Study on Geotechnical Properties of Red Termite Mound Soil

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Abstract: Study on Termite mound soil is the new area of study in Geotechnical Engineering, since the termite mound stands steadily without disturbance even after heavy rainfall, indicating that the termite mound soil has higher shear strength and better geotechnical properties than the regular adjacent soil. Hence, if everything goes as predicted above, just by mixing the regular soil with artificial enzyme that has some properties as that of the termite saliva to enhance its behavior in the geotechnical application as a part of stabilization. In the present study, a series of basic index property tests, Light compaction tests, Direct shear tests, unconfined compression tests are performed over the termite mound soil and adjacent soil for red soil. From results it is found that the termite mound soil possess better geotechnical properties than the adjacent soil.

Keywords**:** *Red termite mound soil, Termite saliva, Shear Strength, Free swell, differential free swell, adjacent soil.*

I. INTRODUCTION

Mounds occur when an above-ground nest grows beyond its initially concealing surface. These mounds despite severe climatic condition can withstand and survive the test of time. No matter what the climatic conditions are, these structure stands erect and provides shelter to all inmates. If this feature of the mounds can be brought to the roads they will be able to survive for a longer period of time despite all the harsh climate condition. Termites (Isoptera) are social insects having 3000 known species, in which 75% are soil feeding and 28 species are pests. Termite hills have clay content above 20% than that of the adjacent soil, reflecting the insect's preference for smaller clay particles for construction. The termite mound has cohesive properties, mechanical strength and hydrophobic nature. The use of the mound soil in vicinal roads improved the sub-base by increasing cohesion and soil stability. The mound surface appears to be solid and impermeable, but it is actually quite porous.

Some scholars have argued that complex carbohydrates exist in the termite mouth in form of mucopolysacharides. These are believed to enhance the gluing properties of the soil hence making it harder. Mound soils are generally rich in clay and metallic minerals, particularly compounds of potassium, calcium, and magnesium, relative to surrounding soils. Many studies on geotechnical properties of red termite mound soil which is published in the literatures Tejas Murthy et.al, (2016), Samuel et.al, (2016), Felix et.al, (2000), Das et.al, (2017), Abe et.al, (2014), Babatope et.al, (2016).

II. MATERIALS AND METHODS

2.1 Materials

For this experimental study Termite mound soil and adjacent soil samples are collected from the Jnanabharathi campus, Bangalore University, Bangalore.

Table-1: Physical properties of red termite mound and adjacent soil

Properties	Termite mound soil	Adjacent soil
Liquid limit	34%	32%
Plastic limit	24%	20%
Plasticity index	10%	12%
Shrinkage limit	17%	17%
Specific gravity	2.59	2.60
Grain size distribution		
% Gravel	0	0
% Sand	33%	42%
% Clay and Silt	67%	58%
Coefficient of uniformity (Cu)	13.3	81.25
Coefficient of curvature (Cc)	1.6	3
Optimum Moisture Content	14%	16%
Maximum Dry Density	17.9kN/m^3	18.9kN/m^3
Soil classification	CL (Inorganic clay with low plasticity)	CL (Inorganic clay with low plasticity)

Fig-1: Termite mound

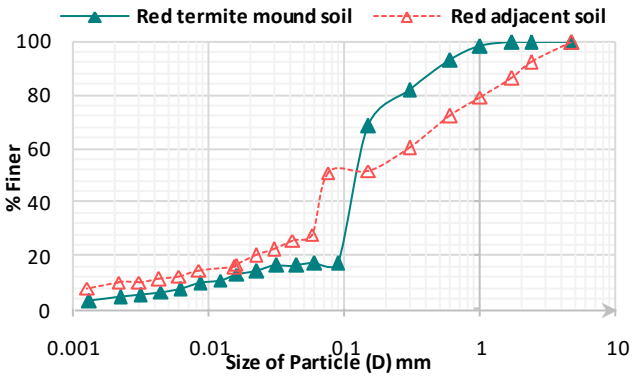

Fig-2: Grain size distribution curve of termite mound and adjacent soil

2.2 Methods

2.2.1 Tests conducted

In the present paper the Atterberg's limits, compaction characteristics, shear strength parameters and unconfined compression strength of the Red Termite mound soil and Adjacent soils are investigated as per IS: 2720 codes.

2.2.2 Flow chart for methodology

The flow of the tests conducted for soils are as shown in the flow chart below with fig-3.

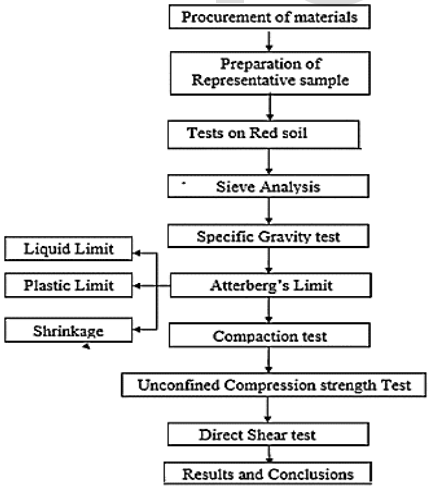

Fig- 3 Schematic representation of methodology adopted

III. RESULTS AND DISCUSSION

3.1 Atterberg's Limits

The Atterberg's limits of the Red termite mound soil and adjacent soils are as shown in the table 2.

Table-2: Atterberg's Limits of red termite mound and adjacent soil

Description	Liquid limit (%)	Plastic limit (%)	Shrinkage limit (%)	Plasticity index (%)
Termite mound soil	34	24	17	10
Adjacent soil	32	20	17	12

The liquid limit results showed that mound in Red soil had values greater than that of adjacent soil. This increase in liquid limit for the mound soil may ascribed to:

(i) Presence of organic content,
(ii) Increase in clay content,
(iii) Higher percentage of chemical /enzymes in the mound soil and
(iv) Presence of finer soil particles. And the increase in water content of the surrounding soil is due to the impermeability of mound soil compared to the surrounding soil.

It is interesting to observe that the plastic limit of the mound soil is more than that of adjacent soil. Such an increase in the plastic limit may be attributed to the increase in the clay content of the mound soil and presence of enzymes.

Shrinkage limit of soil is a good indicator of its expansivity. Higher the shrinkage limit, lower is its expansivity. It can be observed from this table that the shrinkage limit of both the mound soil and the adjacent soils are the same.

3.2 Compaction Characteristics

Light compaction test is conducted to determine the optimum moisture content (OMC) and Maximum Dry density (MDD) of a particular soil. Every soil attains maximum value of Dry density at some ideal moisture content, when compacted under a specified compactive effort. The ideal moisture content is referred to as optimum moisture content, since; either increase or decrease of moisture content from this ideal value of moisture content will never yield maximum achievable Dry Density under a particular fixed level of compactive effort. The OMC and MDD of the Red termite mound soil and adjacent soils are as listed in the table 3 below and the compaction curve for the respective soils are as shown in the fig.4 below..

Table-3: Compaction characteristics of red termite mound and adjacent soil

Materials	Maximum dry density (MDD) kN/m^3	Optimum moisture content (OMC) %
Termite mound soil	17.9	14
Adjacent soil	18.9	16

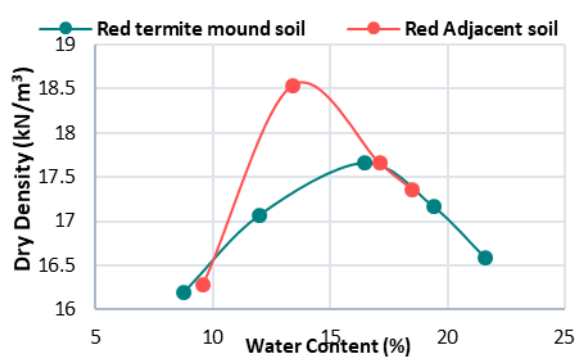

Fig- 4 Compaction curves of termite mound and adjacent soil

Fig.4 presents the dry density versus moisture content relationship for Red termite mound soil and that of adjacent soil. The two samples has a Maximum dry density of 17.9kN/m3 and 18.9 kN/m^3 respectively and respective optimum moisture contents are 14% and 16%.

3.3 Shear Strength Parameters

Direct shear tests are conducted for both undisturbed soil samples and Remoulded soil samples of both the soils at three normal pressures 50kPa, 100kPa and 150kPa respectively. The shear strength parameters of the soils are as listed in the table 4 below and the stress-strain characteristics of the soils at the respective normal pressures are as shown in the fig 5-10.

Table-4: Shear strength properties of red termite mound and adjacent soil

Description	Cohesion (kN/m^2)	Angle of internal friction (°)	Shear strength (kN/m^2)
UNDISTURBED SAMPLE			
Termite mound soil	25	35	42
Adjacent soil	24	42	40
REMOULDED SAMPLE			
Termite mound soil	72	39	86
Adjacent soil	38	42	54

The cohesion (C) for the Red termite soil has 72kPa whereas Red adjacent soils possess 38kPa respectively. Hence, cohesive property of termite soil is much higher i.e., twice than that of the adjacent soil, it's due to clay content, it's mineralogical and physico-chemical behavior due to which the shear strength of the termite soil is higher than that of the adjacent soils. And the angle of internal friction (ϕ) of adjacent soil is higher than the termite soil. It's due the presence of the sand size particles increasing the particle interlocking in the adjacent soils. But, the increase in the cohesion dominates over the increase in the Angle of internal friction resulting to the increase in the shear strength of the termite soils.

i. Stress- Strain Relationship for Undisturbed Red Soil Sample

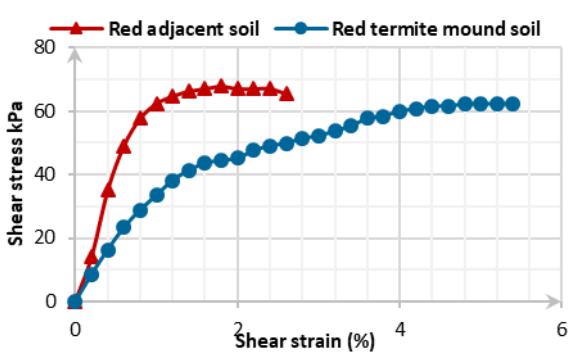

Fig-5 Stress- Strain Relationship for Undisturbed Red termite mound and adjacent soil under the normal stress 50kPa.

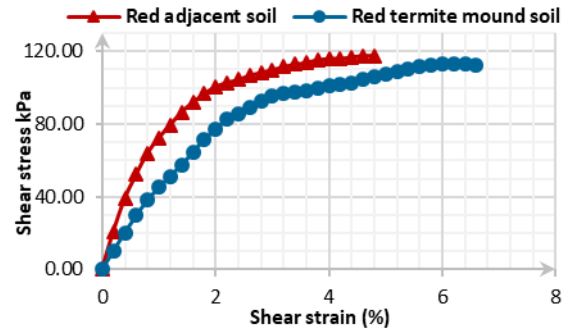

Fig-6 Stress- Strain Relationship for Undisturbed Red termite mound and adjacent soil under the normal stress 100kPa.

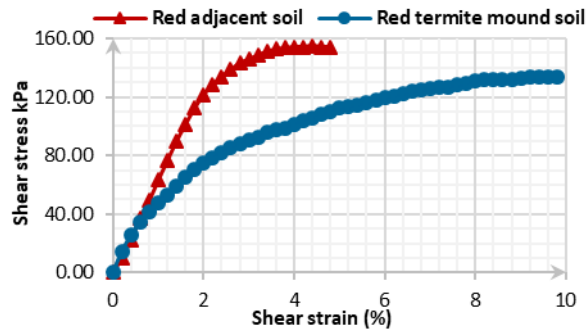

Fig-7 Stress- Strain Relationship for Undisturbed Red termite mound and adjacent soil under the normal stress 150kPa.

Stress-strain relationship for red termite mound soil and adjacent soil under the normal stress of 50 kPa 100 kPa and 150 kPa are shown in figures 5-7 respectively. Test is carried out on undisturbed samples. The Shear stress of adjacent soil is higher than the termite mound soil. It is due to the grain size distribution of soil. Adjacent soil having higher coarse grained soil so that the more shear stress is developed in the adjacent soil.

ii. Stress Strain Relationship for Remoulded Soil samples

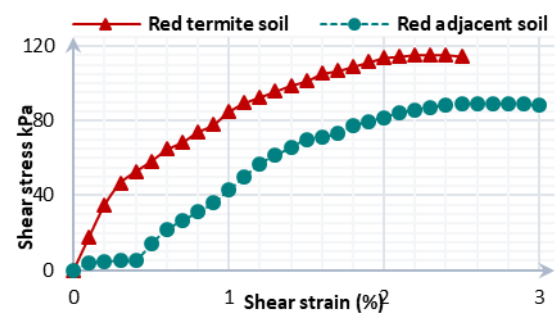

Fig-8 Stress- Strain Relationship for Remoulded Red termite mound and adjacent soil under the normal stress 50kPa.

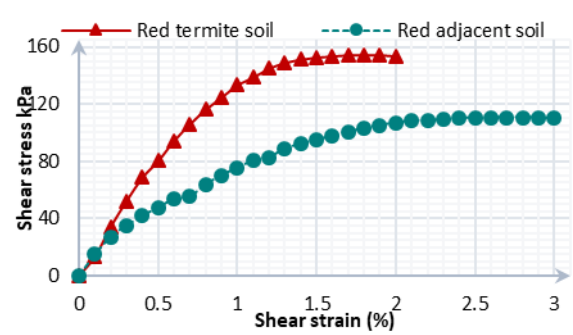

Fig-9 Stress- Strain Relationship for Remoulded Red termite mound and

adjacent soil under the normal stress 100kPa.

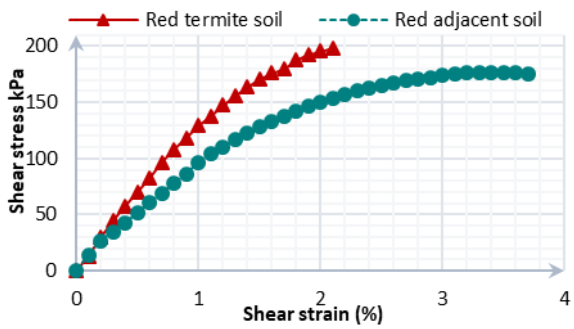

Fig-10 Stress- Strain Relationship for Remoulded Red termite mound and adjacent soil under the normal stress 150kPa.

Stress- strain relationship for Red termite mound soil and Red adjacent soil under the normal stress of 50 kPa 100 kPa and 150 kPa are shown in fig. 8-10 respectively. Test is carried out on remoulded samples. The Shear stress of termite mound soil is higher than the adjacent soil. It is just because of the enzymes present in the termite mound, the cohesion of the soil increases resulting to the increase in the shear stress of termite mound soil.

3.4 Unconfined Compressive Strength Test

i. Specimen preparation and curing procedure for Ucs test:

The unconfined compression mould consists of steel device with an internal diameter of 38mm and height of 76mm. The volume of steel tube was calculated as equal to the sample knowing the volume and the density required, the weight of the sample of the soil mixes are determined and the water content corresponding to the optimum moisture content. Soil and water are mixed well and transferred to the steel tubing device. It was then compressed by rotating or pushing the pistons simultaneously from both the ends, which resulted in a sample of 38 mm diameter and 76 mm in height. These samples were extracted with the help of a sample extruder. The ends of each specimen were trimmed flat normal to its axes to a length. Two identical specimens were prepared for their maximum density at optimum water content for one set of experiment.

The Unconfined compression strengths of Red termite mound soil and adjacent soils are as listed in the table-5 below. The stress-strain characteristics of the soils during UCS test are as shown in the figure 11 below.

Table-5: UCS of red termite mound and adjacent soil

Soil description	UCS (kPa)
Termite mound soil	418
Adjacent soil	268

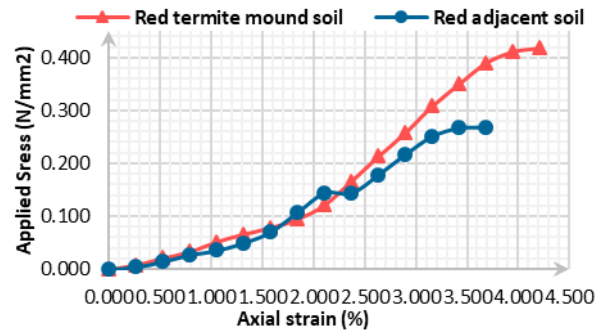

Fig-11 Stress- Strain Relationship for Red termite mound and adjacent soil.

Unconfined Compressive Strength test was conducted immediately for termite mound and adjacent soil and results are presented in table 5 and fig.11 the mound soil exhibits more compressive strength compared to the adjacent soil. The Adjacent soil having 268kPa whereas termite mound soil exhibits the UCS of 418kPa and The increase in the Strength in the Mound soil compare to Adjacent soil due to the chemical/ Enzymes activity that takes place in the mound soil which leads to reduction in the thickness of diffused Double layer and development of bond between soil particles resulting in agglomeration and flocculation of the clay particle.

CONCLUSIONS:

1. Red termite soil has higher clay and silt contents of 67% whereas Red adjacent soils has 51% respectively. From this it can be inferred that the termite soils possess higher cohesion (C) and lesser angle of internal friction (ϕ) when compared to that of adjacent soils irrespective of the type of soils.
2. The termite mound has cohesive properties, unconfined compression strength and hydrophobic nature. The termite species produces a pasty material that works as "structural mortar" composed of saliva and soil. The presence of enzyme activity in the saliva including "Endo Beta 1, 4 Glucanase" gives the strength. And also complex carbohydrates exist in the termite mouth in form of "mucopolysacharides". These are believed to enhance the gluing properties of the soil hence making it harder and stronger.
3. Termite mound soil exhibit better Atterberg's limits in the geotechnical point of view i.e., lesser w_l, lesser I_p and larger ws, than that of the adjacent soil. The termite soils have w_l, I_p and w_s of 34%, 10% and 17% respectively, whereas BC adjacent soil has 32%, 12% and 17% respectively. This amends that the termite soils have better performance than adjacent soils i.e., lesser volumetric changes in the presence of water, leading to the higher strength.
4. The cohesion (C) for the Red termite soil has 72kPa whereas Red adjacent soils possess 38kPa respectively. Hence, cohesive property of termite soil is much higher i.e., twice than that of the adjacent soil, it's due to clay content, it's mineralogical and physico-chemical behavior due to which the shear strength of the termite soil is higher than that of the adjacent soils. And the angle of internal friction (ϕ) of adjacent soil is higher than the termite soil. It's due the

presence of the sand size particles increasing the particle interlocking in the adjacent soils. But, the increase in the cohesion dominates over the increase in the Angle of internal friction resulting to the increase in the shear strength of the termite soils.

5. The unconfined compressive strength of the termite soil has 418kPa respectively, when compared to that adjacent soils that possess 268kPa respectively. Larger than that of the adjacent soils irrespective of the type of the soil.

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