A Review of Sand and Non Woven Coir Stabilization of Black Cotton Soil

Mohd Shehzad[1], Aman Bathla [2] and Sanjeev Singh[3]

[1,2,3] Departments of Civil Engineering, Geeta Engineering College, Naultha, Panipat
Affiliated to Kurukshetra University, Kurukshetra, India

Abstract - *The purpose of this research was to see how Non Woven Coir (NWC)/coir fiber combined with black cotton soil in sub grade affected the results. Black cotton soil combined with coir fiber in varied percentages of 0.15 percent to 0.75 percent is used for this purpose. In another example, soil was mixed with NWC ranging from 0.15 to 0.75 percent and sand ranging from 3 to 15%, and the qualities of the soil were assessed. The study's findings showed that NWC may be built on soft ground, has more stability when restricted than other soil fills, has little long-term settling, and can also be utilized as a stabilizing agent. When NWC and sand were added to black soil, the CBR increased almost linearly.*

1. INTRODUCTION

Expansive soils are particularly troublesome due to their proclivity for substantial volume fluctuations as a result of changes in moisture content. The soil is regarded as undesirable for construction material due to its great flexibility, severe swelling, shrinkage, and low strength when wet (Chen 1988; Dif and Bluemel 1991; Zemenu et al. 2009; Terzaghi et al. 2010; Mokhtari and Dehghani 2012; Meshram et al. 2013). Due to a lack of appropriate soil, large financial investments are necessary for the building of highways, canals, and embankments. The soil of Black Cotton (BC) is very vast. Soil stabilisation can be accomplished in a variety of ways. They include the cohesive non-swelling soil layer (Katti et al. 1983), the sand cushion method (Satyanarayana 1969), chemical stabilisation (Estabragh et al. 2014), bio enzymes (Lopez-Lara et al. 1999), the deep soil mixing method (Madhyannapu et al. 2009), and the mixing of various additives such as lime, cement, fly ash, stone dust, and so on (Cokca 2001; Mishra et al. 2008, Mathur et al. 2012; Phanikumar and Sharma 2004; Sridharan et al. 2006; Agarwal et al. 2016 Eme et al. 2016). Because of the mixing problem, the depth needs to be stabilised, and trustworthy results are not produced, the present methods have limited application. As a result, there has yet to be produced a single, adaptable solution.

Non Woven Coir (NWC)/coir fibre is used to solve this problem, since it provides the bulk of the mass and improves the soil's strength. It has been discovered to be the finest option for subgrade or subbase in pavement. Coir fibre is a natural, biodegradable, fast-binding, low-cost, environmentally beneficial, and non-polluting substance that can be practically replaced by any current polymeric alternative (Meshram et al. 2013). The aim of present study is to improve CBR of black cotton soil by using NWC and sand.

2. LITERATURE REVIEW

Natural geotextiles have not gained popularity, despite the fact that India generates enormous amounts of coir fibre, which may be used for geotechnical and transportation engineering purposes. The ability of coir geotextiles to fulfil various roles in order to improve the engineering behaviour of black cotton soil is demonstrated (Meshram et al. 2014). To boost the shear and tensile strength of soil, it has been combined with randomly scattered fibres (Maher and Ho 1994; Ziegler et al. 1998). Kumar and Devi (2011) investigated the use of needle punched nonwoven geotextiles constructed of coir and jute fibre, as well as the CBR reinforcement ratio value of the geotextiles sub grade achieved by CBR testing. The soil's CBR has improved because to the nonwoven geotextiles.

Kumar and Rajkumar (2012) investigated the performance of woven and nonwoven geotextiles, determining the reinforcement ratio based on the CBR load-penetration relationship of soft subgrade-gravel and soft subgrade-geotextiles-gravel, respectively, for woven and nonwoven geotextiles. The incorporation of woven and nonwoven geotextiles improves the performance of the reinforcement ratio established using the CBR strength test.

Shankar and Chandrasekhar (2012) investigated the most generally used additives for stabilising lithomarge clay utilising sand and coir, such as sand, cement, pond ash, and so on. The geotechnical qualities of clay were found to improve with varied amounts of sand and coir additions.

3. EXPERIMENTAL PROGRAMME

The current work focuses on increasing the CBR of black cotton soil, which is employed as a subgrade material. The first stage involved determining the soil index characteristics, compaction, and CBR values. The soil is mixed with NWC in various percentages (0.15 percent, 0.30 percent, 0.45 percent, 0.60 percent) in the second step, and then compaction and CBR values are calculated. In the third stage, OMC-MDD and CBR values were evaluated in soil mixed with NWC and sand in which NWC was mixed in different percentages viz. 0.15 percent, 0.30 percent, 0.45 percent, 0.60 percent, and 0.75 percent and sand was mixed in different percentages viz. 3 percent, 6 percent, 10 percent, 12 percent, and 15 percent. The NWC was spread at random with BC soil and sand.

4. MATERIAL USED

The materials used in the investigation consist of

(a) Black cotton soil,

(b) Sand,

(c) Non-woven coir.

(a) Properties of Soil

The Atterberg limit test (IS: 2720 (Part 5)-1985), Specific gravity test (IS: 2720 (Part 3)-1980), CBR (IS: 2720 (Part 16) - 1987), Free swell test (IS: 2720 (PART XL) 1977), and Standard compaction test (IS: 2720 (Part 7)-1980) were used to assess the physical characteristics of the clay. The soil is classed as CH (clay of high plasticity and compressibility) according to (IS: 1498-1970).

The test results were examined, and Table 1 shows a summary of the physical parameters of the soil. A example paragraph from the Irjet Template. Even if abbreviations and acronyms have been defined in the abstract, define them the first time they are used in the text. IEEE, SI, MKS, CGS, sc, dc, and rms are examples of abbreviations that do not need to be specified. Abbreviations should only be used in the title and headings if they are unavoidable.

Table -1: Properties of Soil

Properties	Test Results
Liquid Limit (%)	55
Plastic Limit (%)	37
Plasticity Index (%)	18
Specific Gravity	2.72
Optimum Moisture Content (%)	27
Maximum Dry Unit Weight (kN/m3)	1.40
Soaked CBR (%)	1.80
Free Swell Index (%)	33

(b) Properties of sand

Sieve analysis, specific gravity (IS 2720 - Part 3 (Sections 1): 1980), and minimum and maximum dry unit weight test (IS: 2720 (Part 14)-1983) were performed on the sand in the laboratory.

Figure 1 depicts the sand particle size distribution curve, while Table 2 lists other significant parameters. According to the classification system, the sand is classified as SP (poorly graded sand) (IS: 1498-1970). Particle Size Distribution Curve was used to categorise the soil (IS: 1498-1970). D10, D30, and D60 values (i.e. particle size equivalent to 10, 30, and 60 percent finer correspondingly) were determined.

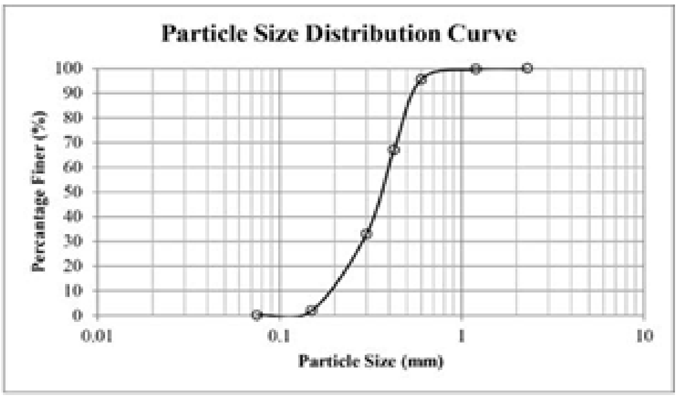

Chart -1: Particle Size Distribution Curve for Sand

Table 2 Properties of Sand

Properties of Sand	
Particle size corresponding to 10% finer, D10	0.19
Particle size corresponding to 30% finer, D30	0.29
Particle size corresponding to 60% finer, D60	0.40
Coefficient of Uniformity, CU	2.10
Coefficient of Curvature, CC	1.10
Specific Gravity, G	2.67
Maximum Density, γ max (kN/m3)	16.46
Minimum Density, γ min (kN/m3)	14.16

(c) Properties of Non Woven Coir

Physical properties of NWC are shown in Table 3.

Table 3 Physical Properties of NWC

PROPERTY	VALUE
Length (mm)	15 - 280
Density (g/cc)	1.15 - 1.4
Tenacity (g/tex)	10.0
Breaking elongation (%)	30.0
Diameter (mm)	0.1 -1.5
Rigidity modulus (dynes/cm2)	1.8924
Swelling in water (diameter)-(%)	5.0
Moisture at 65% RH (%)	10.5
Specific gravity	1.15
Young's modulus (GN/m2)	4.5

5. RESULTS AND DISCUSSION

To complete the intended investigation on CBR of black cotton soil, two sets of experiments were conducted. NWC was randomly mixed with BC soil in one test series, while BC soil was combined with NWC and sand in another.

(a) Tests on BC Soil Mixed with NWC

0.15 percent, 0.30 percent, 0.45 percent, 0.60 percent, and 0.75 percent NWC were mixed with soil in various percentages. For the varying percentages of NWC indicated in Fig.2 to Fig.4, the samples were tested for OMC, MDD, and CBR.

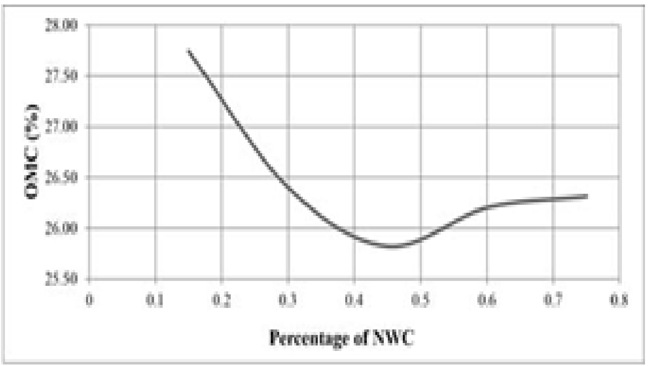

Chart -2: Variation of OMC with Percentage of NWC (mixed in BC soil)

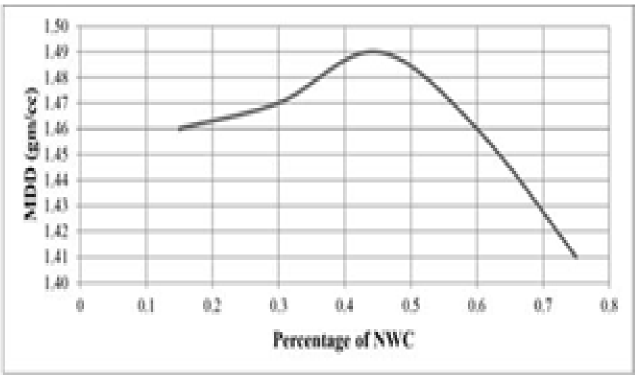

Chart -3: Variation of MDD with Percentage NWC (mixed in BC soil)

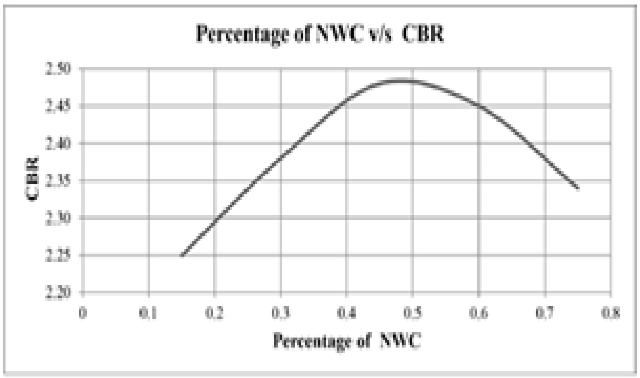

Chart -4: Variation of CBR with Percentage NWC (mixed in BC soil)

(b) Tests on Soil Mixed with NWC and Sand

NWC was incorporated in various percentages in BC soil, including 0.15 percent, 0.30 percent, 0.45 percent, 0.60 percent, and 0.75 percent. Sandn was mixed with BC soil in various amounts, such as 3 percent, 6 percent, 10%, 12 percent, and 15%, as indicated in Tables 4 to 8.

For varied percentages of NWC, the samples were tested for OMC, MDD, and CBR.

Table 4 CBR Value for BC Soil Mixed with 0.15% NWC and Varying Percentage of Sand

Soil Mixed With NWC and Sand	OMC (%)	MDD (gm/cc)	Soaked CBR (%)
Soil, 0.15% coir and 3% sand	22.10	1.410	2.23
Soil, 0.15% coir and 6% sand	20.59	1.438	3.12
Soil, 0.15% coir and 10% sand	19.77	1.557	4.31
Soil, 0.15% coir and 12% sand	18.54	1.579	4.98
Soil, 0.15% coir and 15% sand	16.87	1.610	5.24

Table 5 CBR Value for BC Soil Mixed with 0.30% NWC and Varying Percentage of Sand

Soil Mixed with NWC and Sand	OMC (%)	MDD (gm/cc)	Soaked CBR (%)
Soil, 0.30% coir and 3% sand	23.30	1.520	2.35
Soil, 0.30% coir and 6% sand	22.44	1.535	3.20
Soil, 0.30% coir and 10% sand	20.87	1.555	4.49
Soil, 0.30% coir and 12% sand	19.34	1.580	5.12
Soil, 0.30% coir and 15% sand	17.73	1.610	6.40

Table 6 CBR Value for BC Soil Mixed with 0.45% NWC and Varying Percentage of Sand

Soil Mixed with NWC and Sand	OMC (%)	MDD (gm/cc)	Soaked CBR (%)
Soil, 0.45% coir and 3% sand	24.40	1.620	3.35
Soil, 0.45% coir and 6% sand	23.22	1.635	4.20
Soil, 0.45% coir and 10% sand	21.79	1.664	5.49
Soil, 0.45% coir and 12% sand	20.28	1.680	6.12
Soil, 0.45% coir and 15% sand	18.30	1.710	7.40

Table 7 CBR Value for BC Soil Mixed with 0.60% NWC and Varying Percentage of Sand

Soil Mixed with NWC and Sand	OMC (%)	MDD(gm/cc)	Soaked CBR (%)
Soil, 0.60% coir and 3% sand	23.21	1.540	2.25
Soil, 0.60% coir and 6% sand	22.41	1.600	3.10
Soil, 0.60% coir and 10% sand	20.77	1.670	4.39
Soil, 0.60% coir and 12% sand	19.32	1.690	5.02
Soil, 0.60% coir and 15% sand	18.53	1.720	6.31

Table 8 CBR Value for BC Soil Mixed with 0.75% NWC and Varying Percentage of Sand

Soil Mixed with NWC and Sand	OMC (%)	MDD(gm/cc)	Soaked CBR (%)
Soil, 0.75% coir and 3% sand	23.27	1.520	2.28
Soil, 0.75% coir and 6% sand	22.40	1.532	2.93
Soil, 0.75% coir and 10% sand	20.83	1.551	4.44
Soil, 0.75% coir and 12% sand	19.37	1.579	5.07
Soil, 0.75% coir and 15% sand	18.60	1.597	6.34

On the basis of results, the effect of BC soil mixed with NWC and sand on OMC, MDD and CBR is given below:

(a) **OMC and MDD effects of BC soil including NWC**

It was discovered that when coir was combined with soil, OMC initially reduced and then grew beyond a certain point. Because coir was soaking water, MDD rose at first and then dropped after a specific threshold. Because more voids were produced, OMC dropped and MDD rose as the sand % increased.

(b) **Effect of BC soil mixed with NWC on CBR value**

When BC soil was combined with 0.45 percent NWC, the maximum CBR value was discovered to be 2.48 percent, and after that, the CBR value fell because coir breaks down and cannot bear load beyond a certain point. Because sand took more weight than dirt, the CBR value increased as the proportion of sand increased.

Based on results, the multiple linear regression models were developed for prediction of CBR:

(a) For NWC mixed with BC soil
CBR= -1.89 - 0.018 OMC +3.16 MDD + 35.97 C (R^2 = 98%)

(b) For NWC Mixed with BC soil and sand
CBR= -12.03 + 0.42 OMC + 2.17 MDD- 0.76 C + 0.48 S (R^2 = 94%)

Where,

CBR = California Bearing Ratio in %, OMC = Optimum Moisture Content in %, MDD = Maximum Dry Density in gm/cc, C = Non Woven Coir content in %, S = Sand content in %.

6. CONCLUSIONS

1. The addition of nonwoven coir to BC soil improved the soil's characteristics. The optimal nonwoven coir content was found to be 0.45%. In this example, CBR increases by 67.8% when compared to virgin soil CBR.

2. Soil qualities increase with the addition of sand to BC soil and non-woven coir mixes.

3. For varying percentages of sand and nonwoven coir, the CBR value steadily increases.

REFERENCES

[1] Agarwal, A., Muley, P., and Jain, P.K. (2016). "An Experimental and Analytical Study on California Bearing Ratio of Lime Stabilized Black Cotton Soil." Electronic Journal of Geotechnical Engineering, 21(20), 6583-6599.

[2] Chen, F. H. (1988). "Foundations on Expansive Soils." Elsevier Scientific Publishing Co., Amsterdam.

[3] Cokca, E. (2001). "Use of Class C fly Ashes for the Stabilization of an Expansive Soil." Journal of Geotechnical and Geoenvironmental Engineering, 127 (7), 568-573.

[4] Dif, A. E., Bluemel, W. F. (1991). "Expansive Soils Under Cyclic Drying and Wetting." Geotech. Testing Journal, 14 (1), 96-102.

[5] Eme, D.B., Nwofor, T.C, and Sule, S. (2016). "Correlation Between the California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) of Stabilized Sand-Cement of the Niger Delta." SSRG International Journal of Civil Engineering, 3(3), 7-13.

[6] Estabragh, A. R., Rafatjo, H., and Javadi, A.A. (2014). "Treatment of an Expansive Soil by Mechanical and Chemical Techniques." Geosynthetics International, 21 (3), 233-243.

[7] Indian Standards. (1970). "Classification and Identification of Soils for General Engineering Purposes." IS 1498, First Revision, Reaffirmed 2007, New Delhi, India.

[8] Indian Standards. - 1977 "Indian Standard Methods of Test for Soils: Determination of Free Swell Index of Soils." IS 2720 (Part XL), New Delhi, India.

[9] Indian Standards. (1980). "Indian Standard Code of Practice for Methods of Test for Soils: Determination of Specific Gravity of Fine Grained Soils." IS 2720 (Part 3/section 1), New Delhi, India.

[10] Indian Standards. (1980). "Indian Standard Code of Practice for Methods of Test for Soils: Determination of Water Content Dry Density Relation Using Light Compaction." IS 2720 (Part 7), New Delhi, India.

[11] Indian Standards. (1983). "Indian Standard Code of Practice for Determination of Density Index of Cohesion-Less Soils." IS 2720 (Part 14), New Delhi, India.

[12] Indian Standards. (1985). "Indian Standard Code of Practice for Methods of Test for Soils: Determination of Liquid Limit and Plastic Limit." IS 2720 (Part 5), New Delhi, India.

[13] Indian Standard (1987). "Methods of Test for Soil Laboratory Determination of CBR". IS2720 (Part 16), Second Revision, Reaffirmed 2002, New Delhi, India.

[14] Katti, R. K., Bhangle, E. S. and Moza, K. K. (1983). Lateral Pressure of Expansive Soilwith and without Cohesive Non-Swelling Soil Layer Applications to Earth Pressures of Cross Drainage Structures of Canals and Key Walls of Dams (Studies of K0 Condition). Central Board of Irrigation and Power. Technical Report 32, New Delhi, India.

[15] Kumar, P. S., and Devi, S. P. (2011) "Effect of Needle Punched Nonwoven Coir and Jute Geotextiles on CBR Strength of Soft Sub Grade". ARPN Journal of Engineering and Applied Sciences, 6(6), 114-116.

[16] Kumar, P. S., and Rajkumar, R. (2012). "Effect of Geotextiles on CBR Strength of Unpaved Road with Soft Sub Grade". Electronic Journal of Geotechnical Engg., 17, 1355-1363.

[17] Lopez-Lara, T., Zepeta- Garrido, J. A., and Castario, V. M. (1999). "A Comparative Study of the Effectiveness of Different Additives on the Expansion Behavior of Clays." Electronic Journal of Geotechnical Engineering, 4(5), paper 9904.

[18] Madhyannapu, R.S., Puppala, A.J., Nazarian, S., and Yuan, D. (2009). "Quality Assessment and Quality Control of Deep Soil Mixing Construction for Stabilizing Expansive Subsoils." Journal of Geotechnical and Geoenvironmental Engineering, 136 (1), 119-128.

[19] Maher, M. H., and Ho, Y.C. (1994). "Mechanical Properties of Kaolinite/Fiber Soil Composite." Journal of Geotechnical Engineering,120 (8), 1381–1393.

[20] Mathur, S., Swami, R.K., and Arun, U. (2012), "Lime/Cement Stabilisation for Soil and Granular Materials." National Workshop on Non – Conventional Material/ Technologies, NRRDA, New Delhi, 56-74.

[21] Meshram, K., Mittal, S.K., Jain, P.K., and Agarwal,P.K. (2013). "Application of Coir Geotextile in Rural Roads Construction on BC Soil Subgrade". International Journal of Engineering and Innovative Technology, 3(4), 264-268.

[22] Meshram, K., Mittal, S.K., Jain, P.K., and Agarwal,P.K. (2013). "Application of Coir Geotextile for Road Construction: Some Issues". Oriental

[23] Meshram, K., Mittal, S.K., Jain, P.K., and Agarwal,P.K. (2014). "CBR Improvement of Expansive Black Cotton Soil Using Coir Geotextile". NICMAR-Journal of Construction Management, XXIX (III), 45-50.

[24] Mishra, A. K., Dhawan, S., and Rao, S. M. (2008). "Analysis of Swelling and Shrinkage Behavior of Compacted Clays." Geotech. Geol. Eng., 26, 289– 298.

[25] Mokhtari, M., and Dehghani, M. (2012). "Swell- Shrink Behavior of Expansive Soils, Damage and Control." Electronic Journal of Geotechnical Engineering, 17, 2673-2682.

[26] Phanikumar, B.R., and Sharma, R. S. (2004). "Effect of Flyash on Engineering Properties of Expansive Soil." J. of Geotechnical and Geo- environmental Engineering, 130 (7), 764-767.

[27] Ravi Shankar, A.U., and Chandrasekhar, A. (2012). "Experimental Investigation on Lithomarge Clay Stabilized with Sand and Coir." Indian Highways, 40(2), 21-31.

[28] Satyanarayana, B. (1969). "Behaviour of Expansive Soil Treated or Cushioned with Sand." Proc., 2nd National Conference on Expansive Soils, Texas, 308-316.

[29] Sridharan, A., Soosan, T. G., Jose, B. T., and Abraham, B.M. (2006). "Shear Strength Studies on Soil-Quarry Dust Mixtures." Geotechnical and Geological Engineering, 24, 1163–1179.

[30] Terzaghi, K., Peck, R. B., and Mesri, G. (2010). "Soil Mechanics in Engineering Practice." John Wiley & Sons, Inc., U.K.

[31] Zemenu, G., Martine, A., and Roger, C. (2009). "Analysis of the Behaviour of a Natural Expansive Soil Under Cyclic Drying and Wetting." Bull. Eng. Geol. Environ., 68 (3), 421-436.

[32] Ziegler, S., Leshchinsky, D., Ling, H. I., and Perry, E.B. (1998). "Effect of Short Polymeric Fibers on Crack Development in Clays." Soils and Foundations, 38 (1), 247–253.