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Improvement Stability of Black Cotton Soil by using Marble Dust and Burnt Brick Powder

Awaiz Masjid Shaikh
ce2023.awaiz.shaikh@ves.ac.in
Vivekanand Education Society's Polytechnic College, Maharashtra

Afeef Ismail Kazi
ce2023.afeef.kazi@ves.ac.in
Vivekanand Education Society's Polytechnic College, Maharashtra

Ritash Kalyani Harkude
ce2023.ritesh.harkude@ves.ac.in
Vivekanand Education Society's Polytechnic College, Maharashtra

Hrishikesh Sandeep Kamble
ce2023.hrishikesh.kamble@ves.ac.in
Vivekanand Education Society's Polytechnic College, Maharashtra

Sanskruti Dharmale
sanskruti.dharmale@ves.ac.in
Vivekanand Education Society's Polytechnic College, Maharashtra

ABSTRACT

Black cotton soil is an expansive soil widely found in India, known for its high clay content and significant swelling and shrinkage behavior, making it unsuitable for construction without stabilization. This study focuses on improving its stability and strength using marble dust and burnt brick powder, which are industrial waste materials. Marble dust (rich in calcium carbonate) and burnt brick powder (containing silica and alumina) help form cementitious compounds that enhance soil cohesion, reduce plasticity, and minimize swelling. Laboratory tests such as Atterberg limits, compaction, UCS, and CBR were conducted. Results show significant improvement in strength, density, and load-bearing capacity, providing an economical and eco-friendly solution for construction works.

Keywords: *Black cotton soil, Soil stabilization, Marble dust, Burnt brick powder, California Bearing Ratio (CBR).*

1. INTRODUCTION

Soil forms the foundation of all civil engineering structures, and its strength and bearing capacity directly affect structural stability. In many parts of India, black cotton soil is widely found and poses serious construction challenges due to its high clay content and expansive nature. Rich in montmorillonite minerals, it swells when wet and shrinks when dry, causing cracks, uneven settlement, and structural damage. Therefore, improving its engineering properties is essential. Soil stabilization is an effective method to enhance strength, reduce plasticity, and control volume changes. While traditional stabilizers like lime and cement are commonly used, there is increasing interest in sustainable alternatives such as industrial waste materials. Marble dust, rich in calcium carbonate, improves soil density and cohesion through cementation reactions. Burnt brick powder, containing silica and alumina, participates in pozzolanic reactions that enhance strength and reduce plasticity. The combined use of marble dust and burnt brick powder not only improves the physical and chemical properties of black cotton soil but also promotes environmental sustainability by recycling waste materials. This approach provides an economical, eco-friendly solution for road construction, foundations, and other infrastructure projects.

2. LITERATURE REVIEW

Suthar & Patel (2018) studied the stabilization of black cotton soil using marble dust (5–20%). They found that 10% marble dust gave optimum results, significantly reducing plasticity and increasing MDD and CBR. Marble dust acted as a filler, improving soil strength and sustainability.

Sharma et al. (2020) investigated burnt brick powder (10–40%) for expansive clay. They observed reduced liquid limit and plasticity index, with UCS and CBR improving up to 30% addition. The study confirmed the pozzolanic properties of brick powder as a partial substitute for lime or cement.

Jha & Singh (2021) examined the combined use of marble dust and brick powder. The best performance was at 15% marble dust + 30% brick powder, showing maximum strength and minimum swelling due to filler and pozzolanic effects.

Ramesh et al. (2023) compared marble dust, brick powder, and fly ash. Both marble dust and brick powder reduced swelling and plasticity, while brick powder provided slightly higher strength. The study highlighted environmental and economic benefits of using industrial waste for soil stabilization.

3. METHODOLOGY

3.1 Collection of Soil Sample

Soil collected from depth of 1.0 m.
Air dried and sieved through 4.75 mm IS sieve.

3.2 Laboratory Tests on Natural Soil

Following tests were conducted as per relevant Indian Standards:
Liquid Limit Test (IS 2720 Part 5)
Plastic Limit Test
Shrinkage Limit Test
Standard Proctor Compaction Test (IS 2720)
Unconfined Compressive Strength (UCS) Test
California Bearing Ratio (CBR) Test
Free Swell Index Test

3.3 Preparation of Soil Mix

Soil was mixed with different percentages of MD and BBP.

Mix Proportions

Mix ID	Soil (%)	Marble Dust (%)	Brick Powder (%)
M0	100	0	0
M1	90	5	5
M2	80	10	10
M3	70	15	15

Materials mixed thoroughly in dry condition.
Water added to reach Optimum Moisture Content (OMC).
Samples prepared for testing.

4. APPLICATION

i. Road Construction: Stabilized black cotton soil can be used as subgrade material for pavements and rural roads. The addition of marble dust and burnt brick powder reduces plasticity and swelling, which improves load-bearing capacity and durability.
ii. Foundation for Buildings: Improved soil can be used for shallow foundations in residential and low- rise buildings where black cotton soil normally causes foundation cracks due to expansion and contraction.
iii. Embankment Construction: The stabilized soil can be used in railway and highway embankments, providing better compaction, reduced settlement, and increased shear strength.
iv. Land Development Projects: Used in site filling and land leveling, especially in areas where black cotton soil is predominant.
v. Rural Infrastructure:
Helpful for construction of: Village roads, Footpaths, Small irrigation canals, Storage yards
vi. Waste Utilization
Both materials are industrial waste products:
Marble dust from marble processing industries
Burnt brick powder from demolition or brick kiln waste

5. FUTURE SCOPE

i. Sustainable Construction Material: Using marble dust and brick powder promotes eco-friendly soil stabilization by recycling waste materials and reducing dependence on cement or lime.
ii. Large-Scale Road Projects: Future studies can focus on highway subgrade stabilization, especially in regions with extensive black cotton soil such as parts of India.
iii. Combination with Other Stabilizers: Research can be extended by combining these materials with**:** Lime, Cement, Fly ash, Geopolymers
iv. Long-Term Performance Studies:
More research can evaluate:
Durability under repeated loading
Performance during wet and dry cycles
Long-term settlement behavior.
V. Use in Smart and Green Infrastructure :
The stabilized soil could be incorporated into green building practices and sustainable infrastructure projects.
Vi. Development of Standard Guidelines:
Future research may help create design standards and guidelines for using marble dust and brick powder in soil stabilization.
vii.Cost-Effective Construction
Further economic analysis could demonstrate the cost benefits compared to conventional stabilization techniques, making it suitable for developing regions.

6. CONCLUSION

The stabilization of black cotton soil using marble dust and burnt brick powder is an effective, economical, and eco-friendly method to improve its engineering properties. Black cotton soil, due to its expansive nature and high plasticity, poses serious challenges for construction, causing swelling, shrinkage, and structural damage. The addition of marble dust enhances soil strength and density by providing calcium carbonate, which forms cementitious bonds with soil particles. Burnt brick powder, rich in silica and alumina, reacts with calcium to produce pozzolanic compounds, further improving cohesion and reducing plasticity. When combined, these materials work synergistically to improve unconfined compressive strength (UCS), California Bearing Ratio (CBR), and dimensional stability of the soil.

Besides improving geotechnical properties, this method recycles industrial waste, reduces environmental pollution, and lowers construction costs, making it sustainable. Overall, using marble dust and burnt brick powder provides a practical solution for stabilizing expansive soils, making them suitable for roads, foundations, and other infrastructure projects, while promoting green construction practices.

7. RESULT

7.1 Atterberg Limits

Property	Natural soil	M1	M2	M3
Liquid limit %	62	55	48	42
Plastick limit %	28	30	32	35
Plasticity index	34	25	16	7

Observation

Plasticity index decreases with increase in MD and BBP. Soil becomes less expansive.

7.2 Compaction Test Results

Mix	OMC %	MDD (kN/M^3)
M0	22	15.8
M1	20	16.5
M2	18	17.2
M3	17	16.9

Observation

MDD increases up to M2 (10% MD + 10% BBP).
OMC decreases.

7.3 California Bearing Ratio (CBR)

Mix	CBR %
M0	2.5
M1	4.8
M2	7.5
M3	6.9

Observation

CBR value significantly improved. Suitable for subgrade improvement.

7.4 Free Swell Index

Mix	FSI %
M0	60
M1	40
M2	22
M3	20

Observation

Swelling reduced considerably.

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