STABILIZATION OF SOIL USING COIR FIBER

Ujala Kumar[1], Dr Vikrama Pandey[2], Prashant Ranjan Malviya[3]

[1]M.Tech Scholar, Department of Civil Engineering, B.I.T Sindri, Dhanbad
[2]Professor, Department of Civil Engineering, B.I.T Sindri, Dhanbad
[3]Assistant Professor, Department of Civil Engineering, B.I.T Sindri, Dhanbad

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Abstract *This research focused on the compaction characteristics (MDD, OMC & UCS) and strength properties (CBR Values) of expansive soils such as clayey soil. Compaction characteristics and bearing capacity can be improved by stabilization process of soil. These properties can be improved by controlled compaction using mechanical equipment or by addition of suitable admixture or reinforcing the soil with crumb rubber, plastic waste, fiber etc. here we used natural fiber like coconut coir fiber. Reinforcement of soil with coir fiber is low-cost approach for improving the soil properties such as (unconfined shear strength, MDD value, CBR value). It includes effects of coir fiber on clayey soil based on the results of Standard Proctor tests, unconfined compressive strength tests, Atterberg limit test, and California Bearing Ratio (CBR) tests. Coir Fiber was added in different proportions of 0.25%, 0.50%, 0.75% and 1% respectively. It is found that with addition of coconut coir fiber at 0.5%, with clayey soil M.D.D changes from 1.87 gm/cc to 1.96gm/cc. C.B.R ratio from 2.12% to 6.71% and U.C.S value from 0.2058 kg/cm² to 0.3753 kg/cm² at O.M.C of 12.25%.*

***Key Words*: Coir Fiber, Stabilization, Clayey Soil, Maximum Dry Density**

1.INTRODUCTION

Soil stabilization is the process of improving the soil properties by different methods. Due to various reasons the soil at a particular site does not meet the requirement of particular project such as shear strength, unconfined compressive strength and bearing capacity of soil. In that case, it is most necessary to modify the soil properties as per requirements. This study utilizes coir fiber for improving the strength parameters of clayey soil. Coir fiber extracted from the outer shell of a coconut husk. It is a low-cost material and readily available.by performing soil improvement following advantages can be achieved:

It improves Bearing Capacity of soil

It reduces ground settlements.

Many research work has been done utilizing the coir fiber for stabilization of soil which are:

[1] Sasikala S et al. (2019). When Soil was reinforced with 1.2 % Coconut Coir Fiber, it was observed that there was 47.4 % increase in UCS strength and 4 times increase in soaked CBR value compared to unreinforced soil. The maximum Unconfined compressive strength was increased to 132 kPa from 90 kPa.

[2]Prag M Chaple (2016)

In the test it was observed that the U.B.C has increased from 250kN/m² to 415kN/m² for 0.25% coir fiber, 495kN/m² for 0.50% coir fiber , 445 kN/m² for 0.75% coir fiber and finally it reduces to 360kN/m² for 1% coir fiber.

[3] Singh and Mittal et al (2014)

The CBR value of soil mixed with 1% coir fibre improves from 4.75 percent to 9.22 percent when it is wet, and from 8.72 % to 13.55 % when it is not soaked. When 1 percent randomly dispersed coconut is added to the soil, the UCS increases from 2.75 kg/cm² to 6.33 kg/cm²

[4] Singh and Arif (2014)

They conducted an experimental study on silty sand (SM) (local soil) mixed with varying percentage of coal ash (20%, 30%, 40% and 50%) and coconut coir fibre (0.25, 0.50, 0.75 and 1.0%). They performed unconfined compressive strength (UCS) and California bearing ratio (CBR) tests on the soil mixed with coal ash & coir fibre both. They observed the significant improvement in UCS and CBR value by adding 20% of coal ash and 0.25% coir fiber in the soil. Their results showed that the UCS value is maximum (2.81 kg/cm²), for 20% coal ash mixed with 0.25% coir fiber in soil then the un-soaked and soaked CBR values was increased from 10.5% and 5.6% to 27.7% and 14.6%, respectively. The optimum percentage of soil-coal ash-coir fibre mix is arrived at 79.75:20:0.25 (by weight)

2. MATERIAL USED IN STUDY

2.1 CLAYEY SOIL

Clay is a finely grained natural rock or soil material that is made by the combination of one or more clayey minerals. It contains high percentage of fine particles and colloidal substances, it become sticky when wet. Clays are plastic due to particle size and geometry as well as water content. It becomes hard, brittle and non-plastic upon drying. Clays are distinguished from other fine-grained soils by differences in size and mineralogy., despite the fact that many naturally occurring deposits contain both silts and clay. It is classified as clay when particle size is smaller than 2 μ by ISO 14688.

Table 1 Properties of soil used in study

PARAMETER	VALUES
Liquid Limit	31.3%
Plastic Limit	21.6%
Plasticity Index	9.7%
Specific Gravity	2.36
UCS	20.18 kN/m^2
Unsoaked CBR	2.12%
MDD	16.66%

2.2 COCONUT COIR FIBER

Coconut coir Fiber is obtained from the husk of coconut and belongs to the group of hard structural fibers. The coconut husk is made up of a smooth waterproof outer layer and a fibrous zone. Coir fiber comes in two varieties: brown fiber from mature coconuts and white fiber from immature green coconuts. Brown coir fiber may be utilized in highways projects. This brown coir fiber is elastic enough to twist without breaking. In this study brown coconut fiber has been used.

Physical properties of coir fiber

Table2. source (Ravi Shankar et al.)2012

Lenth in inches	6-8
Density (gm/cc)	1.40
Tenacity (g/Tex)	10.0
Elongation%	30%
Diameter in mm	0.1-0.5
Rigidity Modulus (GPa)	1.8

The size in this study is used 15 cm to 20 cm.

Fig 2 Coir Fiber

Advantages of coir fiber

1. The fibre is abundant, non-toxic in nature, biodegradable, low density and very cheap.
2. The fibre has a high degree of retaining water and also rich in micronutrients.
3. The fibers instead of going to waste are explored for new uses.

3. EXPERIMENTAL ANALYSIS

Various laboratory tests have been performed to determine the properties of the the natural soil and soil mixed with different proportions of coir fiber (0.25%,0.5%,0.75% and 1%). In order to study the properties of stabilized soil, the different tests have been conducted. Those tests are Standard Proctor test, Atterberg's limit test, Unconfined compressive strength test, CBR test.

Following IS:Codes were referred for the performance of the test are as follows :-

1. IS: 2720 (Part 7) – 1980 Standard proctor test
2. IS: 2720 (Part 10) – 1991 Unconfined compressive strength (UCS) test
3. IS: 2720 (Part 16) - 1987 CBR test (California Bearing Ratio) test
4. IS: 2720 (Part 5) - 1985 Atterberg Limit test for liquids and plastics
5. IS:2720 (Part 3) – 1980 Specific gravity test of soil using pycnometer

4. RESULTS AND DISCUSSIONS

4.1 PROPERTIES & CLASIFICATION OF SOIL

After performing various experiment following properties of soil were found

1. Liquid Limit = 31.3%
2. Plastic limit = 21.6%
3. % passing through 75µ = 57.60%

Plasticity Index (PI) = LL-PL
= (31.3-21.6)
= 9.7%

According to plasticity chart value of Ip from equation of A line = 0.73(WL-20)
= 0.73(31.3-20)
= 8.24

As Ip > Value of Ip from A line & liquid limit <35

- Hence, Soil is CL soil (clay of low plasticity)

Based on the above results, the soil was classified as Clay of Low Plasticity.

4.2 EFFECT OF COIR FIBER ON OMC AND MDD

The variation in the OMC and MDD on increasing the Coir fiber as follows:

Table 3 Effect of Coir Fiber on MDD and OMC

Coir Fiber Proportion	Maximum Dry Density	Optimum Moisture Content
0%	1.87 g/cm³	14.53%
0.25%	1.92 g/cm³	14.25%
0.50%	1.96 g/cm³	12.25%
0.75 %	1.93 g/cm³	14.59 %
1.0 %	1.89 g/cm³	18.00%

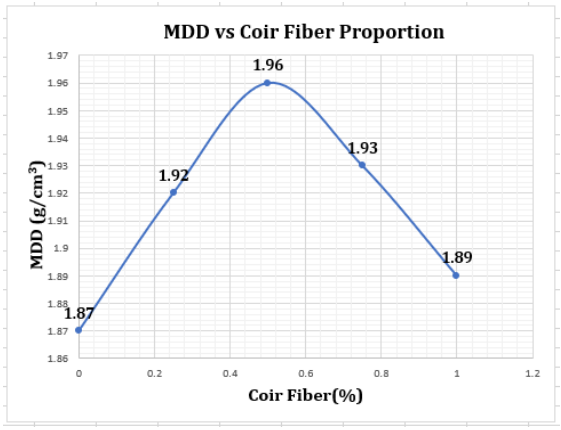

Fig 3: Effect of Coir Fiber on MDD

- From figure 3, it was observed that on increasing coir fiber proportion from 0% to 0.25% and 0.5% MDD value increased from 1.87g/cc to 1.92g/cc and 1.96g/cc respectively. On further increment in coir fiber proportion from 0.5% to 0.75% and 1.0%, The MDD value decreased from 1.96g/cc to 1.93g/cc and 1.89g/cc respectively.

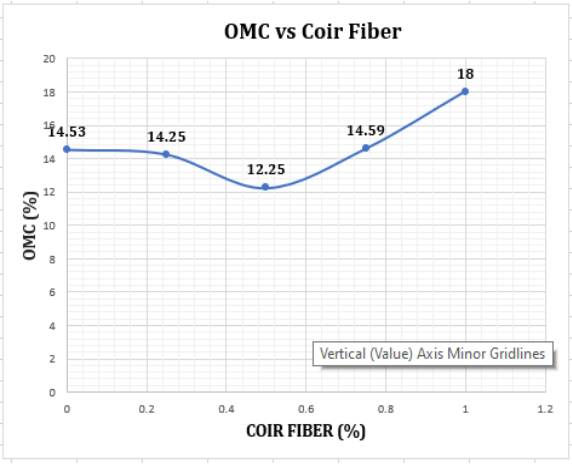

Fig 4 : Effect of Coir Fiber on OMC

- From figure 4, it was observed that OMC decreased from 14.53 % to 12.25% when proportion of coir fiber increases from 0% to 0.5% after that OMC increases to 14.59% and 18% when coir fiber proportion increases from 0.5% to 0.75% and 1% respectively.

4.3 EFFECT OF COIR FIBER ON UNSOAKED CBR VALUE

The variation in the Unsoaked CBR Value on increasing the Coir Fiber Proportion are as follows:

Table 4 Effect of Coir Fiber on Unsoaked CBR

Coir Fiber (%)	0	0.25	0.5	0.75	1
Unsoaked CBR (%)	2.125	4.33	6.71	6.17	5.95

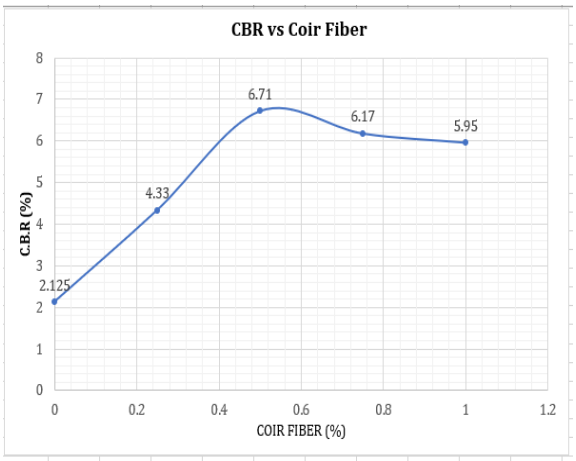

Fig 5 : Effect of coir Fiber on CBR

- Initially CBR value was 2.12% on increasing coir fiber upto 0.50% it increases to 6.71 % then it decreases to 6.17% and 5.95% when coir fiber proportion increases to 0.75% and 1% .

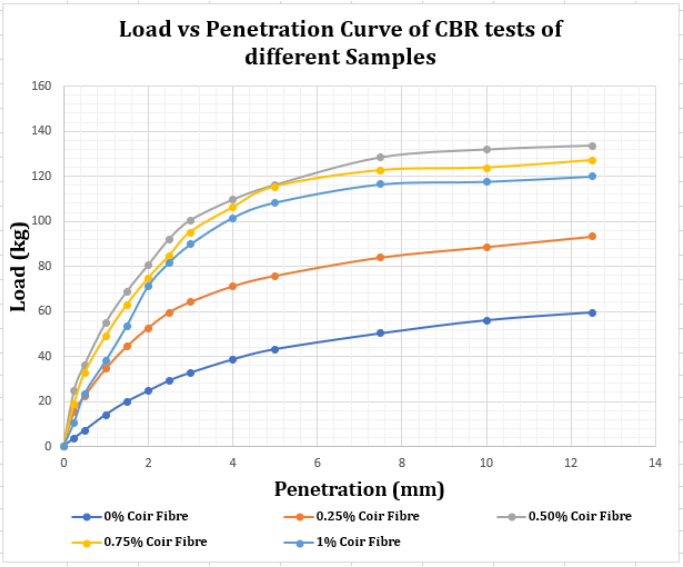

Fig 6: Load vs Penetration curve with different percentage of coir fiber

It was observed that the optimum CBR value comes while adding coir fiber 0.5% to the clayey soil having value of 6.17%.

4.4 EFFECT OF COIR FIBER ON UCS value

The variation in the UCS value on increasing the Coir Fiber Proportion are as follows:

Table 5 Effect of Coir Fiber on UCS values

Coir Fiber (%)	0	0.25	0.5	0.75	1
UCS (kg/cm²)	0.21	0.34	0.38	0.34	0.29

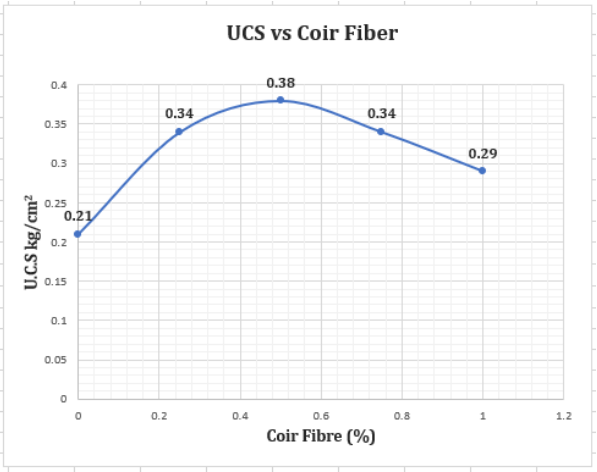

fig 7 : Effect of Coir fiber on UCS

- UCS value of natural soil was 0.21 kg/cm² on increasing coir fiber ucs value increase till 0.5 % of coir fiber to 0.38 kg/cm² after that it decreases to 0.29 kg/cm² at 1% coir Fiber

5. CONCLUSIONS

As per the data and results obtained from the experimental work on the soil stability investigation on clayey soil with different proportion of coir fiber i.e. (0.25%, 0.50% , 0.75% and 1%) as a reinforcing material, following conclusion can be drawn:

- The soil used for the study was clay of low plasticity (CL) soil.
- C.B.R value increased by 3 times on addition of 0.5% coir fiber, CBR value increased from 2.12% to 6.71%.
- M.D.D value increases by 4.62% after addition of 0.5% coir fiber. The M.D.D value increased from 1.87 g/cm³ to 1.96 g/cm³
- U.C.S Value increased by 81 % on addition of 0.5% coir fiber, It increased from 0.21 kg/cm² to 0.38 kg/cm².
- It can be concluded that 0.5% coir fiber in soil is optimum percentage for maximum CBR value and UCS value.
- Since the C.B.R value increased after inclusion of coir fiber so less thickness of subgrade layer is required

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AUTHOR

NAME: UJALA KUMAR
Affiliation: M. Tech Research Scholar
BIT SINDRI