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# Impact of Red Stone Dust and Polymer Fabric in Enhancing the Properties of Black Cotton Soil

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***Abstract***

*To enhance the mechanical properties of problematic black cotton soil, engineers are focusing on reinforcing the soil with geosynthetic materials. This attention is particularly directed towards improving the strength characteristics of black cotton soil, given its inherent challenges associated with volume changes and plasticity. In this comprehensive study, red stone dust waste is introduced in varying percentages ranging from 5% to 35% to stabilize the black cotton soil. The goal is to assess the impact of different proportions of red stone dust on the stabilization of the soil. Furthermore, to augment the stability of the soil, polymer fabric is strategically incorporated at different depths, both in single and double layers. The California Bearing Ratio (CBR) tests are conducted on blends of black cotton soil and red stone dust, with the polymer fabric positioned at depths of H/3 and 2H/3 from the top of the loading surface. The results indicate that the blend containing 25% red stone dust yields the most favorable outcomes in terms of CBR improvement. Additionally, it is observed that the enhancement in CBR values is more pronounced when the reinforcement is applied in a single layer compared to double layers. In summary, the study reveals that the combination of red stone dust and polymer fabric reinforcement offers a promising approach for effectively stabilizing black cotton soil, with the optimal percentage of red stone dust and the configuration of the reinforcement layers playing crucial roles in achieving improved CBR values.*

**Keywords:** California Bearing Ratio, Black Cotton Soils, Red Stone Dust, Geotextile, Unconfined compressive strength

## INTRODUCTION

The most prevalent application of stabilization in engineering is in the construction of road and airport pavements, where the main goals are to increase the stability or strength of soil and to lower the cost of construction [1]. Black cotton soil expands when moisture is present and contracts when moisture is absent. It is possible for the floors to heave, the roadways to heave unevenly, and there may be serious diagonal fissures above window or door frames when it is constructed on black cotton soil [2]. Stabilization of black cotton soils is done by using admixtures, stabilizers and geosynthetic materials such as geogrids, geotextiles etc.,. Without stabilization, it may be nearly difficult to start building an embankment or a road if the subgrade soils are highly fragile. An affordable substitute for other foundation stabilisation techniques is geosynthetics.[3]. It is also, found that as percentage of stone dust increases soaked CBR value increases [4]. The MDD of expansive soils is significantly increased with addition of marble industrial waste content upto 4% [5]. When treated with a fixed 5% Ordinary Portland Cement and different amounts of quarry dust at 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50% by weight of the dry soil, the compaction qualities of plastic soil continuously improved [6,

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7]. For an ideal blend of 15% quarry dust and 15% foundry sand with black cotton soil, the addition of these two materials reduces the swelling behavior and shrinkage limits, raises the MDD of the soil from 1.68 to 1.89 g/cc, lowers the plasticity index, raises the plastic-limit, and increases the CBR value from 4.76% to 12.93%. [8]. Maximum dry density increased from 1.45 g/cc to 1.80 g/cc by adding 30% of stone dust and CBR value increased up to twice by addition of 30% of stone dust in poor soil [9]. Maximum Dry Density and Soaked CBR value increases with the increase in stone dust proportion when black cotton soil is mixed with stone dust by 10%,20%,30%,40%,50% and 60% by weight of soil [4].

The black cotton soil cannot be used as subgrade material for the construction of flexible pavement. Continuous mining activities, in Soorsagar, Mandore and Barli area of Jodhpur city, impact severely on environment and health of the native people [10]. Here, efforts are made to use waste material red stone dust (RSD) to stabilize the soil. The BCS stabilized with 5%, 10%, 15%, 20%, 25%, 30% and 35% RSD. The focus of the study was to decrease the thickness of subgrade of the pavement by using waste and polymer reinforcements.

## MATERIALS AND METHODS

### Black Cotton Soils

BCS is collected from Jadol area in Udaipur Tehsil (0.5 to 1.0 meter from ground level), Rajasthan, India. After removing the top layer of organic debris from the site, the soil is collected. Tests conducted in accordance with IS 2720 part-V were used to determine the liquid and plastic limit. According to the Indian standard classification system, the soil is categorized as clay with high compressibility (CH) based on the A line graph as shown in Figure 1. Table 1 presents the index characteristics of the virgin soil.

**Table 1.** BCS's index characteristics

| S.N. | Properties | Result obtained |
|---|---|---|
| 1 | Color | Grayishblack |
| 2 | Liquid Limit | 66.80% |
| 3 | Plastic Limit | 32.25% |
| 4 | Plasticity Index | 34.55% |
| 5 | Indian standard Classification | CH-Clayof High Compressibility |

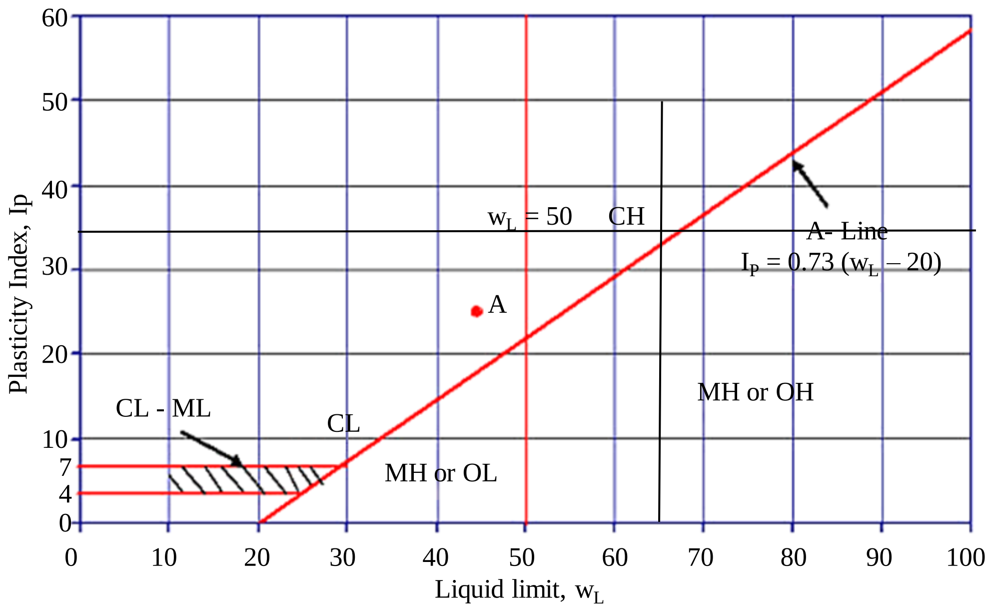


**Figure 1.** A line graph.

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The scanning Electron Micrograph (SEM test) illustrates the presence of voids having honeycomb structure of the black cotton soil as shown in Figure 2. The EDAX test results of BCS are tabulated in Table 2 and graphically represented in Figure 3.

**Red Stone Dust**

The waste RSD is collected from Soorsagar area(Red Sand Stone Mines) in Jodhpur, Rajasthan, India. According to IS code, all tests on the RSD's index and engineering characteristics were conducted, and the test results are presented in Table 3.

**Table 2.** Atomic weight of elements present in the BCS.

| Element | Atomic weight (%) |
|---|---|
| Si | 30.75 |
| O | 29.78 |
| Al | 13.67 |
| Fe | 4.16 |
| Ca | 4.78 |
| K | 3.59 |
| C | 9.11 |
| Mg | 2.71 |
| Na | 1.45 |
| *Total* | *100* |

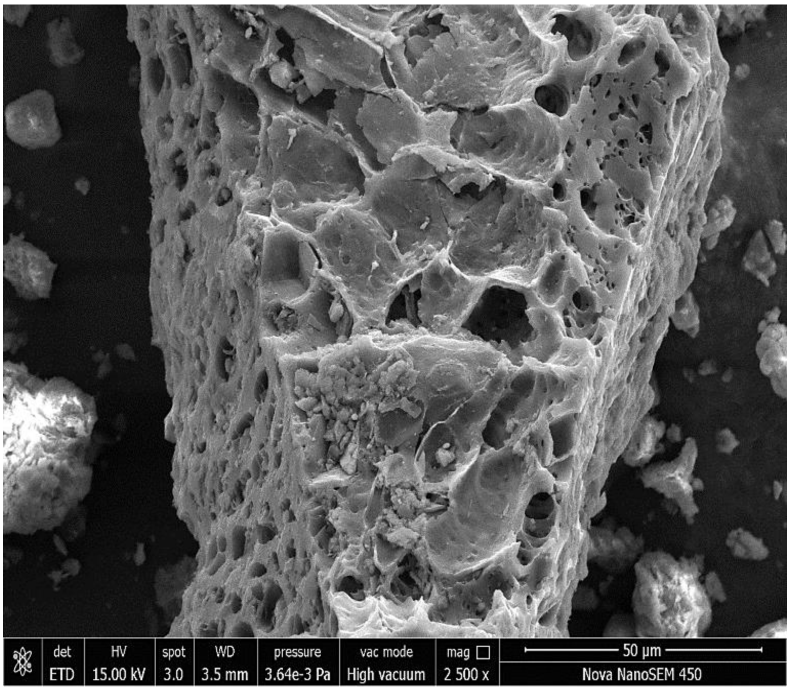


**Figure 2.** Scanning Electro Micrograph of BCS.

**Table 3.** Properties of RSD.

| S.N. | Properties | Result Obtained |
|---|---|---|
| 1 | Color | Red |
| 2 | Water Absorption | 1.2% |
| 3 | Maximum Dry Density | 1.96 g/cc |
| 4 | Optimum Moisture Content | 10.42% |
| 5 | CBR | 48.0% |

 

The micro structural examination (SEM test) of RSD confirms the presence of irregular flaky shapes of the various sizes as shown in Figure 3. The EDAX test of the RSD shows presence of silicon, carbon, oxygen and aluminum elements enlisted in Table 4.

The waste RSD identified had a CBR value that was excessively high compared to the BCS. By increasing the RSD by dry weight of BCS by 5%, 10%, 15%, 20%, 25%, 30%, and 35%, the goal is to raise the CBR value of BCS. The CBR tests were conducted as per the IS standards (IS 2720–part XVI (1987) on BCS with different percentage of RSD specimens. Here light weight compaction is done during preparation of CBR mould specimen.

**Polymer Fabric**

The polymer fabric employed in this application is Non-Woven Geotextile (NWG), specifically crafted from 100% polyester staple fiber and needle-punched, as illustrated in Figure 4. The material properties of NWG are enlisted in Table 5.

Figure 5 shows the schematic diagram of the test setup of CBR test. As per IS specification the CBR mould is filled in three layers. The depth of placement of polymer fabric decided as H/3 and 2H/3 depths from the top of the loading surface. The height of CBR mould is 175 mm as per IS 2720 (Part-16). NWG is placed in single layer and in double layers. The tests were conducted for each blends by placing the NWG in single layer at H/3 and 2H/3 depths and also, in double layers.

1. at H/3 depth= 41.67 mm from the loading surface
2. at 2H/3 depth = 83.33 mm from the loading surface.

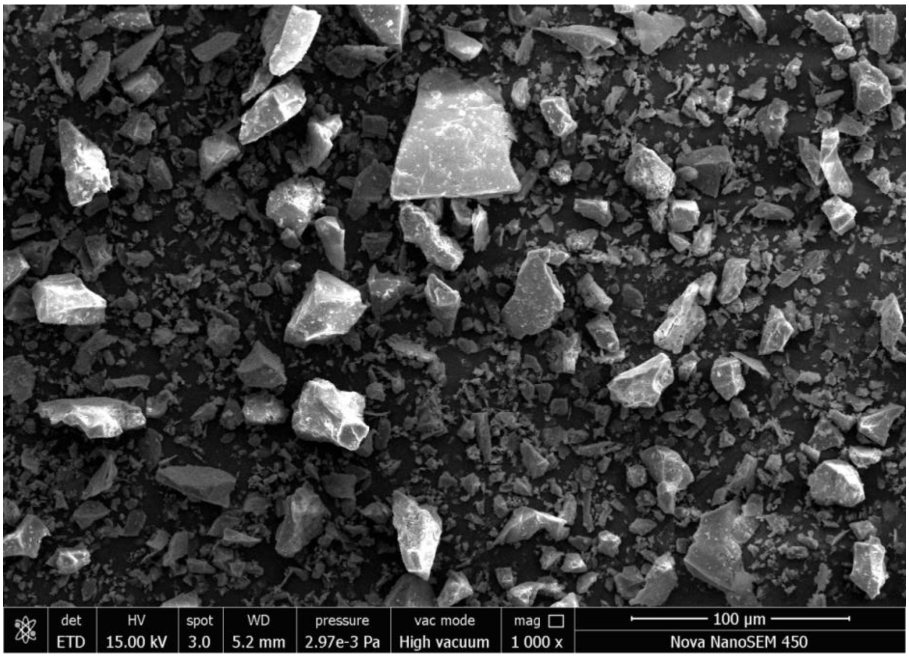


**Figure 3.** Scanning Electro Micrograph of RSD.

**Table 4.** Atomic weight of elements present in the RSD.

| Element | Atomic weight (%) |
|---|---|
| Si | 29.63 |
| C | 44.24 |
| O | 17.89 |
| Al | 8.24 |
| *Total* | *100* |

 

**Figure 4.** Non-Woven Geotextile.

**Table 5.** Material properties of the NWG.

| S.N. | Property BCS | Unit | Average value |
|---|---|---|---|
| ***Mechanical properties*** | | | |
| 1 | Materials | - | 100% polyester staple fibre Needle punched Non woven Geotextile |
| 2 | Tensile Strength | kN/m | 7.73 |
| 3 | Tensile elongation | % | 62 |
| 4 | Grab Tensile Strength | N | 526 |
| 5 | Grab Tensile elongation | % | 68 |
| 6 | Trapezoindal tear strength | N | 216 |
| 7 | CBR puncture strength | N | 1443 |
| **Hydraulic Properties** | | | |
| 8 | Apparent Opening size | | 96 |
| 9 | Water Flow rate-50 mm head | $l/m^2/sec$ | 77 |
| **Physical properties** | | | |
| 10 | Mass per unit area | $g/m^2$ | 169 |
| 11 | Thickness | mm | 1.0 |

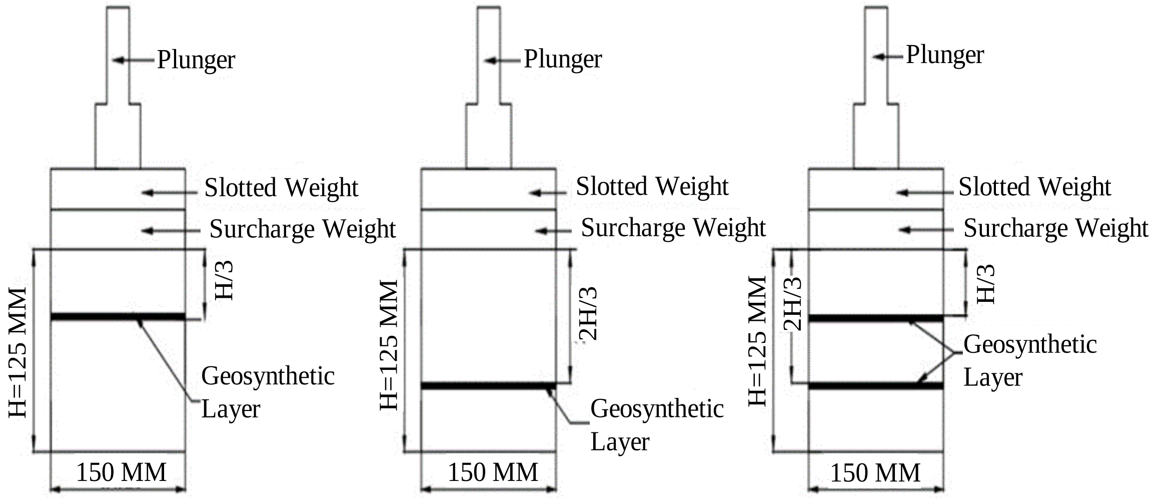


**Figure 5.** Schematic diagram of the test setup.

 

## RESULTS AND DISCUSSION

- The results of tests performed on different soil blends are tabulated in the Table 6. The Maximum Dry Density (MDD) increased from 1.48 g/cc to 1.65 g/cc when 25% of the RSD was mixed with BCS and it decreased when further percentage of RSD added. The Optimum Moisture Content (OMC) decreased from 20.56% to 18.35% when 25% of the RSD was mixed with BCS and it again increased with further addition of RSD.

Figure 6 depicts the relationship between dry density and moisture content, serving as a tool for determining the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) across various soil blends.

**Table 6.** Test results of stabilized soil with RSD.

| | **Properties** | **RSD by weight of BCS** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ***0%*** | ***5%*** | ***10%*** | ***15%*** | ***20%*** | ***25%*** | ***30%*** | ***35%*** |
| 1 | Maximum Dry density (MDD) (g/cc) | 1.48 | 1.49 | 1.52 | 1.58 | 1.63 | 1.65 | 1.64 | 1.59 |
| 2 | Optimum Moisture Content (OMC) (%) | 20.56 | 20.12 | 19.25 | 18.84 | 18.35 | 17.76 | 18 | 18.3 |
| 3 | Liquid Limit (%) | 66.80 | 63.76 | 56.43 | 49.72 | 42.36 | 39.72 | 26.15 | 18.83 |
| 4 | Plastic Limit (%) | 32.25 | 30.29 | 28.28 | 23.65 | 20.67 | 18.52 | 17.46 | 16.24 |
| 5 | Plasticity Index | 34.55 | 33.47 | 28.15 | 26.07 | 21.69 | 21.20 | 8.69 | 2.59 |
| 6 | CBR (%) | 1.78 | 1.98 | 2.25 | 2.85 | 3.46 | 3.89 | 4.65 | 5.1 |
| 7 | Unconfined Compressive Strength (UCS) ($N/cm^2$) | 14.500 | 14.568 | 15.264 | 15.805 | 16.587 | 17.231 | 17.11 | 16.742 |
| 8 | Shear Strength ($N/cm^2$) | 7.28 | 7.284 | 7.632 | 7.902 | 8.293 | 8.616 | 8.555 | 8.371 |

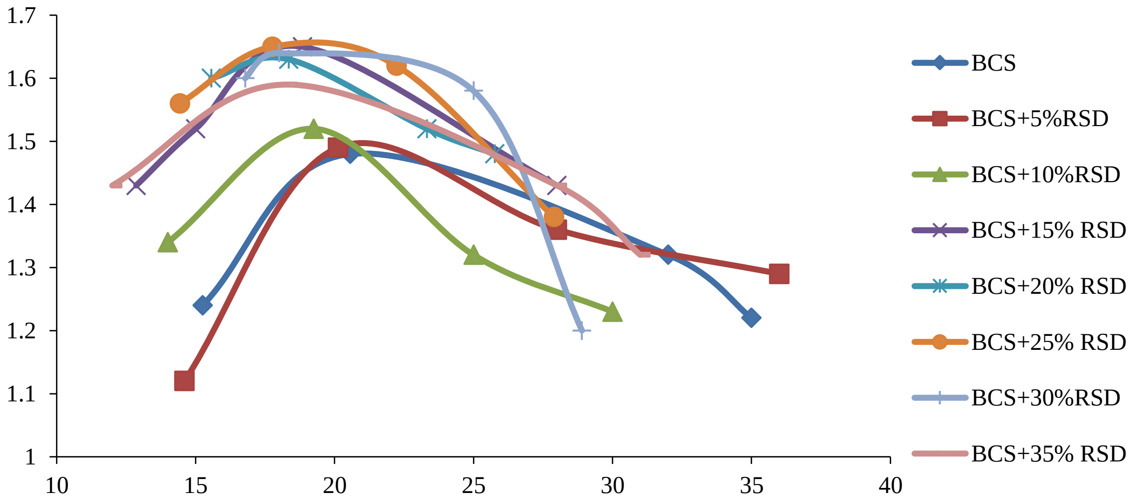

**Figure 6.** Compaction Parameters for the different blends.

Figure 7 illustrates the axial stress versus axial strain graphs corresponding to each blend. UCS of the sample is indicated by the maximum stress observed.

In Figure 8, the graphical representation encompasses the results of the CBR, UCS, and shear strength tests conducted on various blends of BCS+RSD.

The Table 7 depicts 195.75% increment in the CBR value when single layer of NWG placed at H/3 depth from the top of the loading surface for the soil having 35% of RSD when compared with natural BCS. 184.31% increment in the CBR value found when double layers of NWG placed at H/3 and 2H/3 depths from the top of the loading surface for the soil having 35% of RSD when compared with 0% RSD in it.

 

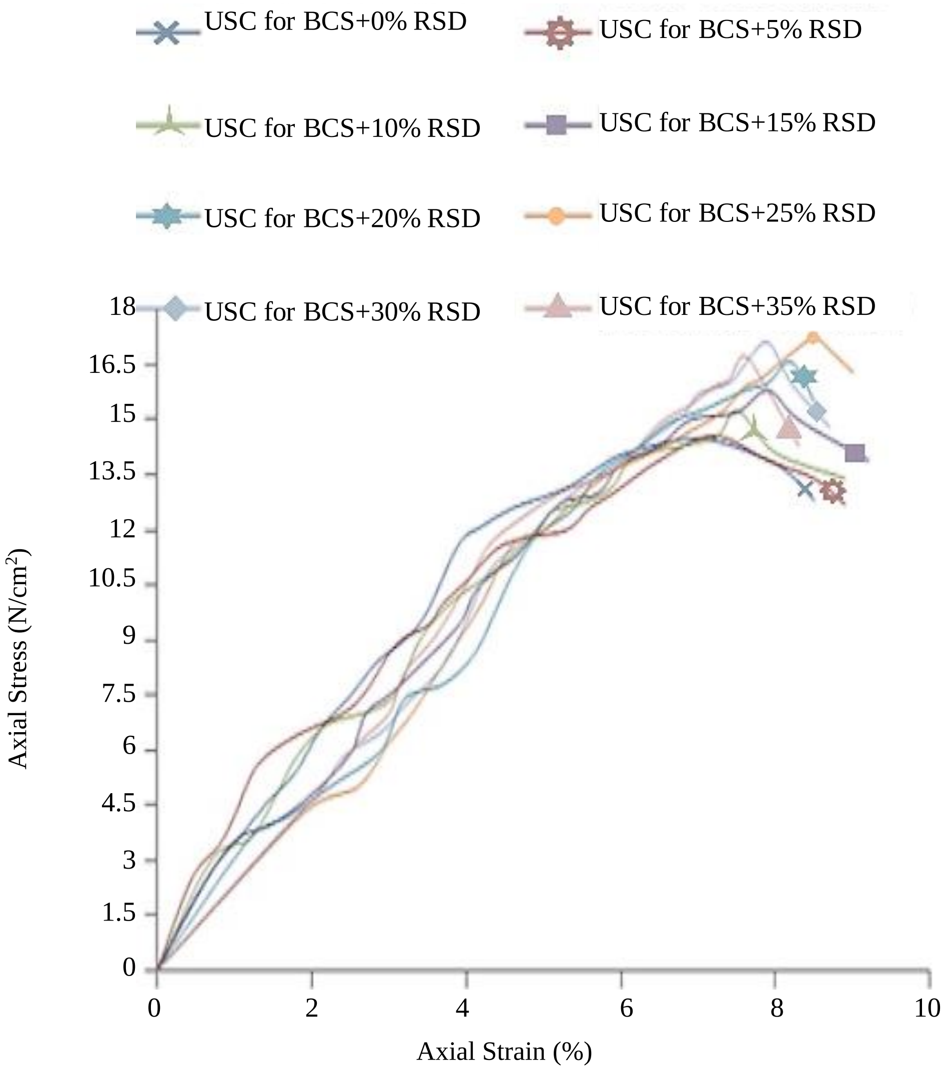


**Figure 7.** UCS Graph for different blends.

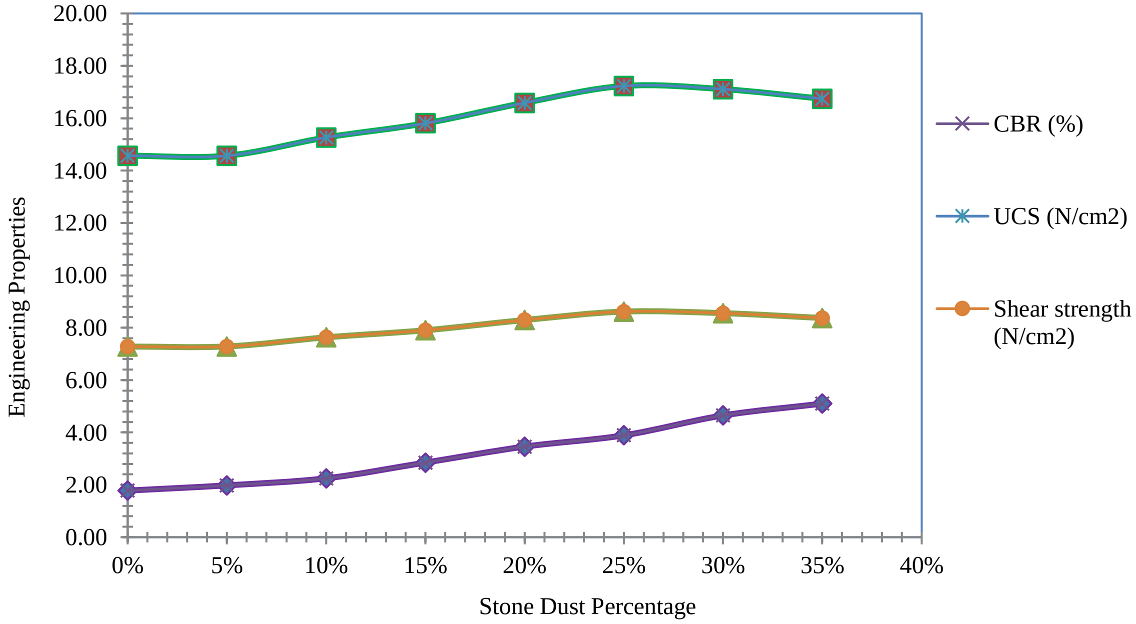

**Figure 8.** CBR, UCS and shear strength of different blends.

**Table 7.** CBR test results.

| | Parameter Description | BCS = Black Cotton Soil RSD = Red Sandstone Dust NWG = Non Woven Geotextile | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ***BCS+0 % RSD*** | ***BCS+5 % RSD*** | ***BCS + 10% RSD*** | ***BCS + 15% RSD*** | ***BCS+ 20% RSD*** | ***BCS+ 25% RSD*** | ***BCS + 30% RSD*** | ***BCS+ 35% RSD*** |
| 1 | CBR (%) 4 Days Soaked Unreinforced Soil from top of the loading surface | 1.78 | 1.98 | 2.25 | 2.85 | 3.46 | 3.89 | 4.65 | 5.1 |
| 2 | CBR (%) 4 Days Soaked Soil Reinforced With One Single NWG @ H/3 Depth from top of the loading surface | 1.88 | 2.18 | 2.45 | 3.05 | 3.78 | 4.32 | 4.95 | 5.56 |
| 3 | CBR (%) 4 Days Soaked Soil Reinforced With One Single NWG @ 2H/3 Depth from top of the loading surface | 1.80 | 2.10 | 2.30 | 2.78 | 3.50 | 3.90 | 4.68 | 5.05 |
| 4 | CBR (%) 4 Days Soaked Soil Reinforced With Two Nos. NWG @ H/3 & 2H/3 Depths from top of the loading surface. | 2.04 | 2.35 | 2.63 | 3.19 | 3.98 | 4.48 | 5.34 | 5.80 |

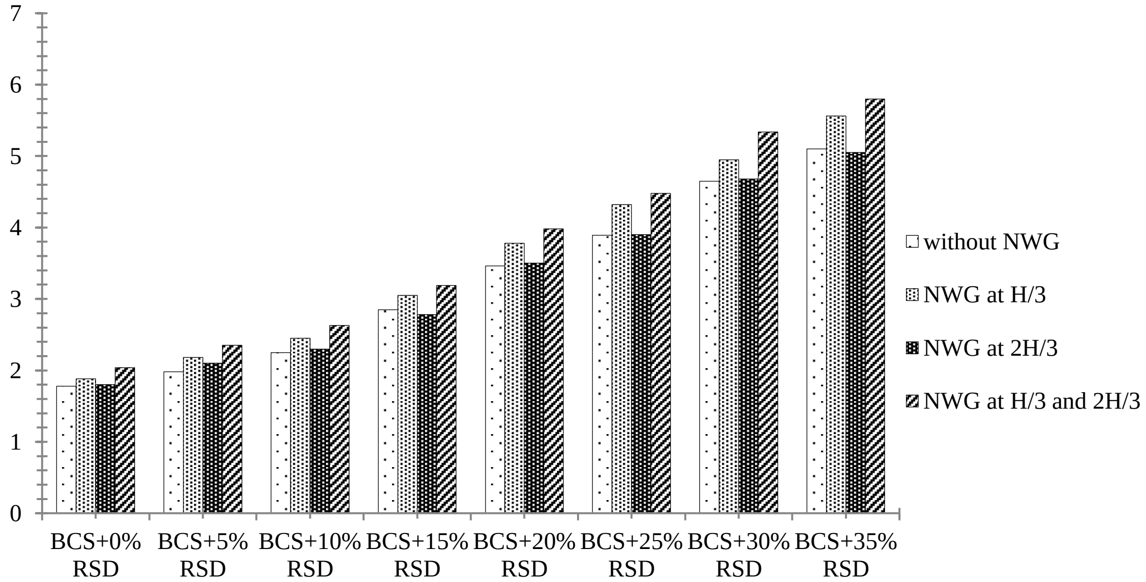


**Figure 9.** CBR test results using NWG at different layers.

Figure 9 presents a comparative analysis of CBR test results, considering scenarios both with and without polymer fabric. Additionally, it illustrates the impact of placement depths and the number of layers of polymer fabric on the outcomes.

## CONCLUSION

The experimental study suggests to use non-woven geotextiles and red stone dust to raise the CBR of black cotton soil. Some of the important inferences drawn from the performed experimental investigations are as follows.

- Maximum dry density increased from 1.48 g/cc to 1.65 g/cc when 25% of stone dust by weight mixed with the BCS.
- 65.098% increase in CBR value observed when 35% of RSD is added in BCS.
- UCS increases from 14.5 $N/cm^2$ to 17.23 $N/cm^2$ when 25% of RSD mixed with the BCS. Then

after it decreases with increment of RSD percentage.

- Shear strength increases from 7.28 N/cm$^2$ to 8.616 N/cm$^2$ when 25% of RSD mixed with the BCS. Then after it decreases with increment of RSD percentage.
- Optimum blend found is BCS+25% SD.
- Soaked (4 days) CBR value increased by 186.52% when the BCS mixed with 35% of the RSD.
- Double layers of NWG show better CBR than the single layer placed at H/3 or 2H/3 depth from the top of loading surface.
- Single layer of NWG placed at H/3 depth gave better CBR value as compared with the NWG placed at 2H/3 depth.

**REFERENCES**

1. Ogundare, D.A., Familusi, A.O., Osunkunle, A.B., & Olusami, J.O. (2018). Utilization of geotextile for soil stabilization. American Journal of Engineering Research, 7(8), 224–231.
2. Zumrawi, M.M.E. (2015). Construction problems of light structures founded on expansive soils in Sudan. International Journal of Science and Research, 4(8), 896–902.
3. Zornberg, J.G. (2017). Functions and applications of geosynthetics in roadways. Transportation Geotechnics and Geoecology, TGG 2017, 17–19 May 2017, Saint Petersburg, Russia, 298-306.
4. Dixit, M. & Patil, K. (2016). Utilization of stone dust to improve the properties of expansive soil. International Journal of Civil Engineering and Technology, 7(7), 440–447.
5. Fazl-A-Zalal, Khan Shahzada, Salman Saeed, Ahmad, I., & Ullah, K. (2017). Stabilization of medium expansive soils in Pakistan using marble industrial waste and bagasse ash. International Journal of Earth Sciences and Engineering, 10, 885–891.
6. Van Bui, D., & Onyelowe, K. (2018). Adsorbed complex and laboratory geotechnics of Quarry Dust (QD) stabilized lateritic soils. Environmental Technology & Innovation, 10, 355–363.
7. Sudam, P.A., Padmavathi, M., Ravikumar, K., & Nagaraju, M. (2019). An experimental study on CBR of expansive soil subgrades using geotextiles. International Journal of Civil and Structural Engineering Research, 7(1), 119–128.
8. Prabhakar, Kori, S., & Venkantaramana, N. (2020). Stabilization of subgrade black cotton soil using quarry dust and foundry sand. International Journal of Recent Technology and Engineering, 8(5), 4859–4863
9. Bshara, A.S., Bind, Y.K., & Sinha, P.K. (2014). Effect of stone dust on geotechnical properties of poor soil. International Journal of Civil Engineering and Technology, 5(4), 37–47.
10. Yadav, S.K. & Borana, S.L. (2017). Monitoring and temporal study of mining area of Jodhpur City using remote sensing and GIS. International Research Journal of Engineering and Technology, 4(10), 1732–1736.

 