iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 11 **Issue:** V **Month of publication:** May 2023

**DOI:** https://doi.org/10.22214/ijraset.2023.51412

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 11 Issue V May 2023- Available at www.ijraset.com*

# Use of Recycled Construction and Demolition Waste Material in Soil Stabilization

Rajiv Pazare[1], Gaurav Yede[2], Ayush Lonare[3], Aniket Khawshi[4], Nayna Charmode[5], Ashutosh Ingle[6]
[1]*Assistant Professor, Department of Civil Engineering, Priyadarshini College of Engineering, Nagpur, Maharashtra, India*
[2, 3, 4, 5, 6]*Student, Department of Civil Engineering, Priyadarshini College of Engineering, Nagpur, Maharashtra, India*

***Abstract:** Along with the growth of the construction sector, waste from construction and demolition has steadily increased. The Building Materials Promotion Council (BMPTC) estimates that India generates 1504.444 million tons of construction and demolition waste (C&D) annually. However, the official capacity is 6,500 tons per day (TPD), which is only about 1%. This article investigates the properties of black cotton soil and explores the use of recycled C&D waste from soil to stabilize black cotton soil. This study focuses on the inexpensive and environmentally friendly properties of C&D waste as a soil stabilization additive. Testing was conducted using different percentages of recycled C&D waste at rates of 15%, 20% and 25% to increase the strength of the Black Earth. The California Bearing Capacity Ratio (CBR) is 7.77 % to 12.36%, and the maximum dry density of (MDD) decreased from 2.104 g/cm$^3$ to 1.86 g/cm$^3$ and Optimum Moisture Content (OMC) showed change and increased from 13.15% to 18.04% with the addition of 25% C&D waste.***

## I. INTRODUCTION

Soil is probably one of the main factors affecting construction. Since everything from houses to shopping malls is built on soil, the foundations of buildings must be on stable soil. Since soil has different strengths, some can support tall buildings and some cannot support the weight of a person. One of these soils is cotton chernozem, which requires special construction methods, one of which is soil stabilization. Soil stabilization is broadly defined as the process of improving the engineering properties of soft soils using stabilizers or additives.

Soil stabilization is mainly carried out in three methods, namely: mechanical stabilization, chemical stabilization, and polymer stabilization. Materials like lime, cement, bitumen, etc. have been used to carry out soil stabilization. Although these materials treat the soil and increase its workability and durability of the soil, it causes harmful effects on the environment, due to carbonation, sulphide attack, etc. Therefore, the main objective of this study is to use recycled C&D wastes for soil stabilization, while reducing the harmful effects on the environment due to illegal dumping, carbonation, and sulphide attacks from using other stabilizers, as well as reduce the need for finite landfill spaces.

There is an extensive history of using soil stabilizing additives to improve poor foundation soil properties by controlling volume change and increasing strength. Al-Sharif et al. (2012) evaluated the use of burned sludge as a stabilizer. The sludge was burned at 550 °C and added to the three clay soil samples in different proportions. The result shows the addition of 7.5% burnt sludge ash (dry weight) increased maximum compressive strength, maximum dry density and minimized soil swelling pressure. Adding more than 7.5% by weight lowers both the maximum dry density and compressive strength of without limitation. Therefore, in this study, it was concluded that calcined sludge can be used as a soil stabilizer. Dhananjay et al. (2019) and Henzinger et al. (2015) conducted a black cotton soil stabilization experiment using demolition waste and concluded that the value of CBR increased as the amount of construction waste increased. His test results showed that the swelling pressure decreased rapidly as the EPS geofoam layer increased. Teja et al. (2018) analysed soil stabilization extending with brick dust.

Parsons & Kneebone (2004) studied the use of cement dust for soil stabilization. Cement dust was added to eight different soils to evaluate the effectiveness of cement dust (CKD) as a stabilizer in each soil. The results were then compared with data from the same type of soil stabilized with lime, cement and fly ash. Strength and wear resistance tests were performed. Results showed the effectiveness of CKD as a soil stabilizer in all soils. Seda et al (2007) studied the benefits of using rubber in scrap tires to reduce swelling potential in open soil. In this article, we conducted a study on the effect of adding small rubber particles from waste tires to extensive soil in Colorado. The results showed a significant decrease in swelling ratio and swelling pressure when rubber was added to the soil samples. Okogbu (2007) stabilized clay with wood ash.

The geotechnical parameters of clayey soil in its native condition, as well as mixed soil with different quantities of wood ash and particle size distribution, specific gravity, Atterberg limits, compaction characteristics, CBR, and compressive strength, were assessed. Results showed a significant improvement in the geotechnical properties of clayey soil, with the best results achieved at the addition of 10% wood ash. However, this study concluded that wood ash cannot completely replace lime as the strength gained lasts only for a short duration. Amadi (2014) assessed the effectiveness of stabilization of combined cement kiln dust and quarry fines on pavement subgrades dominated by black cotton soil. The inclusion of the QF and CKD combination resulted in a significant decrease in the plasticity index, as well as a fall in maximum dry unit weight and an increase in optimum moisture content. This also resulted in a significant increase in CBR, indicating that both materials can be used together for soil stabilization. Karthiket al. and Raut et al. (2014) investigated the use of fly ash for soil stabilization. This study evaluated the effect of fly ash on the stabilization of soft, fine-grained red soils. CBR and other strength tests were performed on the soil and a mixture of soil and fly ash prepared at an optimal moisture content of 9% showed a significant increase in soil CBR. Mudgal et al. (2014) studied the effects of lime and rock dust on the geotechnical properties of cotton chernozem and concluded that the strength and maximum dry density of lime-stabilized soils were increased by adding 20% rock dust. Henzinger et al (2015) investigated the use of demolition waste for soil remediation. They conducted experiments on two treated fine-grain soils: a clay with low plasticity and a clay with very high plasticity. The geotechnical properties of both soils were also determined. The results showed that this tillage was more effective on low plasticity clays than on very high plasticity clays and that the improvement ability of was mainly dependent on the moisture content of the added material. Therefore, it is recommended to use dry ingredients.

This paper focuses on the stabilization of black cotton soil by using recycled aggregates from acquired C&D wastes. Various changes in the properties of Black cotton soil are observed with the addition of recycled C&D wastes.

### A. Need For Present Study

After a careful review of the literature review, the following gaps and shortcomings were identified.

1) Recycled C&D waste is used as concrete aggregate in roadbeds and new construction, but can be used to treat soil and increase durability and stability.
2) India produces approximately 150 million tonnes of C&D waste, of which only 1% is recycled. As a result, there is a growing need to recycle and reuse C&D waste.
3) Recycling of C&D waste is not always cost-effective, so reuse in new projects can reduce overall project costs. Use recycled C&D waste as an inexpensive alternative for soil stabilization. (iv) Recycling and reusing C&D waste reduces the need for non-renewable resources, leading to sustainable development. Therefore, using recycled C&D waste for soil stabilization can reduce the overall environmental impact and limited landfill area.

### B. Materials and Method

Figure 1 below provides details of the methodology conducted in this study. Preliminary testing of raw materials was conducted after material purchase. C&D waste was obtained from ganesh tekdi flyover in Nagpur, Maharashtra. The collected samples went through a separation process, and a 5kg concrete waste sample was crushed with a charger. Addition of crushed concrete samples to soil was performed at rates of 15%, 20% and 25%, respectively. In order to observe various changes and find the optimal amount, crushed concrete samples were added to soil samples in various ratios. The same test was performed in soil stabilized according to IS 2720. Based on the test results, an optimized percentage addition of C&D waste for soil stabilization can be obtained.

### C. Materials Used

This paper focuses on the stabilization of black cotton soil by using recycled aggregates from acquired C&D wastes. Various changes in the properties of Black cotton soil are observed with the addition of recycled C&D wastes. The properties of black cotton soil are given in Table 1.

### D. Black Cotton Soil

Black cotton soil, also known as expansive soil, is one of the most problematic soils in construction. Generally widespread in central and southern India, black cotton soils are heavy clay soils that range from clay to loam and are generally light to dark grey in colour. When dry, black cotton or broad soil shrinks, becomes rock hard, and has a high bearing capacity. It expands when wet or wet, and becomes very loose and loses its load-bearing capacity. The basic mineralogical composition of these soil types has a decisive influence on their expansion behaviour, as they are generally rich in montmorillonite and illite minerals. Large cracks with a maximum width of 150 mm and a depth of 3.0 to 3.5 m are formed in dry conditions, and the soil is compressed in wet conditions. The upward pressure exerted is so great that it tends to push the foundation up, and this back pressure in the foundation causes cracks in the upper wall. The crack is already at the bottom, but it gets wider as you go up. Because black cotton soil has such unique properties, building upon it requires a unique skill set.

Table 1. Properties of black cotton soil

| Sl. No. | Properties | Value |
|---|---|---|
| 1. | Specific Gravity | 2.4 |
| 2. | Grain-Size Analysis<br>Gravel<br>Sand<br>Silt<br>Clay | <br>0%<br>19 %<br>28 %<br>53 % |
| 3. | Liquid Limit | 52.39% |
| 4. | Plastic Limit | 31.43% |
| 5. | Plasticity Index | 20.96% |
| 6. | CBR Value | 7.77% |
| 7. | Optimum Moisture Content | 13.15% |
| 8. | Maximum Dry Density | 2.104 Gm/CC |
| 9. | UCS Value | 1.01% |

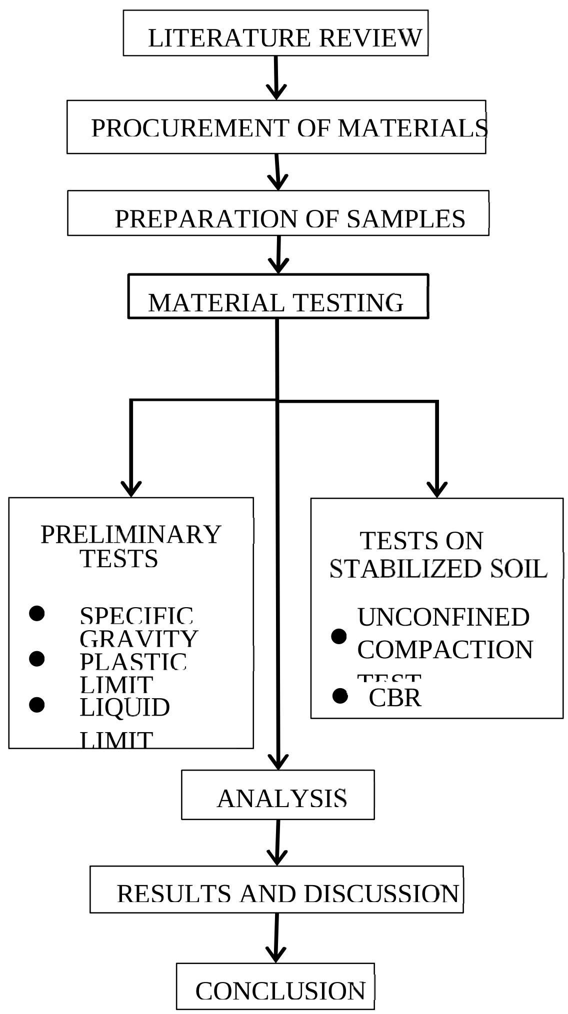



Fig.1 Methodology for soil stabilization

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 11 Issue V May 2023- Available at www.ijraset.com*

### *E. Improvisation Material*

Various additives such as lime, cement, dust, rubber waste, rice hull ash, and burnt mud are commonly used to stabilize the soil. However, C&D wastes such as soil stabilizers have recently been introduced, particularly with recycled concrete aggregates. The C&D waste used in this study was obtained from Ganesh tekdi flyover located in Nagpur, Maharashtra. The typical composition of C&D waste is shown in the chart below (Figure 2).

### *F. Tests*

Crushed concrete was added to the Black cotton sample in the proportions of 15%, 20%, and 25%. After the addition of crushed concrete, the following tests were conducted to observe and understand the behaviour of Black cotton soil (expansive soil).

*1)* Liquid limit test
*2)* Unconfined Compaction test
*3)* Plastic limit test
*4)* California Bearing Ratio test

## II. RESULTS AND DISCUSSION

Engineering properties of soil w.r.t liquid limit, plastic limit, plasticity index, maximum dry density, and moisture con- tent for an addition of 15% to 25% C&D wastes in soil are tabulated in Table 2.

Table 2: Final results for Black Cotton soil.

| Engineering property | Black cotton soil | 15% of C&D Wastes | 20% of C&D Wastes | 25% of C&D Wastes |
|---|---|---|---|---|
| Liquid limit [%] | 52.39% | 50.79% | 53.67% | 51.04% |
| Plastic limit [%] | 31.43% | 26.33% | 23.22% | 20% |
| Plasticity index [%] | 20.96% | 24.46% | 30.45% | 31.04% |
| Maximum dry density [$g.cc^{-1}$] | 2.104 | 2.08 | 1.97 | 1.86 |
| Optimum moisture content [%] | 13.15% | 14.7% | 16.67% | 18.04% |
| CBR [%] | 7.77% | 8.88% | 9.16% | 12.36% |
| UCS [%] | 1.01% | 1.07% | 1.11% | 1.18% |

Table 2 shows that the liquid limit ranges from 50.79% to 53.67% and the plastic limit ranges from 20% to 31.43%, with 15% to 25% C&D waste added. The plasticity index and dry density were high with the addition of 15% C&D waste. Humidity 13.15, 14.7%, 16.67% and 18.04% for C&D waste percentage increase from additive 15% to 25%. on figs. Figure 3 shows the impact of recycled C&D waste on Black Cotton soil at rates of 15%, 20% and 25%, respectively. in Table 2 and Fig.3, we can observe a steady decrease in the liquid limit and soil plasticity limit while continuing to increase the proportion of C&D waste. The soil fluid limit was changed from 52.39% to 49.21% by adding 25% recycled C&D waste and the plastic limit was changed from 26.39% to 22.53%.

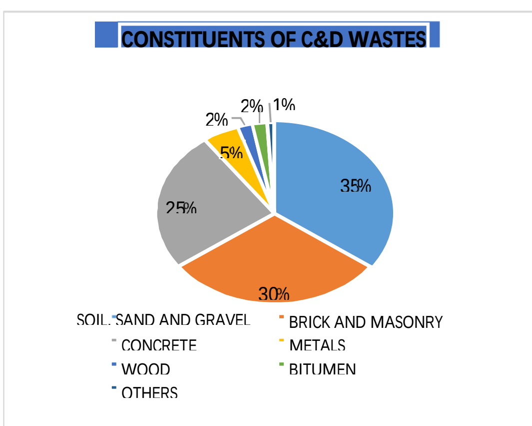



Fig. 2: Constituents of C&D wastes.

Figure 4 shows the change in optimum moisture when adding different percentages of C&D waste at rates of 15%, 20% and 25%, respectively. The optimal moisture content of the black cotton sample was 13.15%, which increased to 18.04% with the addition of 25% C&D waste. Adding 15% and 20% C&D waste increases the OMC to 13.15%, 14.4%, 16.67% and 18.04%, respectively. As you can see in the fig 3, the optimal water content of black cotton soil was significantly increased, demonstrating that the addition of C&D waste improved the TMC of black cotton or expanded soil.

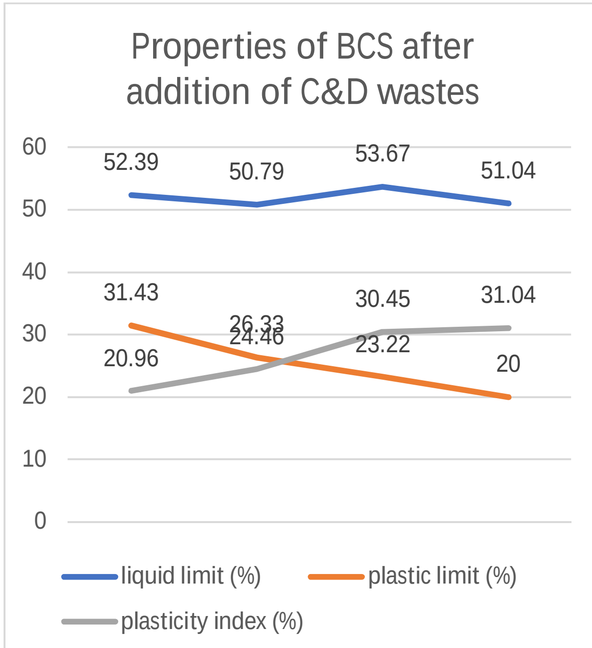



Fig. 3: Atterberg limits of initial and after addition of C&D wastes to black cotton soil.

Figure 5 shows the change in CBR value for various percentages of C&D waste added and the effect of C&D waste on CBR value. In the figure above, it can be observed that the proportion of recycled C&D waste increased after the CBR value of cotton chernozem increased significantly. With the addition of 15%, 20% and 25% C&D waste, the CBR values increased to 7.77% and 8.88%, 9.16% and 12.36%, respectively. As the proportion of C&D waste added increased, the CBR value increased from the original 7.77% to 12.36 with 25% C&D waste added.

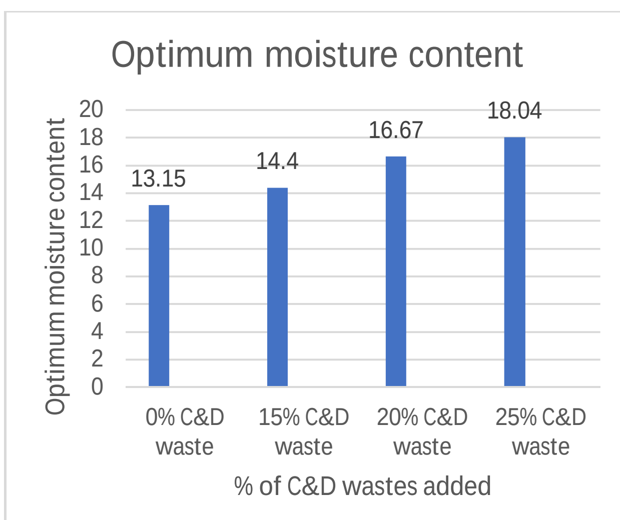



Fig. 4: Optimum moisture content of black cotton soil after adding recycled C&D wastes

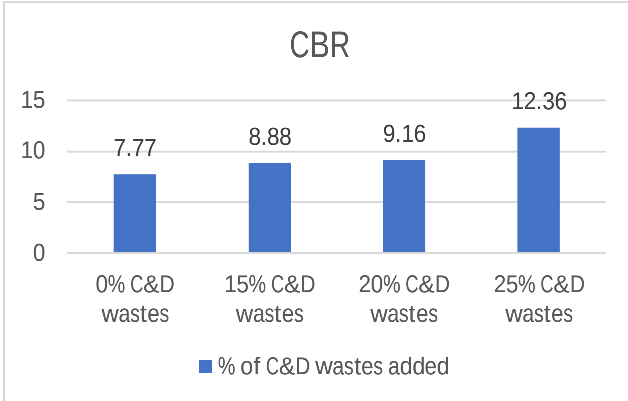



Fig. 5: Values of CBR values before and after addition of C&D wastes

Figure 6 shows the change in maximum density of dry soil samples with the addition of various percentages of C&D waste. The maximum dry density of black cotton samples decreases as the amount of C&D waste increases. In the chernozem cotton samples, the maximum dry density values gradually decrease as the amount of recycled C&D waste increases. 15%, 20% and 25% are added. Waste C&D, MDD values of 2.104, 2.08, 1.97 and 1.86 (gm.cc$^{-1}$) respectively. Adding 25% C&D waste reduced the maximum dry density from 2.104 g/cc $^{-1}$to 1.86 g/cc $^{-1.}$

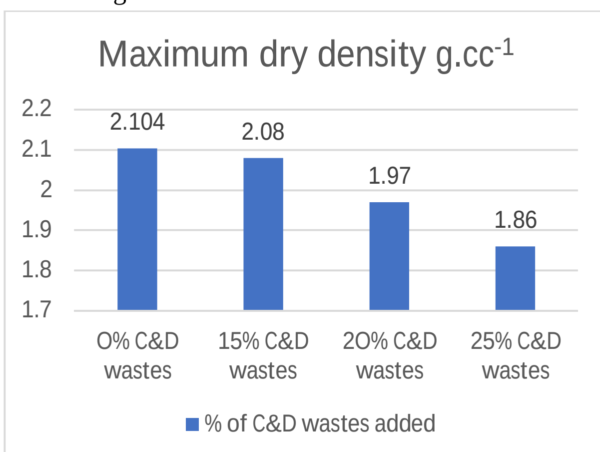



Fig. 6: Values of maximum dry density (g.cc$^{-1}$) before and after addition of C&D wastes

Figure 7, shows the changes in Unconfined compaction test with the addition of different percentage of C&D waste. The UCS of black cotton soil increases from 1.01% to 1.18%.

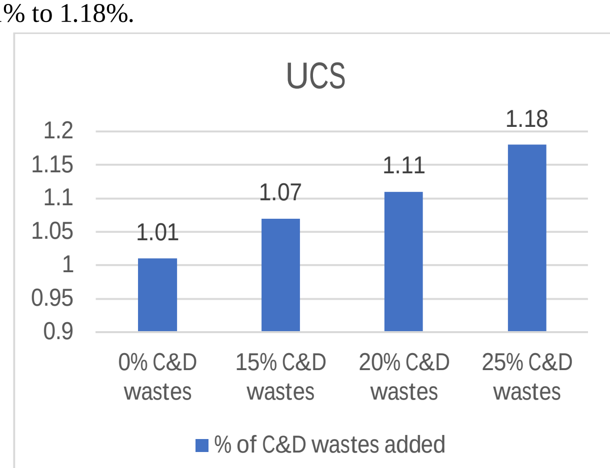



Fig. 7: Values of unconfined compaction test before and after addition of C&D wastes

## III. CONCLUSION

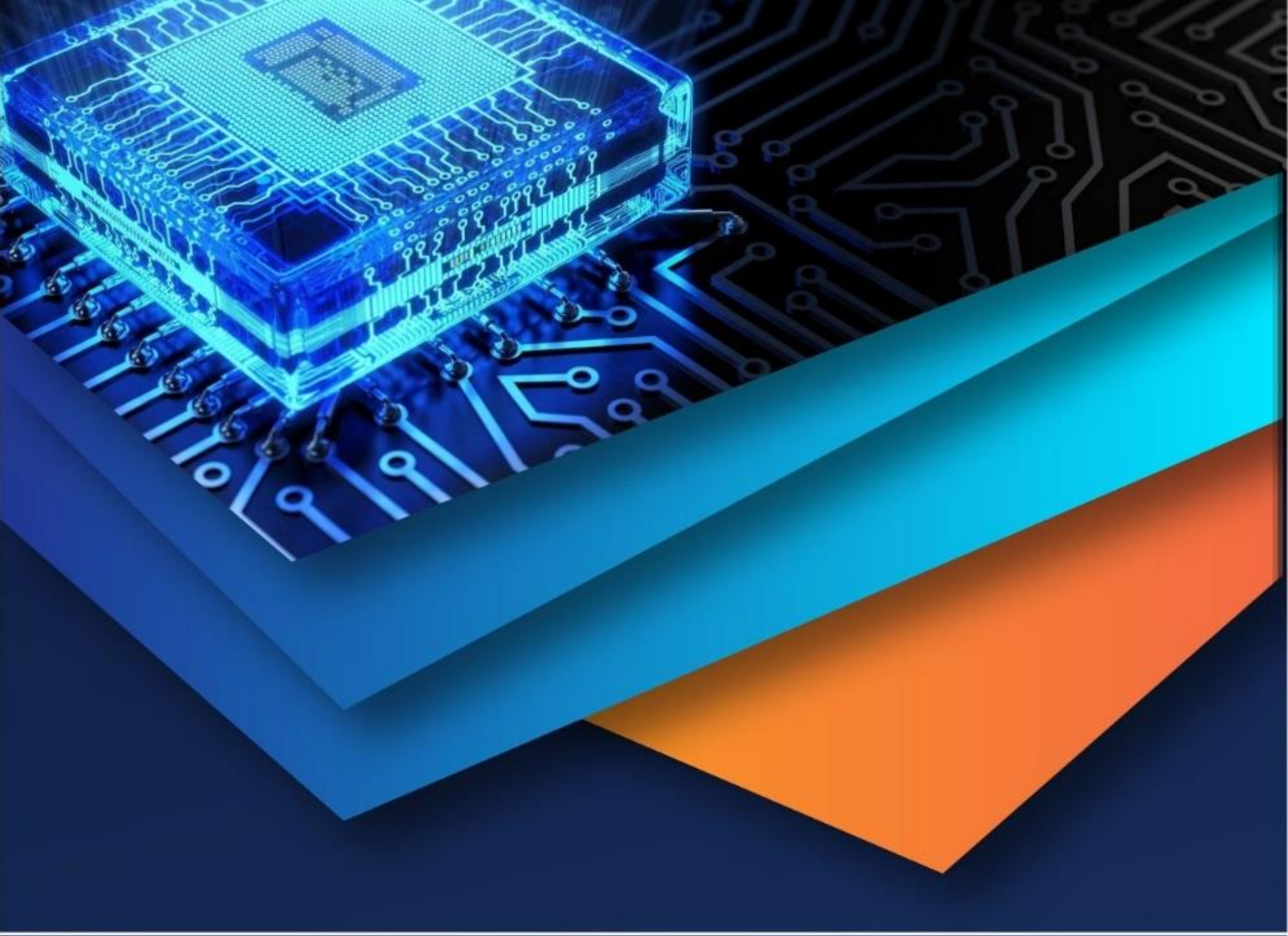
The purpose of this research was to enhance the engineering properties of Black cotton soil, reduce its swelling potential land increase its load-bearing capacity at the same time. Previous research has studied the effect of various additives such as lime, Rice husk ash, cement kiln dust, etc., for soil stabilization but most of these resulted in excessive heaving and pavement failures. The use of C&D wastes as a soil stabilizer has been studied before and the results obtained in this research are similar to the results of other research studies, which goes to proves that C&D wastes can be used as soil stabilizers. In this study, we tried to improve the engineering properties of Black cotton soil with the addition of recycled C&D wastes. The following results have been achieved.

1) With the addition of C&D waste, the optimal moisture values (OMV) of the soil samples changed and varied from the original 13.15% to 18.04% respectively 15% to 25% C&D wastes.
2) Maximum dry density (MDD) of soil decreased from 2.104 $g.cc^{-1}$ to 1.86 $g.cc^{-1}$ respectively 15% to 25% C&D waste.
3) CBR values increased significantly from 7.77% to 12.36%. respectively Add C&D waste at rate of 15%, 20% and 25%.
4) UCS values increased significantly from 1.01% to 1.18%. respectively Add C&D waste at rate of 15%, 20% and 25%.

From the above observations, it can be concluded that the engineering properties of cotton soil are significantly improved. Using C&D waste as a soil stabilizer solves the cotton problem in construction. In addition, pollution of water bodies, green spaces, and public spaces due to large-scale C&D waste generation, the biggest problem of which is the depletion of limited landfills, can be curbed. Using C&D waste as a soil stabilizer not only improves the engineering properties of the soil, but also reduces the cost of the overall project and negates its environmental impact, resulting in a more sustainable construction approach.

## REFRENCES

[1] Amadi, A. 2014. Assessing stabilization effectiveness of combined cement kiln dust and quarry fines on pavement subgrades dominated by black cotton soil. Geotech. Geol. Eng., 32(5): 1231-1238.
[2] Dhananjaya, A.S., Warade, T.G., Wankhede, A.S., Raghuvanshi, S.N. and Tandale, K.H. 2019. Stabilization of black cotton soil by using construction and demolition waste. J. Geotech. Stud., 4(2): 27-31.
[3] Henzinger, C. and Heyer, D. 2015. Use of demolition waste in soil improvement. In: Geotechnical Engineering for Infrastructure and Development: Conference Proceedings of the XVI ECSMGE, 13-17 September 2015, Edinburgh, UK, ICE Publishing, London, pp. 2547-2552.
[4] Karthik, S, Kumar, A.E., Gowtham, P.and Elango, G. 2014. Soil stabilization by using fly ash. IOSR J. Mech. Civil Eng., 10(6): 20-26.
[5] Kaushal, V. and Guleria, S.P. 2015. Geotechnical investigation of black cotton soils. Int. J. Adv. Eng. Sci., 5(2): 15-22.
[6] Mudgal, A., Sarkar, R. and Sahu, A.K. 2014. Effect of lime and stone dust in the geotechnical properties of black cotton soil. Int. J. Geomate, 7(2): 1033-1039.
[7] Okogbue,C.O. 2007. Stabilization of clay using wood ash. J. Mater. Civil Eng., 19(1): 14-18.
[8] Parsons, R.L.and Kneebone, E. 2004. Use of cement kiln dust for the stabilization of soil. Geotech. Eng Transport. Projects, Final Report No. KS-04-3: 1124-1131.
[9] Raut, J.M., Bajad, S.P. and Khadeshwar, S.R. 2014. Stabilization of expansive soils using fly ash and murrum. Int. J. Innov. Res. Sci. Eng. Technol., 3(7): 14283.
[10] Seda, J.H., Lee, J.C. and Carraro, J.A.H. 2007. Beneficial use of waste tire rubber for swelling potential mitigation in expansive soils. Geotech. Spec. Pub., 235(5): 1-9.
[11] Seehra, S.S. 2008. Practical Problems of Highway Construction in Black Cotton Soil Areas and In-Place Remedial Measures: A Case Study.
[12] NBM Media Construction Portal, NBMCW, South Asia.Shelke, M. 2010. Reduction of swelling pressure of expansive soils using EPS geofoam.Indian Geotech. Conf. GEOtrendz, 6: 495-497.Teja, S.L., Kumar, S.S. and Needhidasan, S. 2018. A review and study on stabilization of expansive soil using brick dust. Int. J. Pure Appl. Math., 119(17): 1999-2005.
[13] Yadu, L. 2013. Stabilization of soft soil with granulated blast furnace slag and fly ash. Int. J. Res. Eng. Technol., 2(2): 115- 118




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