International Journal of Scientific & Engineering Research Volume 13, Issue 2, February-2022 447
ISSN 2229-5518

GEOTECHNICAL BEHAVIOR OF SILTY CLAY REINFORCED WITH MARBLE DUST AND CORN SILK FIBER

Saima Mehrooi, Amit Talgotra

ABSTRACT :The motivation behind this research was to learn more regarding the properties of soil strengthened with marble dust and corn silk fiber, which are industrial waste products and corn products, respectively. The use of these waste materials reduces pollution and human reliance on natural resources, resulting in a more sustainable construction approach.The consequences of cornsilk and marble dust fiber on soil strength prospect for silty clay soil are investigated in this study. Cornsilk was mixed with soil at various rates in this study, including.4 %,.8 %, 1.2 %, and 1.8 %. Furthermore, the length of 40mm long fiber was used in the study. After that, the marble dust was blended in various amounts with the best soil fibre mix, including 5%, 15%, 25%, and 35%. The investigation of an influence of marble dust and cornsilk fiber on Atterbers limits, C.B.R., U.C.S., O.M.C., and D.D. was done. Adding marble dust and cornsilk fiber improved the U.C.S. and C.B.R. As per experimental results, the ideal value of C.B.R. and U.C.S. was at 25 % marble dust, 74.6 % soil and 0.4 % cornsilk fiber.

Keywords: Soil stabilization, Marble dust, cornsilk fiber, UCS, CBR, MDD, OMC.

1. INTRODUCTION

Soil improvement is a significant problem in building operations because of the increasing urbanization and industrial development, which forces the construction of other weak or inappropriate soils. Soil improvement is a procedure of employing various technologies to enhance index characteristics and other soil engineering characteristics. The soil is utilized as construction material in many sectors, including road, irrigation, canal structure, etc. Soil improvement is necessary when soil is weak. The soil needs to be modified to meet requirements that vary from location to location.

Soil reinforcement is one of many ways of soil improvement. It is essential to strengthen soil mass by improving its bearing capacity and minimizing settlement and lateral deformation that improves stability. Conventional techniques of reinforcement ensure that strips are continuously included. For a long time in many South Asian Nations, natural materials including jute, bamboo, coir, and corn silk were used for reinforcing purposes. For many millennia, soil stabilization has been done to increase the soil's engineering qualities. Soil stabilization methods include mixing the soil with more strength or binding materials such as calcareous, cement, calcium, and fiber.

Strengthening of the soil leads to increased soil strength, bearing capacity, ductility, and prevents deformations. Soil can be improved using high-strength metal strips, wire, natural and synthetic fibers with comparatively low modulus. Significant progress has been made over the years to improve the soil's engineering characteristics. The study showed that fiber added to the soil was an excellent approach to improve soil's overall technical performance. The technique of fiber reinforcing in all soil types is efficient. The concept of natural fiber soil reinforcement is old. Natural fibers are readily accessible in the area, and they may be used to create composites with cement, lime, and marble dust. It is inexpensive, biodegradable, and beneficial to the environment. Natural fibers such as cocoa (coir), sisal, palm, rice husk, barley straw, corn silk, Etc., may be utilized efficiently in the field of soil stabilization. In specifically, geotextiles, corn silks are developing technical fabrics frequently utilized in geotechnical and biotechnological industries. They can be given different designs, forms, sizes, and compositions based on the site conditions and functional requirements. Civil engineers believe soil to be a complicated substance. For practical design and construction of pavement foundations, embankments, and excavation, we must establish the physical characteristics of soil and know issues. Some problems require the improvement of soil characteristics.

2 Objectives of Research

The following are primary objectives of the research:

1. To assess the impact of marble dust and Corn silk fiber reinforcing material on the index properties of the virgin soil.
2. To study the impact of marble dust and corn silk fiber as reinforcing material on the compaction properties of virgin soil.
3. To study the stress strain behavior of optimum mix based on the UCS test.
4. To determine load v/s penetration graph by using the CBR test.

3 Literature Review

A review of previously conducted research on the subject. It summarizes research on soil reinforcement using marble dust and corn-silk fiber as reinforcing materials and demonstrates soil properties and performance when marble dust and corn-silk fiber are added as reinforcing materials.

- Ankush Kumar Jain et al (2020) investigated the geotechnical behavior of expansive soil amended with marble dust and micro-analyses of the soil at (0%,-100% with an increment of 10%). They concluded that as the amount of marble dust in the soil increases, the plasticity index of the soil decreases significantly. Also, increasing percentages of marble dust, the maximum dry density (MDD), and optimal water content (OWC) of soil increase and decrease, respectively. The soil strength gradually increases with an increase in marble dust content up to 20%, then gradually decreases.
- Nikhil Gupta et al (2020): The Effect of Marble Dust and Paddy Straw on the Strength Characteristics of Clayey

Soil was investigated. They concluded that as the percentage of the paddy straw fiber increased, so did the CBR and UCS value. Also, the MDD value of paddy straw (75mm length) marble dust mix initially increased from 1.86g/cc to 1.90g/cc and then decreased to 1.89g/cc at 1% paddy straw fiber, and the OMC increased with increasing paddy straw fiber percentage.

- Khiem Quang Tran et al (2018) The mechanical behavior of cemented soil was studied using corn-silk fiber. They used the range of cement content (4%, 8%, and 12% by dry soil weight) and fiber content (0%, 0.25%, 0.5%, and 1% by dry soil weight).The result shows that the addition of fiber (0 % -1 %) in cemented soil resulted in a decrease in the maximum weight of the dry unit and an increase in the optimum content of water. With the addition of corn-silk fibers, the compressive strength and tensile strength of cemented soil improved.
- Khiem Quang Tran et al (2018) investigated the impact of corn silk fiber reinforcement on mechanical properties of soft soils at various fiber lengths, i.e.,10mm, 30mm, and 50mm. The length and substance of fibers in the soil matrix notably affect γd and OWC. Fiber content ascending from 0 to 1.5% produces the expansion in γd; further expanding fiber content, the γd diminishes, and OWC increases. Compressive strength improves with the addition of fiber. The most significant increase in compressive strength is 38%. The ideal fiber content in the study was 1%. The compressive strength is altogether influenced by fiber length. The best fiber lengths on compressive quality are 10mm to 30mm.
- Akshaya Kumar et al (2011) studied the effect of marble dust on the strength and durability of Rice husk ash stabilized expansive soil. They concluded that The MDD decreases and OMC of RHA stabilized expansive soil continues to grow regardless of the amount of Marble dust added to the soil, and the UCS of the RHA stabilized expansive soil increased up to 20 percent with the addition of Marble dust.

4 Material and Methodology

4.1 Soil sample:

Because the upper layer of the soil is likely to contain organic matter and other foreign material, the required amount of soil is collected from the area at a depth of 1.5 m below the level. The collected soil sample has been thoroughly examined to ensure that it is relatively homogeneous. The soil is then air-dried, crushed with a wooden mallet, and sieved at 4.75mm This soil is taken from the Manasbal village in the Ganderbal district of Jammu and Kashmir. There is also a lake known as Manasabal lake. Basic tests are conducted in this soil according to the IS Code.

4.2 Marble dust

Marble is a non-foliated metamorphic rock with recrystallized carbonate minerals, most commonly calcite or dolomite. Marble is a metamorphic rock formed by the transformation of pure limestone.

Table 1 Marble dust chemical composition

Oxide component	Marble Dust (Mass%)
SiO2	28.35
AL2O3	.42
Fe2O3	9.70
CaO	40.45
MgO	16.25
TiO	.549
Cr2O3	.24
ZnO	.20

Table 2 Physical properties of marble dust

Properties	Marble powder
Specific Gravity (g/cm3)	2.71
Surface by Blaine (cm2/g)	4372
Colour	Greyish white

4.3 Corn-silk fiber

The rapidly increasing demand has heightened awareness of the importance of reusing forest wastes and agricultural residues/wastes. Non-wood fibrous material is used to stabilize the soil, aiding in the reduction of environmental pollution. The corn-silk fiber is frequently referred to as the lustrous Thread-like fibers that grow on corn ears (maize).

Table 3 Properties of corn-silk fiber

Material property	Values
Fiber length	40mm
Diameter	.1mm - .4mm
Colour	Pale yellow

4.4 Sample preparation

By unit weight of the soil, the samples were made by combining soil, four percentages marble dust, and corn soil fiber. The soils were first dried in an oven. After that, the dry soil was crushed with a hammer. Corn-silk fibers were cut to the desired length, which was 40 mm in this case. These are already sealed in polythene bags to ensure that the moisture content of the fiber is consistent. The fiber, on the other hand, is already dry. Polythene bags were also used to store marble dust. After thoroughly mixing the soil, marble dust, and fiber, the required amount of water, i.e., OMC, was added and mixed uniformly by hand. Because the mixer caused the fibers to tangle or break, most soil-fiber mixing was done by hand rather than with a mixer. The specimens were prepared with varying fiber contents (.4% , .8%, 1.2%, 1.60%). Moreover, there are various marble dust contents (5%, 15%, 25%, and 35%). The IS Code was used to prepare various samples for various UCS, CBR, Compaction tests, and liquid and plastic limit tests. For each fiber and marble dust content, at least three samples were used, with the average being used as the main result in each test.

4.5 Properties of soil

Basic test were conducted on the soil without reinforcement like Water content test, Liquid limit, plastic limit and specific gravity test.

Table 4 : Properties of soil without reinforcement

Property	Value
Natural water content	24.5
Specific Gravity	2.64
Liquid Limit	36
Plastic Limit	27
Plasticity Index	9
Soil classification	MI- CI

4.6 Compaction Characteristics of Soil

The standard proctor test (Light compaction test) is used to determine compaction

Table 5: MDD and OMC of Virgin soil

Soil	Value
MDD (kN/m3)	17.01
OMC (%)	18.50

4.7 Unconfined Compressive Strength

It is a machine used to test cohesive soils for their short-term stability in foundations and slopes with a high loading rate but a low drainage rate. There is no confining pressure

Table 6 : UCS of virgin soil

Soil	qu (kPa)
Virgin soil	102.6

4.8 California Bearing ratio

The California bearing ratio (CBR) is a penetration test used to determine the road and pavement subgrade strength

Table 7: CBR of Virgin soil

Soil	CBR (%) at 2.5mm	CBR (%) at 5 mm	CBR (%)
Untreated			
Soaked	0.80	1.69	1.80
Unsoaked	0.91	1.83	1.91

5 Results AND DISCUSSION

Table 8: Combination of Soil, Marble Dust, and Cornsilk Fiber

Soil (%)	Marble dust (%)	Corn-silk fiber(%)
100	0	0
94.6	5	0.4
84.6	15	0.4
74.6	25	0.4
64.6	35	0.4

5.1 Consistency limits

The index properties of soil are those that indicate its engineering properties.

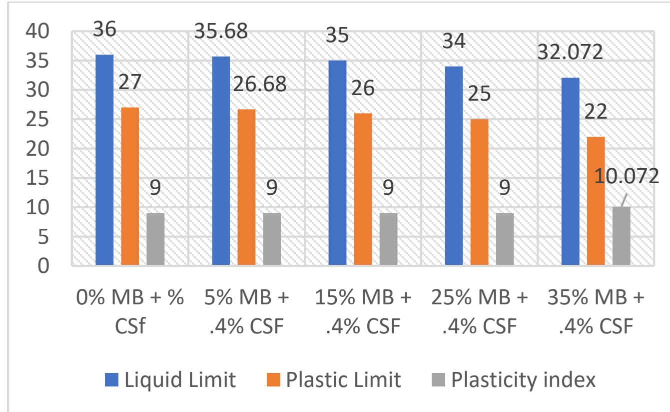

Fig 1 : Consistency Limits Test (LL, PL, PI) the Results of Soil: MB: CSF

The decrease in liquid limit specifies that more water is required for the treated soil to make it fluid.

5.2 Effect of marble dust on MDD and OMC

The compaction test was used to examine O.M.C. and M.D.D. of the soil. Fig.2 shows the effect of fiber content and marble dust on M.D.D. and O.M.C. The M.D.D. The first increase then decreases with the increase in marble dust. The decrease in M.D.D. is due to the reduction of average unit weight of solids in soil mixture because of less unit weight of marble dust and CSF.

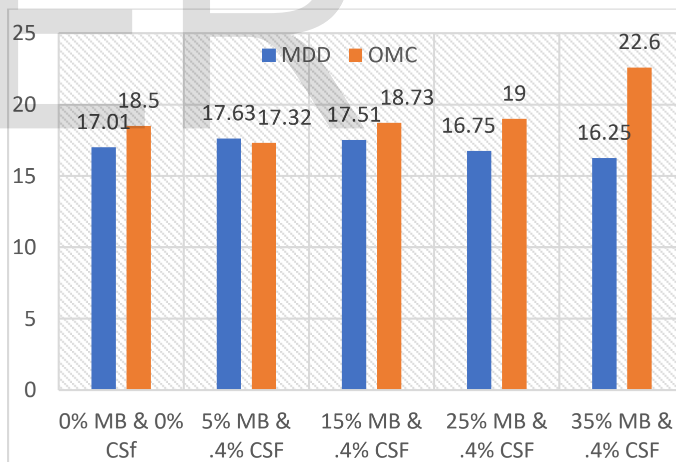

Fig. 2 The effect of MDD and OMC of marble dust and optimum CSF

5.3 Unconfined compressive strength

The stress-strain curves for all soil marble dust and CSF mix from the compression test are shown in Fig 4. The U.C.S. value of the specimen without additive is 102.2 quKPa. The stress-strain curves for reinforced specimens, on the other hand, continued to grow up to 25% MB+ 0.4%CSF. Then it starts to decline at 35% MB and 0.4 % CSF. The results of the stress-strain curves revealed that soil with additives was more ductile than soil without additives. Compressive stress-strain improvement was correctly related to interlocking, which consisted of a three-dimensional spatial network of scattered fibers in the soil matrix. The interlocking force can enhance coherence and prevent marble dust, fiber – soil matrix displacement. Another reason for the increased strength was the attachment of many soil particles to the marble dust-fiber, which resulted in better adhesion of the marble dust-fiber soil matrix—as a result, incorporating marble dust and cornsilk fiber into the soil increased compressive strength and strain.

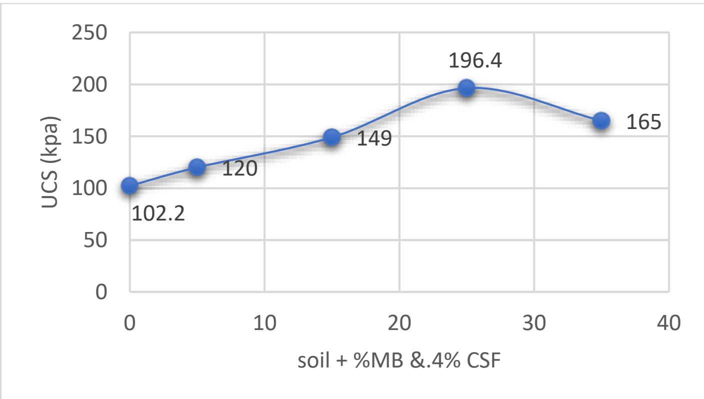

Fig. 3 Stress- strain curve with variation of MB and optimum CSF

5.4 Effect of Marble dust and CSF on CBR

The C.B.R. value has increased with the percentage of marble dust. The increase in C.B.R. in soil mix is due to the presence of marble dust as cement and fibre as reinforcing material.

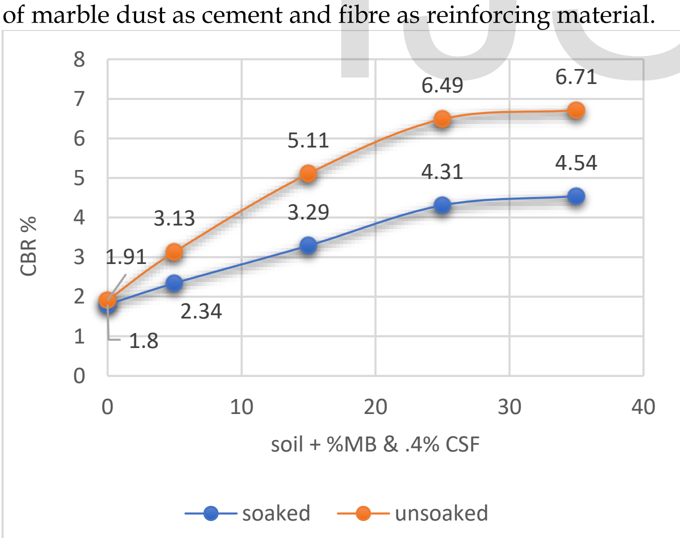

Fig 5.16: Variation of CBR with Different MB % and 0.4% CSF

6. Conclusion

The soil properties reinforced with marble dust and Cornsilk fiber were examined by conducting a sequence of experiments, including liquid limit, plastic limit, compaction tests, U.C.S., and C.B.R. The following conclusion derived from experimental results can be drawn:

- The O.M.C. of soil, marble dust, and CSF mix increases and decreases as the percentage of marble dust and CSF increases.
- The UCS increases up to 25% MB and.4% CSF and then decreases. The untreated soil's UCS was determined to be 102.68 KPa. The results indicate that compared to untreated soil, the estimation of qu of the treated sample increased up to 196.40 KPa, corresponding to 25% MB.4% CSF, i.e., a rise of around 1.9 times.
- The CBR value obtained from the tests revealed that the value increases up to 25% Marble dust + 0.4% CSF content, after which there is a minor increase in CBR. From 0% to 25% Of MB +.4 percent CSF, the CBR value increased from 1.80 to 4.31, a minor increase of 11 %, while from 15% to 25% of MB +.4 % CSF, the CBR value increased 3.29 to 4.31, a 31% increase.
- Furthermore, by increasing the MB from 0% to 35 and 0.4 % CSF, the Unsoaked CBR value increased from 1.91 to 6.17. Between 25% MB +0.4% CSF and 35% MB +0.4 % CSF, there was only a slight increase in CBR. It was discovered that fiber reinforces the soil through cohesion and friction with the soil. The primary benefit is that it imparts ductility to the soil. It is a reasonable engineering requirement.

7. References

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