INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 11, Issue 2 - V11I2-1392)
Available online at: https://www.ijariit.com

Experimental Study on Stabilization of Subgrade Soil and Pavement Design

Dinesh Patil
dineshpatil7249@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

Shubham Janwade
Sjanwade36@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

Aviraj Jadhav
avirajjadhav75@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

Ashish Ghogare
ashishghogare8308@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

Vrashabh Gurav
Vrashabhgurav25@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

Sagar E. Bhoyar
sagarbhoyar8sept@gmail.com
Sinhgad Institute of Technology and Science, Narhe, Pune, Maharashtra

ABSTRACT

This paper presents an experimental study aimed at stabilizing black cotton soil using a sustainable and cost-effective combination of steel slag and seashell powder. The objective is to enhance its engineering properties, particularly the California Bearing Ratio for applications in road construction. The untreated black cotton soil, having a CBR of 5.8%, showed a significant improvement with the addition of 25% stabilizer mix, achieving a peak CBR value of 11.6%. The study emphasizes the dual benefits of improving soil properties while utilizing industrial and marine waste materials, promoting eco-friendly construction practices.

Keywords: - *Black Cotton Soil, Sea Shell Powder, Steel Slag, Pavement Design.*

INTRODUCTION

Black cotton soil is a highly expansive clayey soil with significant shrink-swell behavior, making it problematic for supporting structural foundations. Found predominantly in regions like the Deccan Plateau in India, it poses severe limitations in infrastructure development due to its low strength and poor load-bearing capacity. Stabilization of such soil is essential to enhance its engineering properties. Conventional methods of soil stabilization using cement and lime are effective but are often costly and environmentally damaging due to high carbon emissions. The focus of this study is to explore alternative, low-cost, and sustainable materials: steel slag, an industrial by-product from steel manufacturing, and seashell powder, derived from marine waste. Both materials are rich in calcium compounds and possess binding properties that can enhance soil performance.

METHODOLOGY

The experimental methodology included the collection and preparation of black cotton soil, followed by mixing with varying percentages of steel slag and seashell powder. A series of laboratory tests were conducted to evaluate changes in geotechnical properties.

2.1 Materials Used

1. Black Cotton Soil

Collected from a site in the Deccan Plateau, the soil is highly expansive, with poor engineering properties. Initial tests showed a liquid limit of 56%, plastic limit of 32.89%, and CBR value of 5.8%.

2. Steel Slag

An industrial byproduct from steel manufacturing, steel slag improves load-bearing capacity due to its density and hydraulic properties.

Fig. 1 Steel slag

3. Seashell Powder

Rich in calcium carbonate (~95%), seashell powder aids in binding soil particles and enhancing compaction.

Fig. 2 Seashell Powder

2.2 Mix Proportions and Blending

Soil was blended with steel slag and seashell powder in equal ratios (e.g., 2% slag + 2% seashell = 4% additive). Tests were repeated for each proportion: 4%, 8%, 12%, 16%, 25%, and 30%

2.3 Pavement Design

IITPAVE software was used to design a flexible pavement for a subgrade with improved CBR (up to 11.62%). The software simulated layer thickness and modulus to ensure safety against fatigue and rutting based on MORTH guidelines.

RESULTS

3.1 Black cotton soil :

The basic properties of black cotton soil as mentioned in Table no. 1 by conducting various laboratory test.

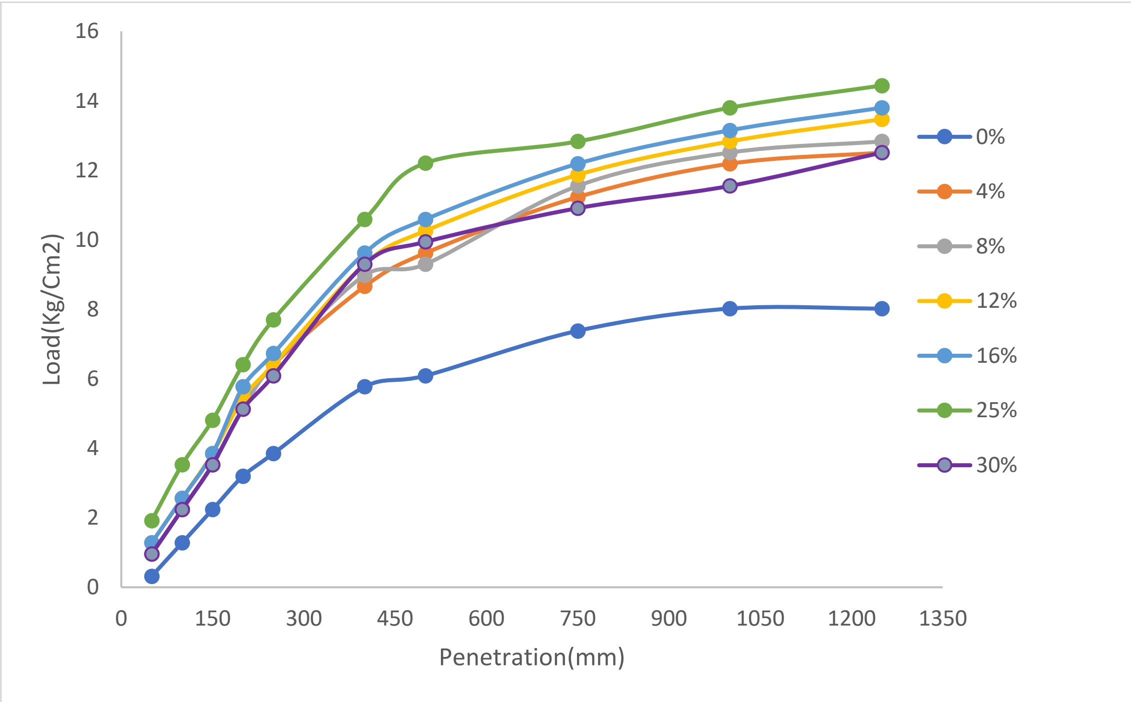
Table 1 Properties of Black Cotton Soil

Water content	40%
Specific gravity	2.6
Maximum Dry Density	1.51 g/cc
Optimum moisture content	29.8%
Classification of soil	Well Graded
Liquid limit	56%
Plastic limit	32.89%

3.2 California Bearing Ratio Value for Different % of Material Added

Table 2 California Bearing Ratio Value for Different % of Material Added

% of Material add in Black Cotton Soil	CBR Value
0%	5.8
4%	9.16
8%	9.46
12%	9.77
16%	10.08
25%	11.62
30%	9.4



Graph 1 California Bearing Ratio load penetration Curve for Different % of Material Added

3.3 Design a bituminous pavement with granular base and sub-base layers:-

Using the following input data for Design a bituminous pavement with granular base and sub-base layers

i) Four lane divided carriageway

ii) Initial traffic in the year of completion of construction = 5000 cvpd (two-way)

iii) Traffic growth rate per annum = 6.0 per cent

(iv) Design life period

(v) Vehicle damage factor = 20 years = 5.2 (taken to be the same for both directions)

(vi) Effective CBR of subgrade = 11.6%

(vii) Marshall mix design carried out on the bituminous mix to be used in the bottom bituminous layer (DBM) for an air void content of 3 % resulted in an effective bitumen content (by volume) of 11.5 %

Lateral Distribution factor = 0.75 (for each direction)

Initial directional traffic = 2500 CVPD (assuming 50 per cent in each direction)

Vehicle Damage Factor (VDF) = 5.2

Cumulative number of standard axles to be catered for in the design N = 131 msa

Effective CBR of subgrade = 11.6%

Effective resilient modulus of Subgrade = $17.6(11.6)^{0.64}$ = 84.48 MPa

Since the design traffic is more than 50 msa, provide a SMA/GGRB or BC with modified bitumen surface course and DBM binder/base layer with VG40 with viscosity more than 3600 Poise (at 60°C).

Select a trial section with 190 mm total bituminous layer (provide 40 mm thick surface layer, 70 mm thick DBM-II, 80 mm thick bottom rich DBM-I); 250 mm thick granular base (WMM) and 200 mm thick granular sub-base (GSB).

Total thickness of granular layer = 450 mm

Resilient modulus of the granular layer = 0.2 x $(480)^{0.45}$ x 62 = 264 MPa

Use 90 % reliability performance models for subgrade rutting and bituminous layer cracking (design traffic > 20 msa)

Allowable vertical compressive strain on subgrade for a design traffic of 131 msa and for 90 % reliability = 0.000301 (0.301 X 10^{-03})

Allowable horizontal tensile strain at the bottom of bituminous layer for a design traffic of 131 msa, 90 % reliability, air void content of 3 % and effective binder volume of 11.5 %, and a resilient modulus of 3000 MPa for bottom rich bottom DBM layer (DBM-I) (using Equation 3.4) = 0.000150 (0.150 X 10^{-03})

Analyse the pavement using IITPAVE with the following inputs (elastic moduli: 3000 MPa, 200 MPa, 62 MPa, Poisson's ratio values of 0.35 for all the three layers, layer thicknesses of 190 mm and 450 mm).

Computed Horizontal tensile strain = 0.000146 < 0.000125. Hence OK

Computed vertical compressive strain = 0.000208 < 0.000301. Hence OK

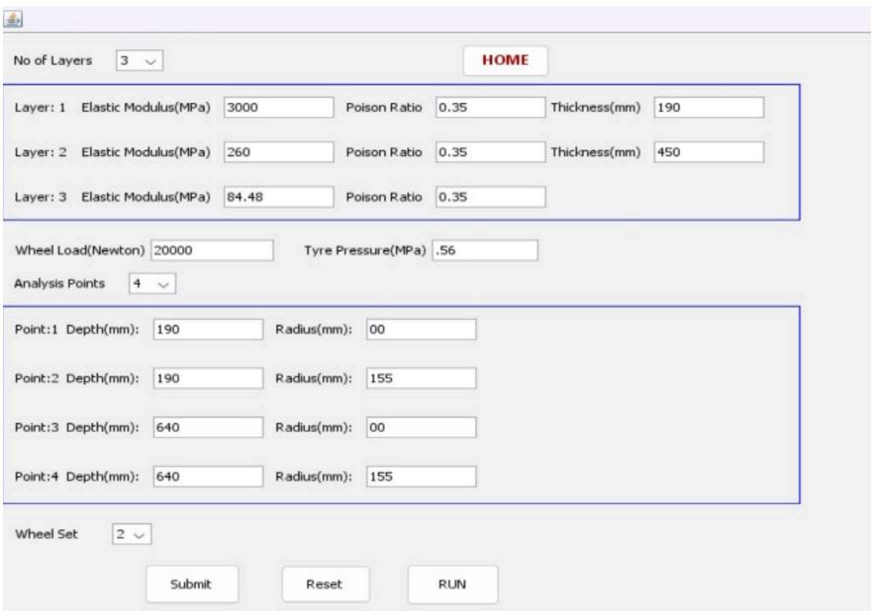


Image 1 IITPAVE Input Data

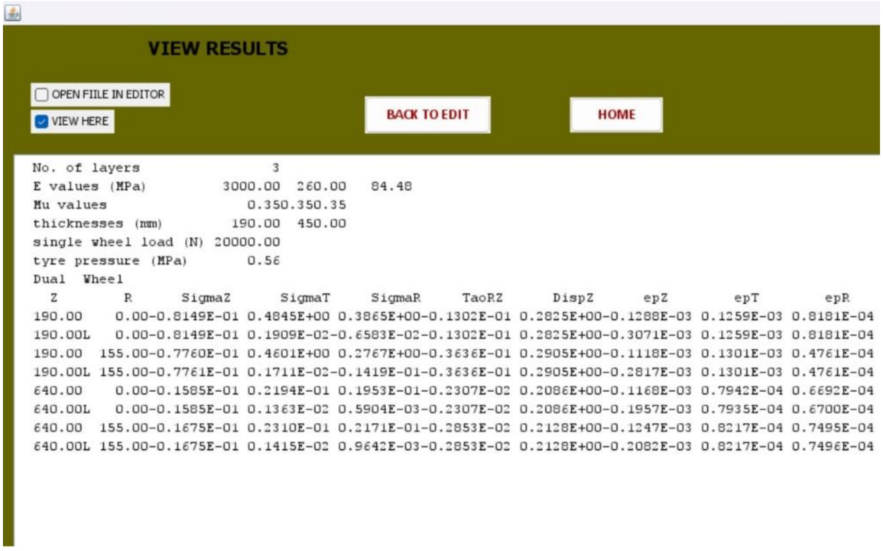


Image 2 IITPAVE Result Data

CONCLUSION

This experimental investigation concludes that black cotton soil stabilized with a combination of steel slag and seashell powder shows significant enhancement in strength and durability. The optimum mix of 25% (12.5% slag + 12.5% powder) yielded a CBR value of 11.6%, almost double the original. This stabilization technique is eco-friendly, cost-effective, and technically efficient for use in road subgrades and low-cost foundation applications in regions with expansive soils.

REFERENCES

[1] Asadullah Ziar et.al. (2023) Cost-Effectiveness Analysis of Design Methods for Rigid and Flexible Pavement: A Case Study of Urban “Road” Archives of Advanced Engineering Science Vol. 2 Iss. 3page no. 134-140
[2] Harshit Saxena et.al (2022) A Review of Flexible Pavement Using CBR International Journal of Science, Engineering and Technology vol-10.4page no.1-5
[3] Deepak Kumar et.al. (2021) A Review on Soil Stabilization Comparing Non-Tradition
[4] additives International Journal of Latest Research in Engineering and Computing, volume 8,Issue 1 page 1-6
[5] Ravindra D Nalawade et.al (2020) Prediction of CBR Value of Stabilized Black Cotton Soi use for Road Construction International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958 (Online), Volume-9 Issue-3,
[6] Rajshekhar G Rathod et.al. (2019) Literature Research on a Different Types Soil
[7] Stabilization Techniques Blue Eyes Intelligence Engineering & Sciences Publication vol3 issue 2 11 page no.108-02
[8] Amit Daiya et.al. (2019) A Review on Comparative Study of Stabilization of Black
[9] Cotton Soil by Natural and Artificial Fibre International Conference on Advancements in Computing & January 2019 page no 493-497
[10] Shubham more et.al. (2018) Stabilization of Black Cotton Soil by Using Steel Slag
[11] International Journal of Innovative Research in Science, Engineering and Technology vol7 issue5 page no.6300-6305 may 2018.
[12] Dr. Sandhyrani et.al. (2018) Stabilization of black cotton soil by using Sisal fibres International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 08