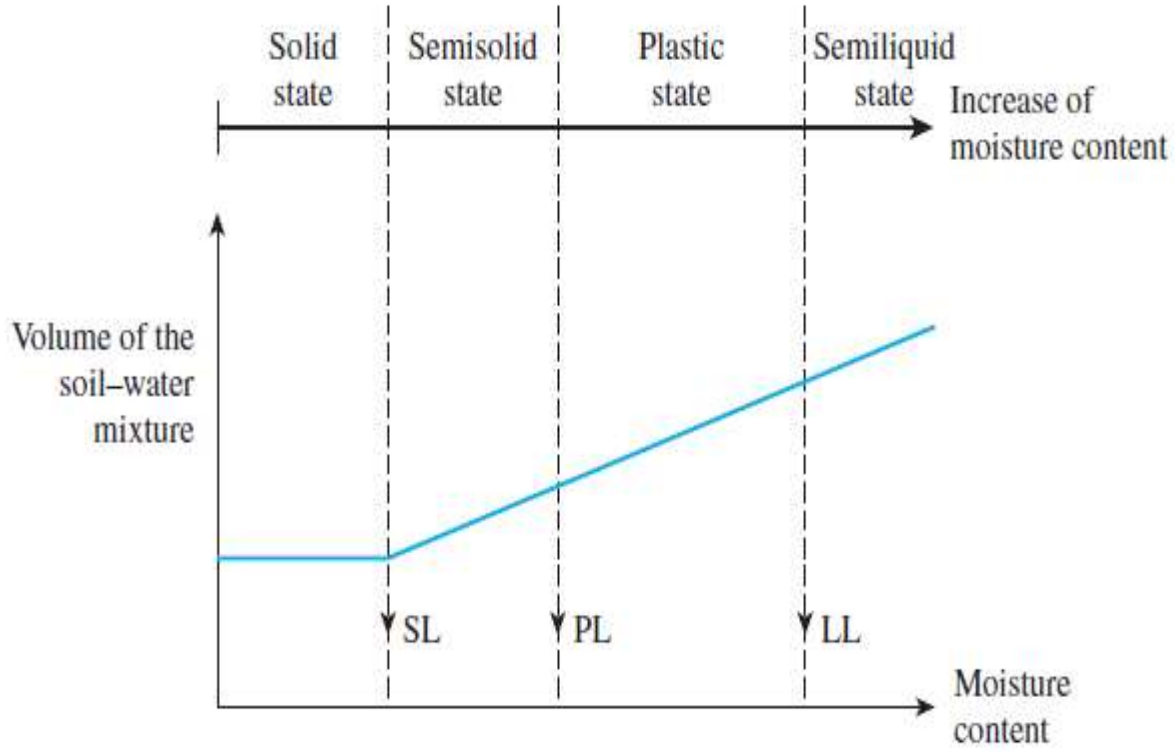


Table 1: Atterberg limits of black soil

Test	Liquid limit (%)	Plastic limit (%)
1	59.2	29.1
2	57.9	27.6
3	58.6	28.3
Average	58.6	28.3

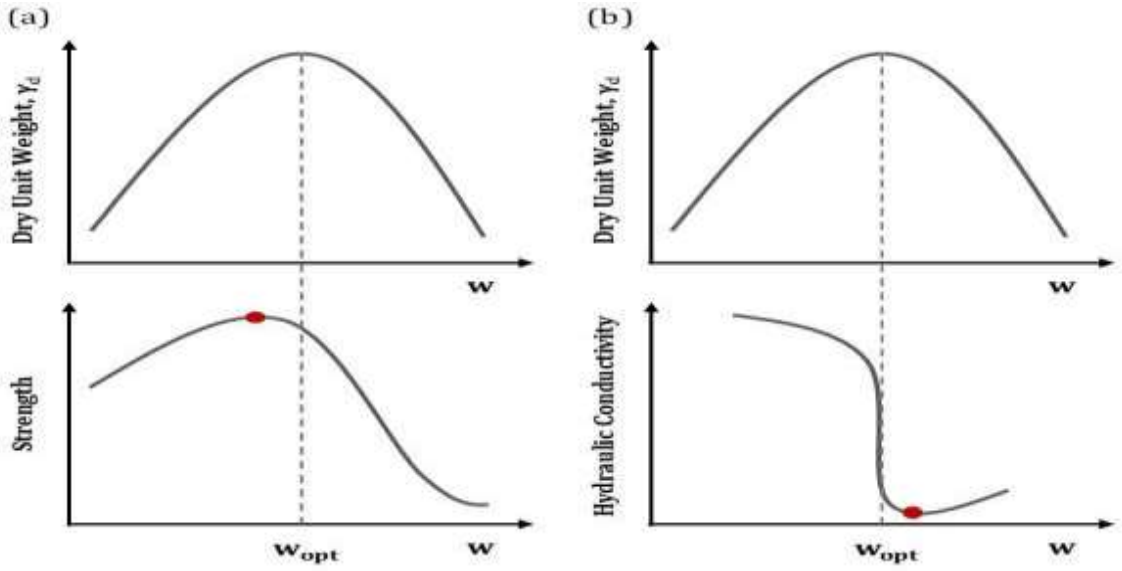
The average liquid limit of the black soil is 58.6%, and the average plastic limit is 28.3%. These values indicate that the black soil has high plasticity and is difficult to work with. The soil has a plasticity index (PI) of 30.3, which is also high.

Compaction Test

The compaction test was conducted on the black soil to determine its maximum dry density and optimum moisture content. The results of the compaction test are presented in Table 2

Table 2 : Compaction test results of black soil

Moisture content (%)	Dry density (g/cm³)
10	10
12	12
14	14
16	16
18	18
20	20
22	22



The results show that the maximum dry density of the black soil is 1.75 g/cm³, which is obtained at a moisture content of 14%. The optimum moisture content of the soil is 14%. The

results suggest that the compaction characteristics of the black soil are poor, as the maximum dry density is relatively low compared to other types of soil

UCS Test

The unconfined compressive strength (UCS) test was conducted on the stabilized black soil samples with different percentages of walnut shell ash (WSA) and lime. The results of the UCS test are presented in Table 3

Table 3: UCS test results of stabilized black soil

Sample	Lime (%)	WSA (%)	UCS (kPa)
1	0	0	135
2	2	0	245
3	4	0	370
4	6	0	490
5	0	2	175
6	2	2	310
7	4	2	480
8	6	2	610
9	0	4	240
10	2	4	400
11	4	4	590
12	6	4	720

The results show that the UCS of the black soil increases with increasing percentages of both lime and WSA. The highest UCS value of 720 kPa is obtained for sample 12, which contains 6% lime and 4% WSA. The results indicate that the combination of lime and WSA is effective in improving the strength of the black soil. It is worth noting that the UCS of the stabilized black soil is significantly higher than that of the unstabilized black soil (sample 1).

CBR RESULTS : The California Bearing Ratio (CBR) test was conducted on the stabilized black soil samples with different percentages of walnut shell ash (WSA) and lime. The results of the CBR test are presented in Table 4.

Table 4: CBR test results of stabilized black soil

Sample	Lime (%)	WSA (%)	CBR (%)
1	0	0	5.6
2	2	0	8.4
3	4	0	11.5
4	6	0	14.5
5	0	2	6.5
6	2	2	9.8
7	4	2	12.5
8	6	2	15.5
9	0	4	8.5
10	2	4	11.8
11	4	4	15.0
12	6	4	18.0

The results show that the CBR of the black soil increases with increasing percentages of both lime and WSA. The highest CBR value of 18.0% is obtained for sample 12, which contains 6% lime and 4% WSA. The results indicate that the combination of lime and WSA is effective in improving the CBR of the black soil. It is worth noting that the CBR of the stabilized black soil is significantly higher than that of the unstabilized black soil (sample 1).

Conclusion

- This study investigated the stabilization of black soil with walnut shell ash (WSA) and lime. The Atterberg limits, compaction characteristics, unconfined compressive strength (UCS), and California Bearing Ratio (CBR) of the stabilized black soil were evaluated.

- The Atterberg limits results showed that the plasticity index of the black soil decreased with increasing percentages of lime and WSA. The compaction test results showed that the maximum dry density of the black soil increased with increasing percentages of lime and WSA.

- The UCS and CBR results indicated that the strength and bearing capacity of the black soil increased significantly with increasing percentages of both lime and WSA. The highest UCS and CBR values were obtained for sample 12, which contains 6% lime and 4% WSA. The results demonstrate that the combination of lime and WSA is an effective method for improving the strength and bearing capacity of black soil.

In conclusion, the study suggests that the use of WSA and lime is a promising technique for the stabilization of black soil for use in construction projects.
The study provides valuable information for engineers and practitioners involved in geotechnical and construction engineering fields. However, further research is needed to investigate the long-term performance and environmental impact of the stabilized black soil.

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