

# Experimental Investigation on Mount Soil and an Ancient Stabilization Technique

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**ABSTRACT:** Experiments have been in a flow for searching methods and developing new additive materials to improve the properties of soil as ground improvement is inevitable for many situations in the context of civil engineering. Attempt is made here to test the properties of termite mound soil anticipating increase in strength parameters of soil. Termite made physical, chemical and biological modification to soil, thus the termite mound soil have many desirable properties as foundation and construction material. Experiments are conducted for grain size analysis, Atterberg's limits, Standard Proctor Test, CBR test, permeability test, direct shear test, and unconfined compressive strength test and proved that termite mound soil have better geotechnical properties compared to surrounding control soil. Also it is recorded that older generation traditionally prepared stabilized soil by mixing unknown ingredients in to locally available mound soil. This set of studies also identified possible natural stabilizer with termite mound soil which has proved a notable increase in the strength parameters of the test soil.

**KEYWORDS:** Termite mound soil, Natural stabilizer, Control soil.

## I. INTRODUCTION

Termites are social insects, in which 75% are soil feeding. During mound construction, the termites cement the soil particles together with their saliva or excreta (Ramesh K. Kandasami,2016). Hence, the physical and chemical properties of these mound soils are different from the surrounding control soils. Heat treated termite mound is wear resistance, impermeable and has cementitious properties which makes it a good building material

Earth as a construction material has been utilized for thousands of years by civilizations. Different methods have been developed according to the local climate and environment as well as local traditions and customs. People from old generations utilize Termite mound soil for construction of houses by using ancient stabilization techniques. They prepared a particular soil mix through the addition of certain natural ingredients with the locally available termite mound soil. There is no particular documentation available on how this soil mix had been prepared. These old houses provide an excellent seasonal comfort for hot and cold climate. All information available from ancient techniques contain secret ideas, such ideas should be verified with modern research methodology and experiments

The present study aims to adopting and applying biomimetic systems that will need in a sustainable future. It will helps to effective utilization of locally available termite soils and other suitable stabilizing agents and thus improving soil strength and durability.

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## II. MATERIALS USED

### 1. Termite mound soil

Termite mound soil is collected from Airapuram, Ernakulum. The location is having an elevation of 23m. The soil was brick red in colour and having some amount of water is present in it. Since it is very hard, greater effort is required to collect samples from the mound. The properties of Mound soil found are shown in table 1.

TABLE 1: PROPERTIES OF MOUND SOIL

Properties	Value
Specific Gravity	2.17
Natural water content (%)	17
<b>UCC strength test</b>	
Compressive Strength (kN/m <sup>2</sup> )	19.62
Shear strength (kN/m <sup>2</sup> )	9.8
<b>Direct shear test</b>	
Cohesion, C	0
Angle of internal friction, $\Phi$	2°51'
<b>Standard Proctor test</b>	
Maximum Dry Densit(g/cc)	1.78
Optimum Moisture Content	14%
Coefficient of Permeability (cm/sec)	9.89x10 <sup>-5</sup> ( <i>poor drainage</i> )
CBR Value (%)	6.3
Liquid Limit (%)	40
Plastic Limit(%)	14
Plasticity index(%)	26
Particle Size Distribution	
Gravel (%)	0
Sand (%)	56
Clay (%)	41
Soil classification	SC, Clayey sand

### 2. Surrounding Control soil

Surrounding control soil is collected from 3m away from termite mound. After removing the vegetation from the top soil, Samples are collected with more easily than the mound soil. Control soil was dark brown in colour. The properties of control soil are shown in table 2

TABLE 2. PROPERTIES OF CONTROL SOIL

Properties	Value
Specific Gravity	2.3
Natural water content (%)	20
Liquid Limit (%)	32
Plastic Limit(%)	9
Plasticity index(%)	23
Particle Size Distribution	
Gravel (%)	17
Sand (%)	51
Clay (%)	30
<b>UCC test</b>	
Compressive Strength (kN/m <sup>2</sup> )	7.5
Shear strength (kN/m <sup>2</sup> )	3.75

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Standard Procter test	
Maximum Dry Density (g/cc)	1.5
Optimum Moisture Content	12%
Coefficient Permeability (cm/sec)	$2.2 \times 10^{-4}$
CBR Value(%)	2.4

### 3. Bral Fish

Bral fish is a fresh water fish. The body of Bral is long and cylindrical with a huge mouth and Snake like head. These are often found in ponds, paddy fields and in rivers. The secretion of Bral posses a little adhesion in water. The adhesives from Bral fish are also having some medicinal value too. Shown in fig (a)

### 4. Liana stem

Lianas are woody climbers and they often found in tropical forests.They are known as Structural parasite, because they do not take water or nutrient directly from host tree, but it affects the plant growth indirectly. Lianas are implicated in large tree mortality. However the general practice is to cut the lianas immediately, otherwise it damages to the surrounding trees too. Liana stems Shown in fig (b)

### 5. Coir fiber

Coir fiber is a natural and hard fiber extracted without any treatment from the husk of coconut. Coconut husk is kept submerged in water up to 6 months and then bitten to loosen coir. It is very coarse with very low aspect ratio. And is abundant in Kerala thus they are very cheap. For this study fiber was collected from Alappuzha. Coir fiber is shown in fig (c).The properties of coir fiber are shown in table 3.

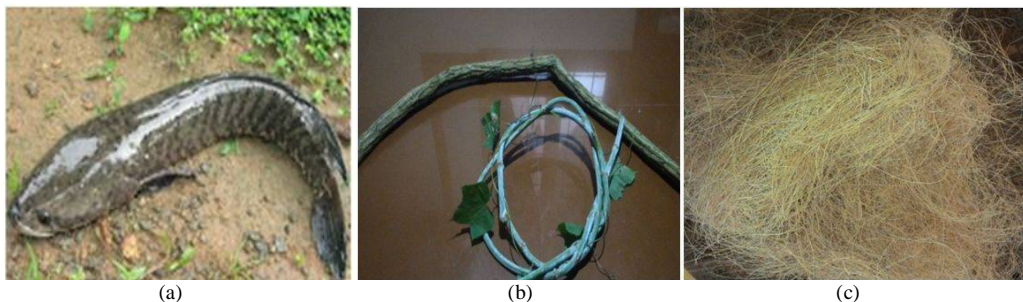


Fig. 1 Materials Required are (a) Bral Fish (b) Liana stem (c) Coir fiber

TABLE 3. PROPERTIES OF COIR FIBER

PROPERTIES	Diameter	Length	Specific gravity	Density	Young's modulus	Tensile strength	porosity
VALUE	0.1-0.3 mm	15-20cm	1.4	1.4g/cc	2.1GPa	128MPa	40%

The natural coir fiber of random length varies between 15mm to 20 mm was used as reinforcing material in this study. The average diameter of fiber was 0.2mm. Young's modulus value is greater than other reinforcing materials

## III. PREPARATION OF NATURAL STABILIZER

Natural stabilizer (N.S) is a mixture of liana juice and bral fish secretion and its preparation is carried out by the following steps.

### Step 1:

Cut the liana stem in to small pieces, squish it with a hammer

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Fig 2.Squished Liana stem

## Step 2:

- Pour water containing Bral fish secretion into this squished liana stem. Add ½ liters of Bral fish secretion to 1kg of liana stem, for an approximate proportion.
- Keep this solution for 12hours.



Fig 3.Secretion of Bral fish



Fig 4. Mixture after 12 hr

## Step 3:

- Squeeze out the Gum type solution from the mixture.
- Used it as natural stabilizer. This gives more workability and good mixability, better compaction and binding with soil.



Fig 5.Squeezing out the solution

## IV. METHODOLOGY

Stabilized soil is a composite mixture of termite mound soil and some additives. The new composite material has improved mechanical or chemical properties. For clarity the matrix additives will be divided into 2categories: fibers and stabilizers. Through experimentation it was found that the optimal method in which to mix the Natural stabilizer and fibers was by hand in dry soil. The dry materials were mixed until a general uniformity was achieved. In the first

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phase, Mound soil is mixed only with the Natural stabilizer, where the optimum N.S content is obtained from standard proctor test. An optimum N.S content is fixed. In the second set, 0 to 1% Coir fibres content is selected from literature. The percentage of coir fiber by dry weight of soil was taken as 0.25%, 0.5%, 0.75% and 1% to the above selected mix and optimum fiber percentage is found out keeping N.S content as constant. The above selected percentage for N.S and coir fibers is chosen and soil samples are prepared. The methods adopted for the project is given below.

1. Collection of termite and control soil
2. Determination of geotechnical properties of mound soil and control soil
3. Collection of natural stabilizers(liana, bral fish, coir fiber)
4. Preparation of natural stabilizers
5. Find out the optimum stabilizer content and coir fiber content.
6. Preparation of stabilized soil mix.
7. Conduct test on geotechnical properties of soil mix
8. Analyze the strength behavior of coir fiber added soil mix

## V. EXPERIMENTAL RESULTS AND DISCUSSION

### 1. Comparison of Mound Soil and Control Soil

- a. Comparison of consistency limits: From literature, the organic matter, organic carbon, nitrogen are more in termite soil than surrounding control soil.

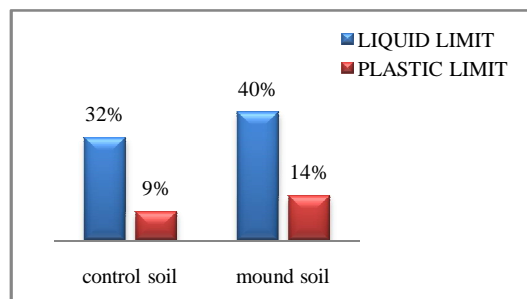


Fig 6: Comparison of consistency limits

It is observed that the termite mound soil have high consistency limits, plasticity index than control soil, which indicated that termite soil have good clay fraction than control soil and its plasticity due to the presence of non soil constituents of termite soil

- b Comparison of dry density v/s W.C: In the standard Proctor test compaction tests, the range of densities achieved with different moisture contents results in a typical bell-shaped curve (Figure 7) about the highest density (or OMC).

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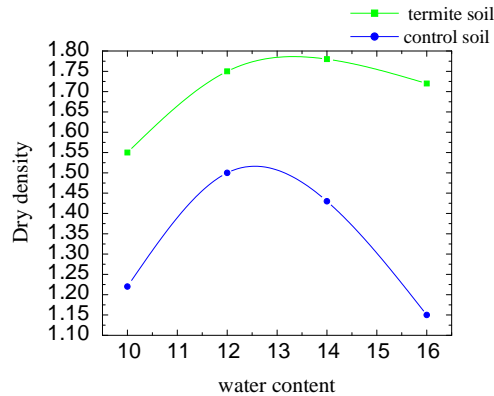


Fig 7: Variation of Dry density with Water content

The termite mound soils when compacted in the laboratory had a maximum dry density of 1.78 g/cm<sup>3</sup>, corresponding to an OMC of 14% (Figure 5). The dry density measured in a control soil 1.5 g/cm<sup>3</sup> and corresponding OMC is 12%.

### 3. Optimization of Additives

(a) Optimization of Natural stabilizer content: Natural stabilizer was then slowly poured while being mixed thoroughly by hand with constant attention paid to the homogeneity of soil-stabilizer mixture.

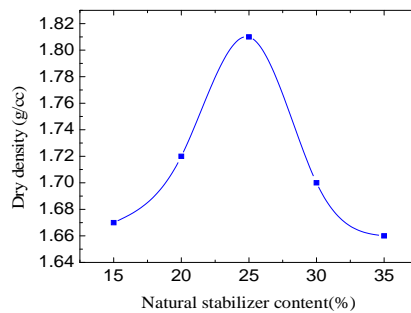


Fig8: Variation of Dry density with Natural stabilizer content

By increasing the percentage of natural stabilizer content from 15-35% the voids in termite soil filled with stabilizer and gets maximum density, further increase in stabilizer content there should be a decrease in density, it is due to the voids filled with stabilizer. Maximum compacted dry density obtained as ( $\rho_{dmax}$ ) 1.81 g/cm<sup>3</sup> and natural stabilizer content is 25% i.e, optimum natural stabilizer content is 25%.

(b) Optimization of Natural coir fiber content: In order to find out the optimum fiber content ucc test is conducted as per IS 2720(part 10) - 1973 specification with the varying percentages of coir fiber (0 to 1 %).

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TABLE 4. UCC STRENGTH BY % INCREASE IN FIBER CONTENT

Soil Sample	UCC Strength (kN/ m <sup>2</sup> )	Cohesion, C (kN/ m <sup>2</sup> )
ONC+ Mound Soil + 0.25% fiber	39.85	19.92
ONC+ Mound Soil + 0.50% fiber	<b>68.53</b>	34.26
ONC+ Mound Soil + 0.75% fiber	45.78	22.89
ONC+ Mound Soil + 1% fiber	39.38	19.68

Optimum fiber content is found out by UCC Test. Maximum UCC strength obtained at 0.5% fiber content. By the addition of coir fiber reduces the plasticity and increases the strength. Optimum Natural coir fiber content is 0.5%.

### 3 Properties of Stabilized Soil

(a) Comparison of UCC Strength Test of Different Soil Sample

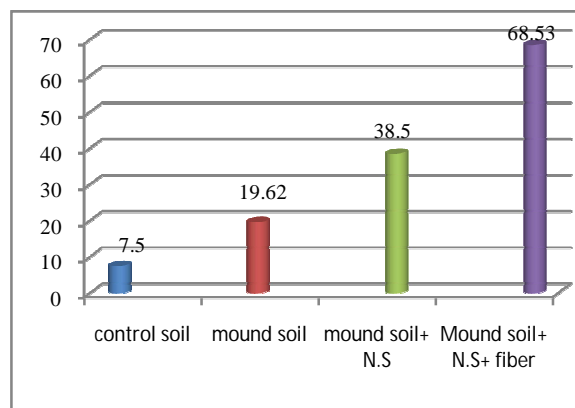


Fig 9: Comparison of UCC strength

From the Fig.9, it is clear that compressive strength of termite soil is increased from 19.62kN/m<sup>2</sup> to 38.5kN/m<sup>2</sup> by the application of stabilizer. Increased the compressive strength of coir fiber added soil mix up to 68.53kN/m<sup>2</sup> from control soil of 7.5 kN/m<sup>2</sup>. Stabilized soil with fiber strength is 3.5 times greater than that of mound soil. Stabilized soil with fiber strength is 9 times greater than that of control soil.

(b) Comparison of CBR Values

It is clear from the tests results that the Unsoaked CBR value of soil increases as the fiber added to the stabilized soil. Results from Table 2 show that maximum Unsoaked CBR value of stabilized mound soil is 1.73 times (355 %) that of plain mound soil without coir fiber.

TABLE 5: SOAKED CBR VALUE FOR DIFFERENT SOIL SAMPLE

Soil type	CBR Value (%)	Increase in CBR	% increase in CBR
Control soil	2.4	-	
Mound soil	6.3	3.9	162
Stabilized soil without fiber	10.77	8.37	355
Stabilized soil with 0.5%coir fiber	10.92	8.52	405

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In case of Unsoaked test the maximum CBR value of stabilized mound soil with 0.5% coir fiber (Table 5) is 2 times (405 %) that of plain mound soil without fiber. From specification CBR value greater than 10 belongs to the strong subgrade classification.

### (c.) Variation in UCC Strength with time

For estimating the strength behaviour of stabilized mound soil without fiber, twelve number of UCC samples are prepared and compressive test is conducted. The result shows that a great improvement in the compressive strength with time.

TABLE 6. UCC STRENGTH WITH TIME

Days	1	7	14	28
Compressive strength, $q_u$ (kN /m <sup>2</sup> )	38.5	1814	1973	2307
Cohesion ,C (kN /m <sup>2</sup> )	19.25	907	986.5	1154

First day strength attained by stabilized soil with coir fiber is 38.5kN/m<sup>2</sup>. And at the time of 28<sup>th</sup> day the strength shows a greater rise in its compression by a value of 2307 kN/m<sup>2</sup>. Cohesion is also increases up to 1154 kN/m<sup>2</sup>. From literature study, the use and adoption of the right stabilisation method can improve the compressive strength of a soil and increase its resistance to erosion and mechanical damage. 28<sup>th</sup> day strength is 55 Times greater than that of 1st day UCC strength.

## VI. CONCLUSION

- The geotechnical properties of termite mound soil and control soil was studied. Mound soil has better properties than the surrounding control soil.
- As per experimental research the optimum of natural stabilizer content obtained is 25% and coir fiber is 0.5% to the dry weight of termite soil.
- Compressive strength of Stabilized soil with fiber is 3.5 Times greater than that of mound soil.
- The maximum CBR value of Reinforced soil is 2 times that of plain mound soil. It belongs to strong classification. Thus it may be suitable as a subgrade soil.
- The 28<sup>th</sup> day UCC strength is 55 Times greater than that of 1st day strength. Thus there is a significant increase in compressive strength by time. Thus greater durability value.

## REFERENCES

- [1] Alake Olaniyi and Akaninyene Afangide Umoh, "Influence of curing media on the compressive strength of termite mound-lime blended cement mortar", Malaysian Journal of Civil Engineering, vol.3, pp. 349-365, 2014.
- [2] Ayininuola G.M., "Termite Social Insect Impact on Soil Geotechnical Properties", IOSR Journal of Mechanical and Civil Engineering, vol.11, no 3, pp. 18-20,2014..
- [3] Ayininuola G.M. "Variability in Geochemical Properties of Termitaria University of Ibadan Case Study", The Pacific Journal of Science and Technology, vol. 10, no.1, pp. 567-572,2009.
- [4] Babatope A. Alababan,Kehinde A. Adekola, Thomas J. Esumobi "Compressive strength of rice husk stabilized termite hill soil" , CIGR Journal, vol. 18, no.1, pp.41-47,2016.
- [5] Gabriel N. N. Dowson, Pearl Atwere1, W. Dubbin, Prosper M. Nude, Baba E. Mutala, Eric K. Nartey, Richard J. Heck, "Characteristics of termite mounds and associated acrisols in the coastal savanna zone of Ghana and impact on hydraulic conductivity" Natural Science, vol.4, no.7,pp. 423-437 2012.
- [6] Ilse L. Ackerman , Wenceslau G. Teixeira , Susan J. Riha ,Johannes Lehmann , Erick C.M. Fernandes, "The impact of mound-building termites on surface soil properties in a secondary forest of Central Amazonia" applied soil ecology, vol. 37,pp.267-276,2007.
- [7] L. Zhang and W.L.Deng, "Characterization of the Polysaccharide from Adhesive Discs of Parthenocissus tricuspidata", Asian Journal of Chemistry; vol. 25, no. 2 .pp. 874-876,2013.



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(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

- [8] L. Rosemary Gillman, Marilyn K. Jefferies, G. N. Richards, "Non-Soil Constituents Of Termit Mounds", Aust. J. biol. Sci.,vol.25, pp.105-13, 1972.
- [9] Nik Fatini Nik Azmin, Norizan Ahmat1, Nik Khairunissa Nik Abdullah Zawawi, "chemical constituents from the lianas of gnetum cuspidatum blume", Malaysian Journal of Analytical Sciences, vol 20, no 2,pp.388 – 392,2016.
- [10] Paul O. Awoyera, Isaac I. Akinwumi "Compressive Strength Development for Cement, Lime and Termite-hill Stabilised Lateritic Bricks", The International Journal Of Engineering And Science, vol 3,no2, pp.37 – 43 2014.
- [11] Prasad Nair Pariyarath ,"Extraction and Biochemical Studies of Soil Binding Proteins from Termite Mound", International Journal of ChemTech Research, vol.6, no.14, pp 5733-5739, 2014.
- [12] Ramesh K. Kandasami,Renee M. Borges, Tejas G. Murthy, "Effect of biocementation on the strength and stability of termite mounds", The International Journal Of Engineering And Science, vol. 3, no. EG2, pp.99–113, 2016.
- [13] Udoeyo, F,Cassidy A, Jajere, S, "Mound soil as construction material", ASCE Journal, vol. 12, no.3, pp.205-211, 2000.