iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** III **Month of publication:** March 2025

DOI: https://doi.org/10.22214/ijraset.2025.68076

Soil Stabilization Using Construction and Ceramic Wastes

Azmil Bani[1], Fayida P[2], KT Muhammad Shibin[3], Zakariyya[4], Kadeeja Thasneem[5]
[1, 2, 3, 4, 5]*Department of Civil Engineering, MEA Engineering College*

Abstract: This study explores the feasibility of using ceramic and construction waste to enhance the engineering properties of weak soils. Laboratory experiments incorporating 10% and 15% ceramic waste and 5%, 10%, and 15% construction waste evaluated their impact on unconfined compressive strength (UCC), California Bearing Ratio (CBR), and consistency limits. The results showed significant improvements in soil stability, strength, and load-bearing capacity, with increased UCC and CBR values indicating enhanced structural integrity. It addressing both environmental concerns and engineering challenges. By repurposing waste materials, this method reduces landfill disposal and supports the development of sustainable infrastructure.

Keywords: soil stabilization, ceramic waste, construe waste, Atterberg's limits, UCC, CBR, MDD, OMC

I. INTRODUCTION

Clay soil, known for its low shear strength, high compressibility, and poor drainage, poses significant challenges in construction and infrastructure development. Traditional stabilization methods often rely on chemical additives or expensive materials, which can have environmental and economic drawbacks. As sustainable alternatives, construction and ceramic waste have gained attention for their potential to enhance soil properties while addressing waste management concerns. Construction waste, including recycled concrete aggregates and crushed brick, improves soil strength, durability, and drainage while reducing plasticity and increasing load-bearing capacity. Similarly, ceramic waste from broken tiles, pottery, and other ceramic products enhances compressive strength, minimizes swelling behavior, and improves erosion resistance. These waste materials, often discarded in landfills, can be repurposed for soil stabilization, reducing environmental impact and promoting sustainable construction practices. This study explores the feasibility of utilizing construction and ceramic waste as cost-effective and eco-friendly stabilizers for clay soil, contributing to both improved geotechnical performance and circular economy principles.

II. SPECIFIC OBJECTIVES

1) Measure changes in soil properties such as shrinkage, swelling, and permeability when stabilized with construction and ceramic waste.
2) To evaluate and compare compaction properties, unconfined compressive strength and California bearing ratio values of clay soil with different percentages of construction and ceramic wastes.
3) To identify the optimal proportions of construction and ceramic waste to be mixed with clay soil for effective stabilization.

III. MATERIALS AND METHODS

The materials required for the study are clay soil, ceramic waste powder, and construction waste powder. Laboratory tests such as specific gravity test, hydrometer analysis, Atterberg's limit test, UCC strength test, heavy compaction test, and CBR test were conducted to determine the basic properties of the collected soil sample. The ceramic waste powder and construction waste powder will be added to the soil in various proportions. Then, tests such as the standard Proctor test, unconfined compressive strength test, ,and California Bearing Ratio test were conducted to evaluate the effects of these additives on soil properties.

A. Clay soil

Clay is a finely-grained natural rock or soil material that combines one or more clay minerals with possible traces of quartz, metal oxides and organic matter. Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure. Clays are plastic due to particle size and geometry as well as water content, and become hard, brittle and non–plastic upon drying or firing. This soil can be collected from nearby locality.

B. Construction waste

Construction waste, which includes materials like concrete, bricks, and mortar, can serve as an effective stabilizer by enhancing soil properties and contributing to sustainable construction practices. This can be obtained from wandoor town.

C. Ceramic waste

Ceramic waste, including materials like broken tiles, pottery, and bricks, can be repurposed to enhance the properties of clay soils, offering both environmental and economic benefits.

D. Mix proportion

Mix proportion adopted for this study is given in below (TABLE I). Six set of soil samples was treated with various percentage of CW and CRW.

TABLE I
MIX PROPOTION

Trail 1		Trail 1	
Ceramic waste(CW)%	Construction waste (CRW)%	Ceramic waste(CW)%	Construction waste(CRW)%
10	5	15	5
10	10	15	10
10	15	15	15

IV. RESULTS AND DISCUSSION

A. The Basic Properties

Basic properties of untreated sample of black clay soil are given in TABLE II.

TABLE II BASIC PROPERTIES OF SOIL

SI No	Property	Value
1	Liquid limit	45%
2	Shrinkage limit	23.16%
3	Plastic limit	34.4%
4	Plasticity index	10.6%
5	Optimum moisture content	20.8%
6	Maximum dry density	1.74 g/cc
7	California bearing ratio	0.86 %
8	UCC strength	3.161×10^{-3} g/cc
9	Specific gravity	2.25

B. Properties of Soil Treated with CW and CRW

Unconfined compressive strength test, heavy compaction and California Bearing Ratio test were conducted to determine the change in properties of soil treated with various percentages of CW and CRW.

1) Variation of UCC Values with Varying Percentage of CW and CRW.

The UCC values and cohesion values of treated clay soil is given in TABLE III.

TABLE III
RESULTS OF UCC

Sample	UCC value	Cohesion value
Clay soil +10 % CW & 5 % CRW	4.934×10^{-3} kg/cm^2	2.467×10^{-3} kg/cm^2
Clay soil +10 % CW & 5 % CRW	5.853×10^{-3} kg/cm^2	2.93×10^{-3} kg/cm^2
Clay soil +10 % CW & 5 % CRW	6.218×10^{-3} kg/cm^2	3.105×10^{-3} kg/cm^2
Clay soil +10 % CW & 5 % CRW	7.29×10^{-3} kg/cm^2	3.645×10^{-3} kg/cm^2
Clay soil +10 % CW & 5 % CRW	7.84×10^{-3} kg/cm^2	3.92×10^{-3} kg/cm^2
Clay soil +10 % CW & 5 % CRW	7.43×10^{-3} kg/cm^2	3.715×10^{-3} kg/cm^2

The variation in UCC values of samples with different proportions CW and CRW are presented in Fig 1.

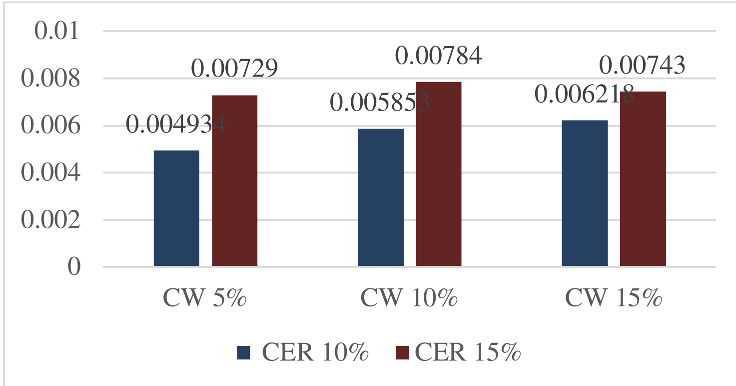


Fig. 1 Graphical analysis of UCC value of 6 trails

The optimum UCC value of $7.872x10^{-3}$ kg/cm^2 was achieved in trial 5 with 15% ceramic waste and 10% construction waste. This indicates that a balanced proportion of ceramic and construction waste can enhance strength, while excessive amounts may lead to reduced cohesion and increased porosity.

2) Variation of MDD and OMC Values with Varying Percentage of CW and CRW.

The MDD and OMC values and cohesion values of treated cly soil is given in TABLE IV.

TABLE IV
RESULTS OF HEAVY COMPACTION

Sample	MDD	OMC
Clay soil +10 % CW & 5 % CRW	1.79g/cc	19.6 %
Clay soil +10 % CW & 5 % CRW	1.81 g/cc	18. 89 %
Clay soil +10 % CW & 5 % CRW	1.82g/cc	18.82 %
Clay soil +10 % CW & 5 % CRW	1.83g/cc	17.8 %
Clay soil +10 % CW & 5 % CRW	1.85g/cc	16.71 %
Clay soil +10 % CW & 5 % CRW	1.86g/cc	16.35 %

The variation in MDD values of samples with different proportions CW and CRW are presented in Fig 2.

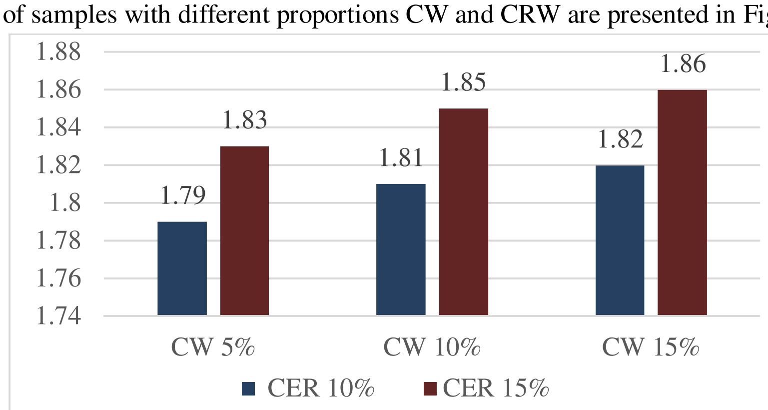


Fig. 2 Graphical analysis MDD of 6 trails

The addition ceramic waste and construction waste to clay increased the dry density. The maximum dry density is 1.86 g/cc while added 15% ceramic waste and construction waste. It is due to improved particle packing, increased friction, reduced porosity, and enhanced soil structure.

3) Variation of CBR Values with Varying Percentage of CW and CRW.

The CBR values of treated cly soil is given in TABLE V.

TABLE V
RESULTS OF CBR TEST

Sample	CBR values
Clay soil +10 % CW & 5 % CRW	16.97 %
Clay soil +10 % CW & 5 % CRW	22.28 %
Clay soil +10 % CW & 5 % CRW	27.72 %
Clay soil +10 % CW & 5 % CRW	34.48 %
Clay soil +10 % CW & 5 % CRW	39.21 %

The variation in CBR values of samples with different proportions CW and CRW are presented in Fig 3.

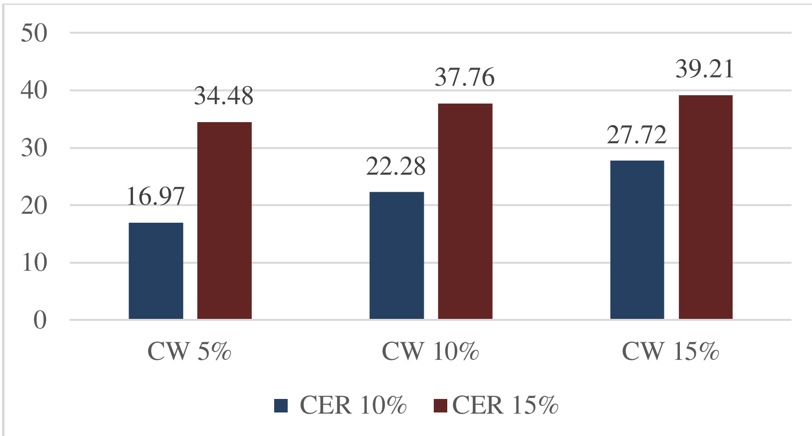


Fig. 3 Graphical analysis CBR values of 6 trails

The addition of ceramic waste and construction waste to clay at 15% results in a CBR value of 39.21%, indicating a substantial enhancement in the subgrade strength the clay, attributed to improved particle packing, increased friction, and reduced porosity, ultimately improving its overall stability and load-bearing capacity.

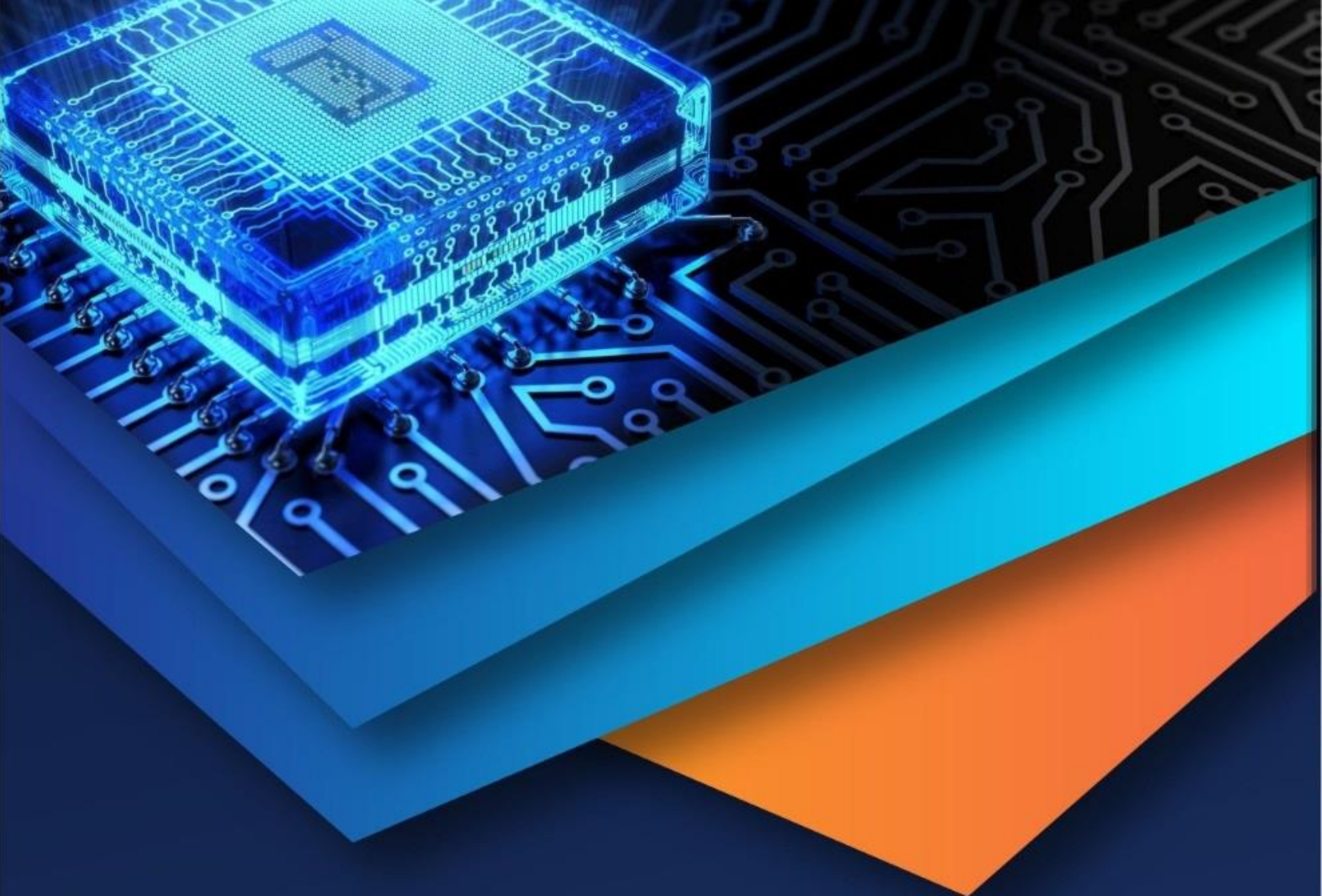
V. CONCLUSIONS

This study demonstrates the effectiveness of stabilizing clay soil using 15% ceramic waste and 10% construction waste, which provided the best balance between strength enhancement and workability. The unconfined compressive strength (UCC) rose from 3.16×10^{-3} kg/cm² to 7.872×10^{-3} kg/cm², demonstrating enhanced soil strength. Additionally, the dry density increased from 1.74 g/cc to 1.86 g/cc, while the optimum moisture content decreased from 20.8% to 16.35%, resulting in better compaction and load-bearing capacity. A significant improvement was observed in the California Bearing Ratio (CBR) value, which increased from 0.869 to 39.21%, making the soil more suitable for subgrade applications. These improvements are attributed to the interlocking effect of angular and rough-textured ceramic and construction waste particles, the pozzolanic reactions enhancing cementitious bonding, and the reduction in plasticity, which minimizes soil expansiveness. Future research should explore the long-term performance of stabilized soil under different environmental conditions, the integration of additional industrial waste materials such as fly ash and lime, and field trials to validate laboratory findings. Additionally, an environmental impact assessment and cost-benefit analysis are necessary to ensure large-scale application remains sustainable and economically viable.

REFERENCES

[1] S. Abdullah and A. Iravanian, "Using Waste Ceramic Dust in Stabilization of Clay Soils," International Journal of Construction Engineering and Technology, 2022.
[2] A. K. Adeeb and M. Furkhan, "Stabilization of Soil by Using Demolished Waste Acquired from Construction Site," 2020.
[3] C. Henzinger and D. Heyer, "Use of demolish waste and soil improvement in geotechnical engineering for infrastructure and development," Conference Proceedings of the XVI ECSMGE, Edinburgh, pp. 2547-2552, 2015.

[4] C. A. James, U. O. Josiah, and L. E. Joseph, "Comparative Study of Effect of Waste Ceramic and Marble Dusts on Geotechnical Properties of Expansive Soil," Journal of Scientific and Engineering Research, vol. 4, no. 10, pp. 514-520, 2017.
[5] S. A. Kumar, "Stabilization Of clay soil with ceramic dust," Electronic Journal of Geotechnical Engineering, vol. 17, pp. 3915-3926, 2012.
[6] P. Rathore and T. S. Kumar, "Soil Stabilization Using Ceramic Waste: An Experimental Study," vol. 14, no. 14, pp. 47-65, 2023.
[7] H. Singh and A. S. Ziya, "Soil stabilization by Construction and Demolition waste," Journal of Emerging Technologies and Innovative Research, pp. a145-a153, 2021.
[8] A. Upadhyay and S. Kaur, "Review on Soil Stabilization Using Ceramic Waste," 2016.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY