Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 10(X), 2022:
http://dx.doi.org/

Stabilization of black cotton soil using coconut fiber.
Estabilización del suelo de algodón negro con fibra de coco.

Arathi K U[1] Athulya K M[1] Vinaya V[1] Pooja P V[1] Athira V V[2]

[1]UG Student, [2]Assistant Professor
Department of Civil Engineering
Rajadhani Institute of Science and Technology
Palakkad (Kerala), India
Corresponding author mail id: 11170071@ammini.edu.in

ABSTRACT

Black cotton soil is a soil with low bearing capacity, swelling and shrinkage characteristics. Due to its peculiar characteristics, it forms a very poor foundation material. As black cotton soil is an expansive soil; it creates problem for lightly loaded structure than moderately loaded structure. Through this project, we are trying to study the improvements in the properties of soil by adding coconut fiber of varying percentages. Tests will be conducted to determine liquid limit and unconfined compression strength. Stabilization of soil is an effective method for improving the properties of soil. It has great significance in the future projects.

Keywords: Soil stabilization, CBR, Atterberg limits.

RESUMEN

El suelo de algodón negro es un suelo con baja capacidad de carga, características de hinchamiento y contracción. Por sus características peculiares, forma un material de cimentación muy pobre. Como el suelo de algodón negro es un suelo expansivo; crea un problema para la estructura con una carga ligera que la estructura con una carga moderada. A través de este proyecto, estamos tratando de estudiar las mejoras en las propiedades del suelo agregando fibra de coco en diferentes porcentajes. Se realizarán pruebas para determinar el límite de líquido y la resistencia a la compresión no confinada. La estabilización del suelo es un método eficaz para mejorar las propiedades del suelo. Tiene una gran trascendencia en los proyectos futuros.

Palabras clave: estabilización de suelos, CBR, límites de Atterberg.

INTRODUCTION

Urbanization in recent decades demands to take up construction of civil engineering projects even in weak soil due to land constraints. Black cotton soil is one such soil which lacks engineering properties such as shear strength and bearing capacity. In India, Black soil

covers about 30% of land area and is found majorly in states of Andhra Pradesh, Karnataka, Maharashtra, Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh and Tamil Nadu. Therefore such soils are to be stabilized before taking up construction works. Stabilization is a process of fundamentally changing the properties of soft soils by adding binders or stabilizers, to increase the strength and stiffness of the weak soils (Chackraborthy et al., 2014; Ikeagwani et al 2019). Stabilization by using waste products or by products can reduce this cost and also finds the solution for waste disposal. Coir or coconut Fiber belongs to the group of hard structural fibers. It is an important commercial product obtained from the husk of coconut. The coir fiber is elastic enough to twist without breaking and it holds a curl as though permanently waved (Eden et al., 2012). Shorter mattress fibers are separated from the long bristle fibers which are in turn a waste in the coir fiber industry. So this coir Fiber waste can be used in stabilization of soil and thus it can be effectively disposed off.

MATERIALS AND METHODS

Material collection

Black Cotton Soil

Expansive soils, popularly known as black cotton soils in India are, amongst the most problematic soils from Civil Engineering construction point of view. Of the various factors that affect the swelling behavior of these soils, the basic mineralogical composition is very important. Most expansive soils are rich in mineral montmorillonite and a few in illite. The degree of expansion being more in the case of the former.

Table 1 Properties of soil

PROPERTIES	VALUE
Specific gravity	2.07
Grain size distribution	Poorly graded
Liquid limit	58.8%
Plastic limit	29.72%
Plasticity index	29.08%
Liquidity index	0.27%
Consistency index	1.27%
Dry density	1.76 g/cc
Optimum Moisture Content(OMC)	23%

Fig 1 Black cotton soil

Coconut Fiber

Coconut fiber is extracted from the outer shell of a coconut. It is the natural fiber of the coconut husk where it is a thick and coarse but durable fiber. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts.

Fig 2 Coconut fiber

Determination of geotechnical properties

Properties of Black Cotton Soil

Black soils are highly argillaceous, very fine grained and dark, and contain a high proportion of calcium and magnesium carbonates. They are very tenacious of moisture and exceedingly sticky, when wet. Due to considerable contraction on drying large and deep cracks are formed. These soils contain abundant iron and fairly high quantities of lime, magnesia and alumina. Black soils are poor in nitrogen, phosphorus and organic matter. The soils are generally rich in montmorillonitic and beidellitic group of clay minerals.

Table 2 Properties of black cotton soil

PROPERTIES	VALUE
Specific gravity	2.7
Liquid limit(%)	68
Plastic limit(%)	27
Shrinkage limit(%)	11
Maximum dry density(KN/m3)	15.5
Optimum moisture content (%)	25.21
Cation exchange capacity(Meq/100g)	41.82
Specific surface area(m2/g)	63
Fine sand(%)	38

Properties of Coconut Fiber

Compared to other typical natural fibers, coconut fiber has higher lignin and lower cellulose and hemicellulose, together with its high microfibrillar angle, offers various valuable properties, such as resilience, strength, and damping, wear, resistance to weathering, and high elongation at break.

Table 3 Chemical Composition of Coconut / Coir Fiber

PROPERTIES	VALUE
Lignin	45.84%
Cellulose	43.44%
Hemi-Cellulose	00.25%
Pectin's and related Compound	3.00%
Water solubility	5.25%
Ash	2.22%

Table 4 Physical Properties of Coconut / Coir Fiber

PROPERTIES	VALUE
Length in inches	6-8
Density (g/cc)	1.40
Tenacity (g/Tex)	10.00
Breaking elongation (%)	30%
Diameter in mm	0.1 to 1.5
Rigidity Modulus(dyne/cm2)	1.8924

Tests Conducted

Atterberg limits test

1. Liquid limit

The liquid limit (LL) is conceptually defined as the water content at which the behaviour of a clayey soil changes from plastic to liquid. The Liquid Limit is determined as per I.S: 2720 (Part V)- 1985: "Indian standard for determination of liquid and plastic limits", Bureau of Indian Standards Publications. The test method also allows running the test at one moisture content where 20 to 30 blows are required to close the groove in a Cassagrande apparatus.

2. Plastic limit

The plastic limit (PL) is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface. The test is done as per I.S: 2720 (Part V)-1985: "Indian standard for determination of liquid and plastic limits", Bureau of Indian Standards Publications. If the soil is at moisture content where its behaviour is plastic, this thread will retain its shape down to a very narrow diameter. The sample can then be remoulded and the test repeated. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm. A soil is considered non-plastic if a thread cannot be rolled out down to 3.2 mm at any moisture.

California Bearing Ratio Test (CBR test)

CBR is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding

penetration of standard material. The CBR values of the test samples were determined corresponding to plunger penetrations of 2.5 mm and 5 mm as per the standard procedure laid down in IS: 2720, Part XVI (1965).

Unconfined Compression Test

In the unconfined compression test, the sample is placed in the loading machine between the lower and upper plates. Before starting the loading, the upper plate is adjusted to be in contact with the sample and the deformation is set as zero. The test then starts by applying a constant axial strain of about 0.5 to 2% per minute. The load and deformation values are recorded as needed for obtaining a reasonably complete load-deformation curve. The loading is continued until the load values decrease or remain constant with increasing strain, or until reaching 20% (sometimes 15%) axial strain. At this state, the samples is considered to be at failure (Kundan et al., 2013; Vidya et al., 2015). As for the results, the axial stress is usually plotted versus the axial strain. The maximum axial stress, or the axial stress at 20% (sometimes 15%) axial strain if it occurs earlier, is reported as the unconfined compressive strength σc.

Table 5 Tests conducted without coir fiber

TESTS CONDUCTED	RESULTS
Liquid limit	46.6%
Plastic limit	24.8%
UCC	55.2
CBR	3.5

Tests are conducted at 2%, 2.5% and 3% of coconut fibers

Table 6 Tests conducted by adding coir fiber

TESTS CONDUCTED	2%	2.5%	3%	REMARKS
Liquid limit	51%	54.75%	59.79%	Increase in compressibility
Plastic limit	30%	34.5%	36.8%	Increase in toughness
UCC	68.2	70.8	74.8	Increased strength
CBR	4.25	5.4	6.58	Increased strength

CONCLUSION

Based on the laboratory tests and experimental studies in the above study the following conclusions were drawn.

1. The UCC and CBR values increased for 2%, 2.5% and 3% of coir pith.
2. Addition of 2%, 2.5% and 3% of treated coir pith increased the CBR value4.25, 5.4 and 6.58 respectively ,when compared to the CBR value of untreated coir pith which is about 3.5. The higher the CBR value, harder will be the surface.
3. Increase in CBR value indicates the improved strength of black cotton soil.

REFERENCES

Chakraborty S., Mukherjee S.P., Chakrabarti S. and Chattopadhyay B.C. 2014. Improvement of Subgrade by Lime and Rice Husk Ash Admixtures, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 4, pp. 11034 – 11040.

Eden J.E. 2012. Rice Husk Ash Stabilization of Reclaimed Asphalt Pavement Using Cement as Additive, Proceeding of Geo Congress, pp. 3863-3872.

Ikeagwuani C.C., Obeta N., Agunwamba J.C. (2019). Stabilization of black cotton soil subgrade using sawdust ash and lime, Soils and Foundations, Volume 59, Issue 1.

IS: 2720 Part XVI (1965): "Methods of test for soils".

IS: 2720 (Part V)-1985: "Indian standard for determination of liquid and plastic limits".

Kundan Meshram, 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 (IJEIT), Volume 3, Issue 4, pp. 264 -268.

Vidya Tilak B., Rakesh Kumar Dutta and Bijayananda Mohanty. (2015). Effect Of Coir Fibers On The Compaction And Unconfined Compressive Strength Of Bentonite-Lime-Gypsum Mixture, Slovak Journal of Civil Engineering, Vol. 23, No. 2, pp. 1 – 8.

Received: 15th February 2021; Accepted: 04th May 2021; First distributed: 06th May 2021.