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Utilization of Bamboo Fibers for Modification of Black Cotton Soil Properties

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ABSTRACT

Soil stabilization is the process which involves enhancing the physical properties of the soil in order to improve its strength, durability etc. by blending or mixing with additives. The different types of method used for soil stabilization are: Soil stabilization with cement, Soil stabilization with lime, Soil stabilization using bitumen, Chemical stabilization and a new emerging technology of stabilization by Geo textiles and Geo synthetic fibers. In this study, we are making use of bamboo fibers as geo synthetic material for stabilization of soil. With the introduction of bamboo fibers to the soil the CBR values will improve and thickness of pavement layer also gets reduced. It also reduces the intensity of stress on subgrade. Bamboo fibers is such a geosynthetic material which is easily available, ecofriendly and also cost effective. With the application of soil stabilization method in construction the overall cost gets reduced when compared to the ordinary method of construction.

The Highway Research Board (HRB) classification of the soil strata like black cotton soil and sedu soil is done using suitable sampling technique such as Core Cutter Method. To determine the characteristics like Grading by Sieve Analysis, Atterbergs Limits i.e Liquid limit using Cone Penetration Method and Casagrande Method, Plastic limit by rolling the sample to 3mm diameter thread, Shrinkage limit using Shrinkage apparatus, Optimum Moisture Content and Maximum Dry Density using Standard Proctor Test and also California Bearing Ratio by conducting CBR test. The pavement thickness was designed using pavement design catalogues published by IRC SP:20-2002. The estimation for the street is finished by considering the thing, for example, Earthwork Excavation for Roadway and Drains, Jungle Cutting, compacting and reviewing and so forth., according to SR 2016-17, PW, P and IWT circle Andhra Pradesh and proposing of particulars for the blend of Bamboo strands as Geo Synthetic material for adjustment.

KEYWORDS: *stabilizers, Bamboo fibers, liquid limit, plastic limit, OMC, MDD, CBR*

I. INTRODUCTION

A creating nation like India which has a gigantic land territory and populace, requests huge foundation for example systems of streets and structures. Wherever land has been used for different structures from common house to spans, high rises to airplane terminals and from country streets to interstates. Practically all the structural building structures are situated on different soil strata. Soil might be characterized as the material which comprises of shake particles, sediment, sand and earth. It is shaped because of the continuous deterioration or crumbling of rocks because of characteristic changes that incorporates breaking down of shake because of stresses emerging from extension or withdrawal with temperature changes. Enduring and deterioration from substance changes that happen when water, oxygen and carbon dioxide step by step consolidate with minerals inside the stone development, hence it is separating to sand, residue and mud. Transportation of soil materials by wind, water and ice structures diverse soil developments, for example, those found in waterway deltas, sand ridges and frosty stores. Temperature, precipitation and waste assume significant jobs in the development of soils as in the distinctive climatic areas. Under various channel systems there shaped various soils from a similar unique shake course of action.

II. LITERATURE REVIEW

Sujitkawade et al., were studied the effect of geogrid and lime on the properties of the soil. Their key objectives are to evaluate the properties of the soil prior and later the mixing up of lime and geogrid to it. The various tests they have conducted and were natural water content determination, Compaction test, Atterbergs limits, specific gravity, Compaction test, and Compressive Strength test. After the study and executing the entire above tests, they concluded that and they concluded that there was a significant increase in the compressive strength of the soil for optimum lime content of 15% which was found.

AyushMithal and Dr. ShalinuShukla were examined the effectuality of use of geotextiles as a reinforcement material for stabilization of soil for various engineering works. Their aim is to study and bring in the properties of Geotextiles

(such as Mechanical property, Physical property, , Hydraulic property, Durability property and Endurance property), Fibers of Geotextiles, (both natural and synthetic fibers), functions of Geotextiles, application of geotextiles Types of Geotextiles and impact of geotextiles on environment. They have finalized that, because of the versatile functions of geotextiles they should be used in many strategic civil engineering works. The usage of geotextiles not only reduces the cost of construction but also reduces maintenance cost.

Vegulla . Raghudeep et al . were examined that the outcome of vitrified polish waste on the properties of the soil. Their subjective was to suss out the decrease in pavement thickness due to an increase in CBR after adding of polish waste. They have carried out the various tests like Atterbegs limits, Grain size distribution, Compaction tests and CBR tests on soil solely and with addition of vitrified polish waste. They summarized that with 10% add on of vitrified polish waste has ensured that there is consequent increase in CBR value and meaningful decrease in thickness of the pavement.

III. EXPERIMENTAL INVESTIGATIONS

The Highway Research Board (HRB) classification for the soil strata like black cotton soil and are done using appropriate sampling technique such as Core Cutter Method. In order to find the characteristics such as Atterbergs Limits i.e Plastic limit rolling the soil sample up to 3 mm dia. thread, Liquid limit by using Casagrande Method and Cone Penetration Method, Shrinkage limit by using Shrinkage test rig, Grading of sample by wet or dry Sieve Analysis, Optimum Moisture Content and Maximum Dry Density by using California Bearing Ratio apparatus and Standard Proctor Test. To find the properties such as liquid limit, shrinkage limit, plastic limit, maximum dry density, optimum moisture content,, CBR value and shear strength for various proportions of Geo synthetic material with black cotton soils.

The thickness of the pavement can be calculated using pavement design catalogues available in IRC SP:20-2002. Various suggestions of specification for the partial replacement of Bamboo fibers for black cotton soil stabilization. Executing CBR and Shear using Unconfined Compression Test for the samples which are immersed four days in water. The different tests were conducted in order to determine the different characteristics and properties of the soil. The procedure of each of the tests has been explained below.

A. liquid limit

The Liquid Limit is determined in the laboratory by Casagrande's Apparatus. About 300 gms of an air dried sample passing through 425µ IS Sieve is taken in a dish & mixed with distilled water to form an uniform paste. A portion of this paste is placed in this cup of liquid limit device & surface is smoothened & leveled with a spatula to a maximum depth of 1em. A groove is cut through the sample along the symmetrical axis of the cup, The handle is turned at the rate of 2 revolutions / second until the two parts of soil sample come into the contact at the bottom of the groove along the distance of 12 mm. Number of blows is counted care is taken that Number of blows is fall in between 10 & 40. A plot is made between the water content as ordinate & the Number of blows on Log Scale as abscissa.

The liquid limit is obtained from the plot corresponding to 25 blows and express as nearest whole number.

B. plastic limit

A bout 100 gms of air dried sample passing through 425µ IS Sieve is taken in evaporating dish, It is mixed thoroughly with distilled water till it becomes plastic &can be easily moulded with fingers About 10gms of Plastic soil mass is taken in One hand & a ball is formed. The ball is rolled with fingers on glass plate to form a soil thread of Uniform diameter the rate of rolling is kept about 80-90 strokes per minute. If the diameter of the thread becomes smaller than3mm without crack formation, it shows that the water content is more than plastic limit & the soil is kneaded further. This results in the reduction of water content as some water is evaporated due to the heat of the hand. The soil is re-rolled and the procedure repeated till the thread crumbles. The water content at which the soil can be rolled into thread approximately 3mm in diameter without crumbling is known as Plastic Limit.

C. standard proctor test

The Standard Proctor Mould is cleaned, dried and greased lightly. The mass of the empty mould with the base plate, but without collar, is taken. The collar is then fitted to the mould. The mould is placed on a Solid Base & filled with fully matured soil to about 1/3 rd its height. The Soil is compacted by 25 blows of the rammer with a free fall of 310mm. The blows are evenly distributed over the surface. The soil surface is scratched with a spatula before the second layer is placed. The mould is filled to about 2/3 rd height with the soil and compacted again by 25 blows. Similarly, the third layer is placed & compacted. The third layer should project above the top of the mould into the collar by not more than 6mm.

The mass of the mould, base plate & the compacted soil is taken, and thus the mass of the compacted soil is determined. The Bulk Density of the soil is computed from the mass of compacted soil & the volume of the mould. Representative soil samples are taken from the bottom middle & top of the mould for determining the water content. The Dry Density is computed from the bulk density & water content.

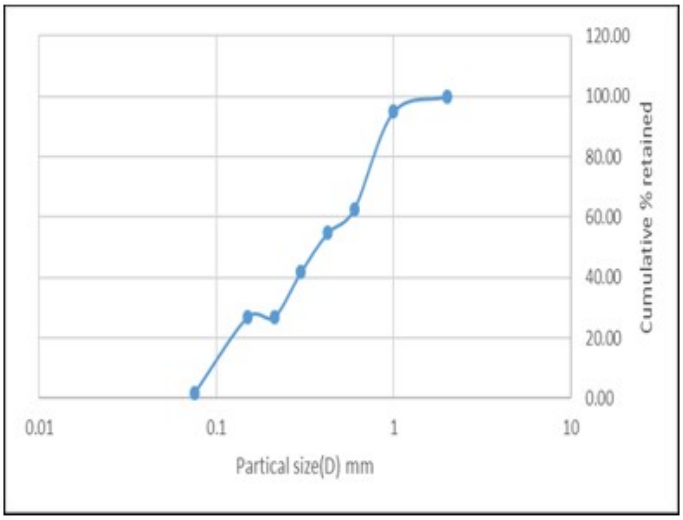
A Compaction Curve is plotted between the water content as abscissa & corresponding dry density as ordinate. The water content corresponding maximum dry density is called as Optimum Moisture Content.

D. California bearing ratio test

The test consists of causing the plunger to penetrate the specimen at the rate of 1.25 mm per minute. The loads required for penetration of 2.5mm & 5mm are recorded by the proving ring attached to the plunger. The Load is expressed as a percentage of Standard Load at the respective deformation level and is known as California Bearing Ratio (CBR) Value.

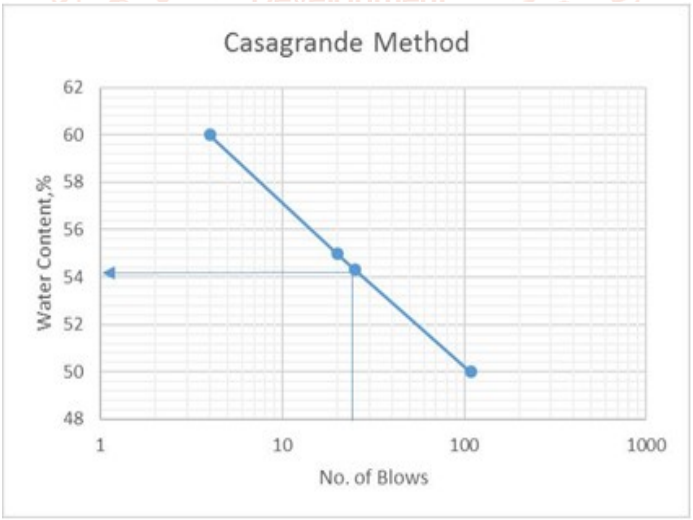
The CBR Value is determined corresponding to both 2.5mm & 5mm Penetration and the greater value is used for design purpose.

Sl. No.	IS sieve Size	Particle size D(mm)	Mass of soil retained M1(g)	% Mass of soil retained (M1/M) *100	Cumulative% retained, C	Cumulative% Fine N=100-C
1	2.000	2.000	0	0.00	0.00	100.00
2	1.000	1.000	06	05.22	5.22	94.78
3	0.600	0.600	37	32.17	37.39	62.61
7	0.150	0.150	00	0.00	73.04	26.96
8	0.075	0.075	29	25.22	98.26	01.74
9	Pan	0	0	0.00	98.26	01.74



Liquid limit test on Black cotton soil using Casagrande's method

Trial No.	Water Content, %	Water Amount, ml	No. of Blows
1	50.00	75.0	106
2	54.33	81.5	24
3	55.00	82.5	21
4	60.00	90.0	5



Liquid limit as obtained from graph = 52.33% (corresponding to 25 blows)

PLASTIC LIMIT TEST

Trial Number	1
Container No.	GT-19
Mass of empty container, M_1 g	31.15
Mass of container + wet soil, M_2 g	44.15
Mass of container +dry soil, M_3 g	43.50
Mass of water = M_w= M_2-M_3	02.65
Mass of dry soil= M_d= M_3-M_1 g	12.35
Plastic Limit,% W_p=(M_w/M_d)*100	20.46

PLASTICITY INDEX

Soil Sample – 1

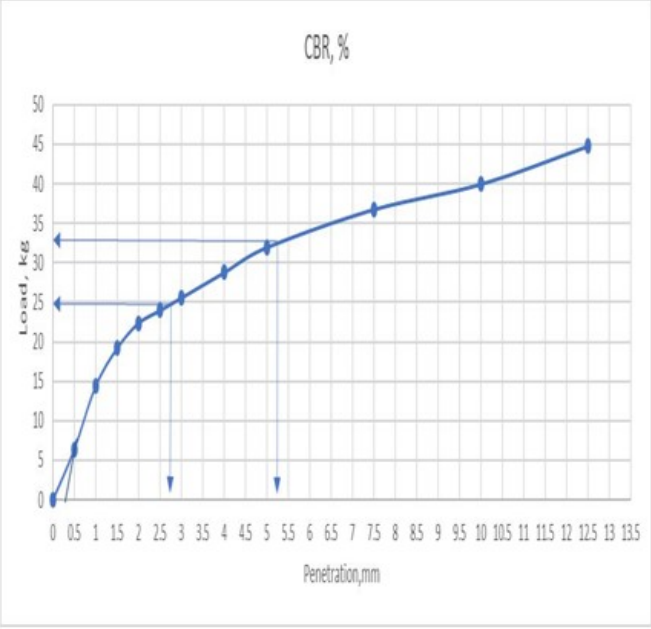
Ip = WL – WP = 60 – 21.46 = **37.36%**

STANDARD PROCTOR TEST

Trials	1	2	3	4
Mass of Empty mould, m1 (g)	3686.00	3686.00	3686.00	3690.00
Mass of mould + Compacted soil,m2(g)	5358.00	5390.00	5421.00	5430.00
Mass of Compacted soil, M= m2-m1(g)	1672.00	1704.00	1735.00	1740.00
Bulk density, Yb=(M/V)g/cc	1.67	1.70	1.74	1.74
Container number	2	3	4	GT-24
Water added	0.22	0.24	0.26	0.28
Mass of container, M1(g)	29.50	22.50	16.00	29.50
Mass of Water, Mw=M2-M3(g)	10.00	14.50	11.00	12.50
Mass of Dry soil, Md=M3-M1(g)	62.50	76.50	51.00	54.50
Water content, w=(Mw/Md)*100	0.160	0.190	0.216	0.229
Dry Density, Yd= Yb/(1+w) g/cc	1.370	1.374	1.377	1.359

California Bearing Ratio (CBR) Test on Black cotton soil

Penetration (mm)	Trial 1	Division	Load (kg)
0	0	0	0
0.5	0.8	4	6.4
1	1.8	9	14.4
1.5	2.4	12	19.2
2	2.8	14	22.4
2.5	3	15	24
3	3.2	16	25.6
4	3.6	18	28.8
5	4	20	32
7.5	4.6	23	36.8
10	5	25	40
12.5	5.6	28	44.8



Load as obtained from graph at 2.5 mm penetration = 25 kg,

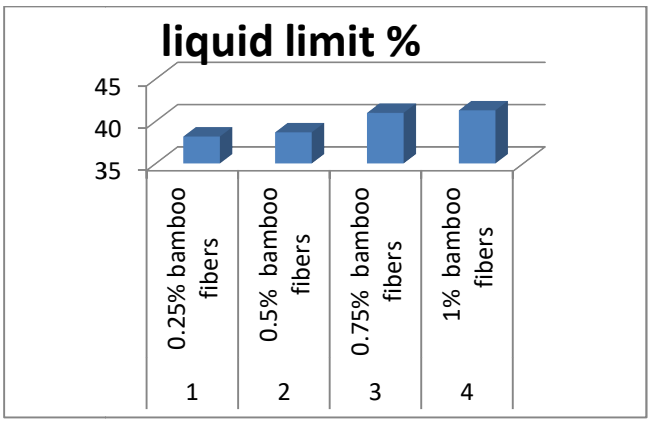
CBR of Specimen = (25/1370) *100=1.812%

Load as obtained from graph at 5 mm penetration = 34 kg

CBR of Specimen = (34/2055) *100=1.645%'

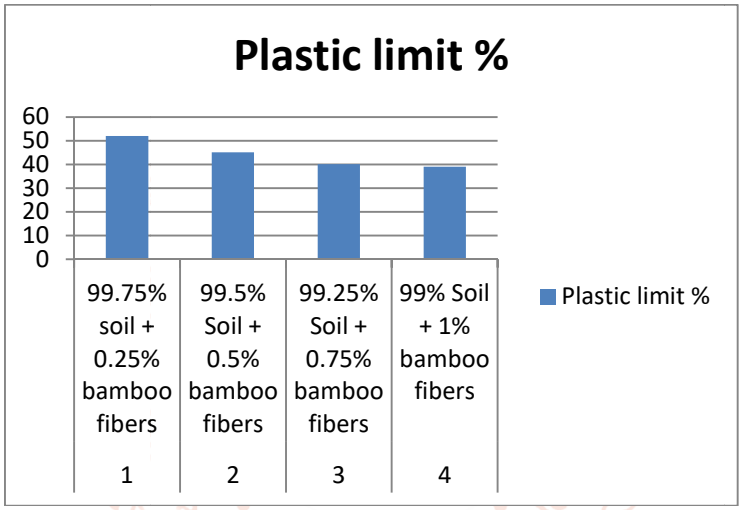
RESULTS AFTER REINFORCING BAMBOO FIBERS WITH BLACK COTTON SOILS LIQUID LIMIT TEST

S.NO.	Mixed proportions	liquid limit %
1	99.75% soil + 0.25% bamboo fibers	38.2
2	99.5% Soil + 0.5% bamboo fibers	38.7
3	99.25% Soil + 0.75% bamboo fibers	41
4	99% Soil + 1% bamboo fibers	41.3



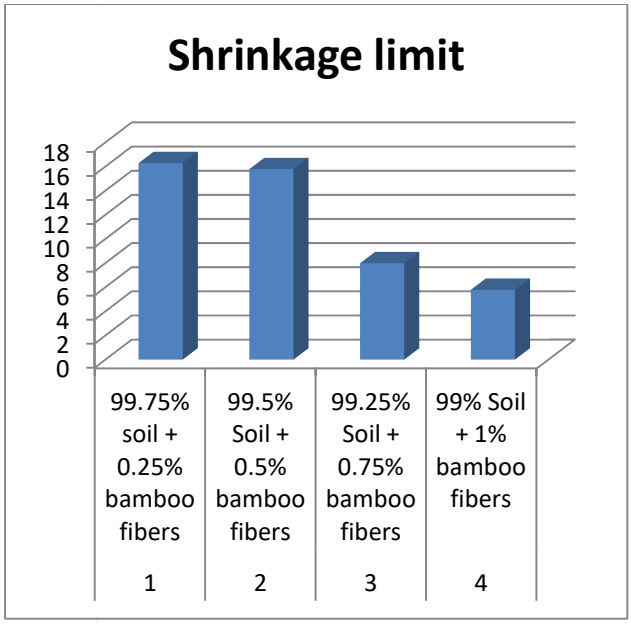
PLASTIC LIMIT TEST

S.NO.	Mixed proportions	Plastic limit %
1	99.75% soil + 0.25% bamboo fibers	52.04
2	99.5% Soil + 0.5% bamboo fibers	45.05
3	99.25% Soil + 0.75% bamboo fibers	40.05
4	99% Soil + 1% bamboo fibers	39



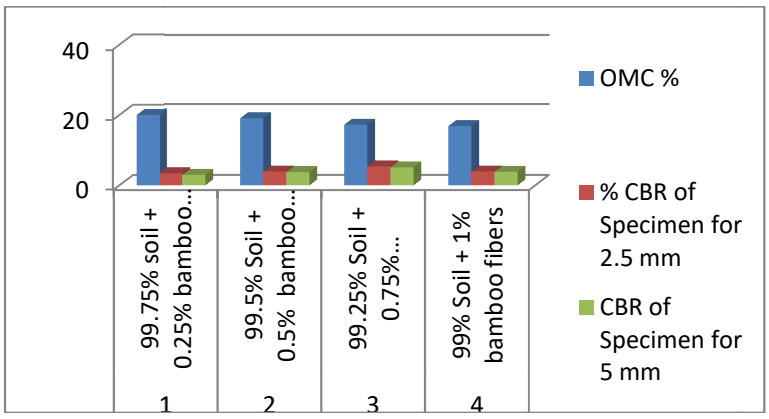
SHRINKAGE LIMIT TEST

S. NO.	Mixed proportions	Shrinkage limit
1	99.75% soil + 0.25% bamboo fibers	16.3
2	99.5% Soil + 0.5% bamboo fibers	15.8
3	99.25% Soil + 0.75% bamboo fibers	8.0
4	99% Soil + 1% bamboo fibers	5.8



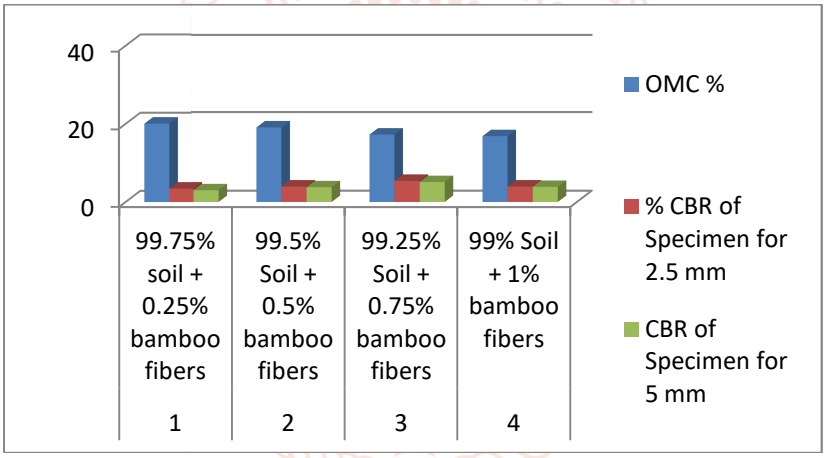
COMPACTION TEST

S.NO.	Mixed proportions	OMC %	MDD g/cc
1	99.75% soil + 0.25% bamboo fibers	20.12	1.402
2	99.5% Soil + 0.5% bamboo fibers	19.01	1.423
3	99.25% Soil + 0.75% bamboo fibers	17.19	1.566
4	99% Soil + 1% bamboo fibers	16.8	1.379



CBR TEST RESULTS

S.NO.	Mixed proportions	OMC %	%CBR @2.5mm	%CBR 5 mm
1	99.75% soil + 0.25% bamboo fibers	20.1	3.47	3.02
2	99.5% Soil + 0.5% bamboo fibers	19.01	3.96	3.80
3	99.25% Soil + 0.75% bamboo fibers	17.19	5.41	5.12
4	99% Soil + 1% bamboo fibers	16.8	3.96	3.88



BILL OF QUANTITIES

SL. No.	DESCRIPTION OF WORK	Unit	Quantity	Rate, Rs	Amount, Rs
1	Clearing and grubbing road land	Sqm	3750	5.45	20437
2	Excavation for road way in soil by mechanical means	Cum	1875	42.00	78750
3	Loosening the ground up to a level of 500mm below the Subgrade level	Cum	1875	48.50	90937
4	Construction of granular sub-base	Cum	375	1288	1207500
5	compacting graded stones aggregate to wet mix macadam	Cum	412.5	1332	799200
6	Providing and applying primer coat	Sqm	3750	32.6	122250
7	Providing and applying tack coat on primed granular surface	Sqm	3750	28.1	105375

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5	compacting graded stones aggregate to wet mix macadam	Cum	412.5	1332	599400
6	Providing and applying primer coat	Sqm	3750	32.6	122250
7	Providing and applying tack coat on primed granular surface	Sqm	3750	28.1	105375
8	Bamboo fibers	1024544			

THE TOTAL COST PER 1 KM LENGTH OF ROAD WITHOUT USE OF BAMBOO FIBERS =2424449 RS
THE TOTAL COST PER 1 KM LENGTH OF ROAD WITH USE OF BAMBOO FIBERS = 2346879 RS.

RESULTS AND DISCUSSION

- The liquid limit of the soil alone was found to be 52%
- The liquid limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, by weight of soil is found to be 39.2%, 39.7%, 42.0% and 42.3% respectively.
- The liquid limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers is found to be decreased by 34.66%, 33.83%, 30.0% and 29.5% respectively, when compared to liquid limit of soil alone.
- The plastic limit of the soil alone was found to be 20.46%
- The plastic limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be 22.27%, 33.33%, 35.59% and 37.50% respectively.
- The plastic limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers is found to be decreased by 21.3%, 43.5%, 51.8% and 58.8% respectively, when compared to plastic limit of soil alone.
- The plasticity index of the soil alone was found to be 37%.
- The plasticity index of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be 11.93%, 6.37%, 6.41% and 4.8% respectively.
- The plasticity index of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of bamboo fibers is found to be decreased by 69%, 84.47%, 83.36% and 87.54%.
- The shrinkage limit of the soil alone was found to be 23.309%
- The shrinkage limit of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be 16.471%, 15.876%, 8.043% and5.826% respectively.
- The shrinkage limit of the soil with the addition of 0.25%, 0.5%, 0.75% and 1% of bamboo fibers is found to be decreased by 29.31%, 31.88%, 65.49% and 75%.
- The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 21.4% and 1.378 g/cc respectively.
- The MDD of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be 1.401 g/cc, 1.425 g/cc, 1.565 g/cc and 1.378 g/cc respectively and the corresponding OMC is found to be 20.1%, 19%, 17% and 16% respectively.
- The MDD of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be increased by 1.6%, 3.4%, 13.5% and 0% respectively and the corresponding OMC is decreased by 6%, 11.2%, 20.56% and 21.02% respectively.
- The CBR value of soil alone was found to be 1.82%
- The CBR valueof the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be 3.49%, 3.96%, 5.41% and 3.96% respectively.
- The CBR value of the soil with addition of 0.25%, 0.5%, 0.75% and 1.0%, bamboo fibers by weight of soil is found to be increased by 91.75%, 117.5%, 197.25% and 117.5% respectively.

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