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SOIL STABILIZATION USING DEMOLISHED CONCRETE WASTE AND FLY ASH IN HIGHWAY CONSTRUCTION

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ABSTRACT

The long-term performance of pavement structures is significantly influenced by the stability of the sub-base and base soil layers. Stabilizing these soil layers can enhance their properties and overall strength, ensuring better durability and performance of the pavement. In India, black cotton soil constitutes the fourth largest soil group and is characterized by its porous and fragile structure, which contributes to its relatively lower strength compared to other soil types. Additionally, black cotton soil has a high swelling capacity, making it more susceptible to volume changes and stability issues. Therefore, stabilizing black cotton soil is crucial to improve its suitability for use in pavement construction. The stabilization of black cotton soil using construction and demolition waste holds significant potential for improving the performance of pavement structures. By increasing the CBR value, the strength and durability of the sub-base and base layers are enhanced, leading to a reduction in pavement thickness and overall construction costs. This study contributes to the broader field of sustainable engineering by integrating waste materials into soil stabilization processes.

Keywords: High swelling capacity Black cotton soil, Fly ash, California bearing ratio, Sub-base, Base layers, Swelling Capacity

INTRODUCTION

The long-term performance of pavement structures heavily relies on the stability and strength of the sub-base and base soil layers. Stabilization of these layers is crucial to enhance their properties and overall performance. In India, red soil, which constitutes the third largest soil group, often requires stabilization due to its inherently lower strength, porous structure, and high swelling capacity.

Importance of Black Soil Stabilization

Black Cotton soil, due to its fragile and porous nature, exhibits lower strength compared to other soils, making it less suitable for use in pavement structures without stabilization. Stabilization techniques improve its engineering properties, making it more suitable for construction purposes. Common stabilizers include lime, fly ash, and granulated blast furnace slag. Recently, construction and demolition (C&D) waste has emerged as a significant stabilizer due to its availability and cost-effectiveness.

S.P.Kanniyappan et al (2019) Long term performance of pavement structures depends on the stability of sub-base and base soil. Stabilization of sub-base and base soil improves its properties and strength. Red soil is the third largest soil group in India and it possess lower strength compared to other soil due to its porous and fragile structure and it has a higher swelling capacity, thereby it requires stabilization. Red soil stabilization is usually done using lime, fly ash, granulated blast slag etc., of which construction & demolition waste is the major factor. This project aims to study the engineering properties of red soil & to determine the pavement thickness. The debris is added in varying percentage to the soil & the CBR value is calculated. The variation in CBR value may result in the reduction of pavement thickness.

Vipul Kerni et al (2022) soil stabilization is one of the primary and major processes in the construction of any highway. The aim of this paper is to evaluate the utilization of fines (passing 1.18 mm IS sieve) obtained from demolished concrete structures in subgrade soil stabilization. The evaluation involved the determination of the California Bearing Ratio (CBR) value of the clay soil in its natural state as well as when mixed with different proportion of fines. Results showed that the CBR (both Uncooked and Soaked) value of the clay soil is improved substantially by the addition of fines and the highest CBR value was achieved at 10% fines.

Vinod Kumar Reddy et al (2022) Stabilization of soil is the process by which the soil properties can be modified to meet the requirements. Clay soil has a very high swell index which leads to improper settlement of roads and footings. Improvement of strength and subgrade characteristics of soil by stabilization is one of the popular techniques nowadays. Construction demolition waste in soil stabilization is still under research as much work has not been done in this area. This paper presents a comparative study of utilization of C&D waste in soil stabilization. The results showed that with increase in the content of C&D waste, the reaction between water and C&D waste is enhanced, OMC and MDD are yielded to better results at 8% of C&D. In this process, UCS and CBR were increased whereas plastic limit doesn't show any significant changes. And liquid limit was reduced at 5% and becomes more or less the same with increase in C&D content. It was concluded that using C&D was helpful in improving the soil properties up to 8% C&D and declines with increase in C&D waste.

METHODOLOGY

Sample Collection and Preparation: Red soil samples are collected from different locations to ensure variability and representativeness. The soil is then mixed with varying percentages of C&D waste (e.g.,0%, 5%, 10%, 15%, 20%,25%,30%).

Laboratory Tests:

Atterberg Limits: To determine the plasticity characteristics of the soil.

Proctor Compaction Test: To find the optimum moisture content (OMC) and maximum dry density (MDD) of the soil.

California Bearing Ratio (CBR) Test: To evaluate the strength of the soil with different percentages of C&D waste.

Data Analysis: The CBR values obtained from the tests are analyzed to determine the optimal percentage of C&D waste that provides maximum improvement in soil strength.

Pavement Design: Based on the improved CBR values, the pavement thickness is designed using standard pavement design guidelines (e.g., IRC 37:2018 for flexible pavements).

RESULT AND DISCUSSION

Optimum moisture contain and dry density

The assurance of most extreme dry thickness and ideal dampness content is crucial for assessing the compaction attributes of soil, which in turn affects its engineering properties and suitability for construction. The Standard Delegate Compaction Test and Altered Delegate Compaction test are widely used methods for evaluating these parameters. By conducting these tests, engineers can establish the optimal moisture content needed to achieve the highest compaction density, ensuring the stability and durability of structures built on the soil. Value of our result of optimum moisture contain and dry density displayed in table 4.4.

Table 1 Optimum moisture contain and dry density

% Replacement of soil	% of OMC	Dry Density (gm/cc)
0	12.32	1.48
5	14.32	1.56
10	16.45	1.68
15	18.23	1.78
20	20.14	1.81
25	21.54	1.89
30	22.12	1.83

Discussing the marks of Standard Proctor tests showed on soil samples blended in with various extents of crushed demolition concrete aggregates. With the addition of crushed demolition concrete aggregates and fly debris, the thickness of the dirt initially increased and then decreased.

Maximum Dry Density (MDD) adding 25% of crushed demolition concrete waste and fly debris brought about a huge expansion in the most extreme dry thickness of the dirt example from 1.48g/cc to 1.89g/cc. This increase indicates a decrease in voids ratio and a more compact soil structure.

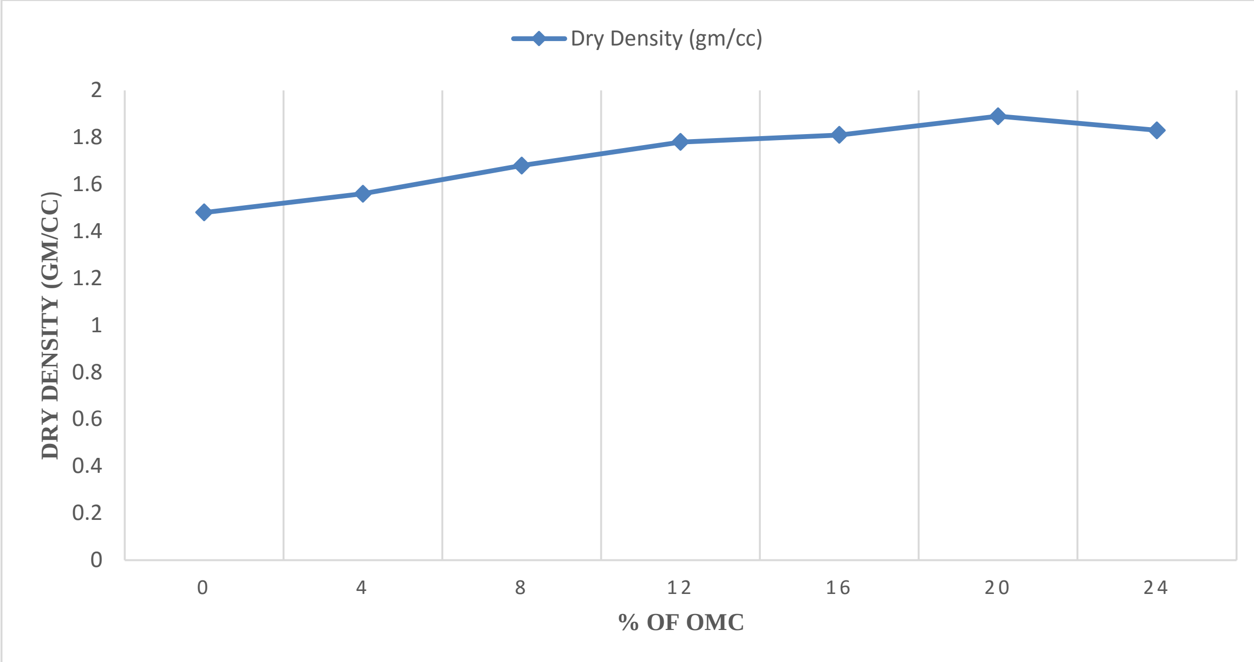

Figure 1 Graf optimum moisture contain and dry density

The California Bearing Ratio (CBR)

The California Bearing Proportion (CBR) test you depicted is to be sure a typical technique used to assess the mechanical strength of soil subgrades and base courses for asphalt plan. The test gives important data on the heap bearing limit of soil and its reasonableness for development purposes, especially in street and asphalt designing.

Table 2 California Bearing Ratio test

S.N	% Replacement of soil	CBR Value %
1	0	3.08
2	5	6.75
3	10	11.90
4	15	16.24
5	20	20.17
6	25	23.56
7	30	21.81

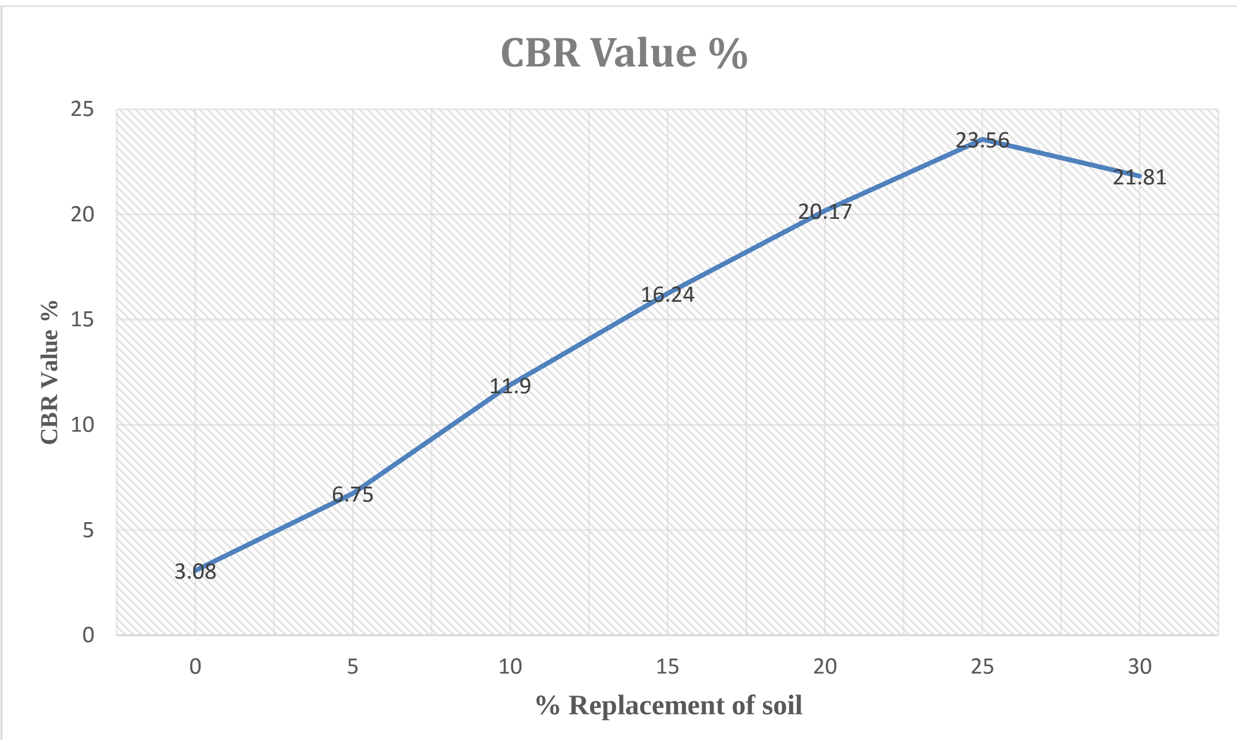

Figure 2 CBR Value for different % of replacement of soil

The results of California Bearing Ratio (CBR) tests reveal an interesting trend in the behavior of black cotton soil with varying percentages of demolished concrete and fly ash. Initially, as the proportion of demolished concrete and fly debris is expanded, the CBR worth of the soil gradually rises. This suggests an enhancement in the heap bearing limit of the dirt due to the addition of demolished concrete aggregate. The notable increase in CBR value from 3.08% to 23.56 % with the calculation of 25% demolished concrete and fly ash underscores the potential for utilizing this material to advance the engineering chattels of the soil, particularly in terms of its load-bearing capacity.

CONCLUSION

The stabilization of red soil using construction and demolition waste holds significant potential for improving the performance of pavement structures. By increasing the CBR value, the strength and durability of the sub-base and base layers are enhanced, leading to a reduction in pavement thickness and overall construction costs. This study contributes to the broader field of sustainable engineering by integrating waste materials into soil stabilization processes.

- ❖ The addition of demolished concrete and fly ash to the black cotton soil the results of MDD is increased. The MDD expanded from 1.48g/cc to 1.89g/cc with a 25% addition of (12.5 % demolished concrete and 12.5% of fly ash).

- ❖ The CBR worth of the dirt significantly improved with the expansion of demolished concrete and fly ash, rising from 3.08 % to 23.56 %. This suggests that the soil's load-bearing capacity increased substantially.

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