INVESTIGATIVE STUDY ON SOIL STABILIZATION USING FIBER WASTE MATERIALS

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ABSTRACT

Soil having poor bearing and shearing strength need stabilization to make it suitable for construction purpose. If the soil is weak and has not enough stability to resist heavy loading, the soil should be reinforced and stabilized. As the quality of the soil is increased, the ability of the soil to distribute the load over a greater area is generally increased. Soil stabilization refers to alteration of soil properties to improve the stability or bearing power of the soil by controlled compaction, proportioning or by adding admixtures. Soil stabilization can be done by different methods like mechanical, chemical stabilization or by using different types of admixtures. Sustainable development cannot be done without adaption of new technology to make the structure enduring. Soil stabilization by using waste coir fibers and Tyre waste material is one of the most economical approaches. The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength.

A study has been carried out to investigate the strength of soil by reinforcing with randomly distributed waste coir fibre materials and tyre waste with varying percentages of reinforcement by conducting different tests like, compaction test, CBR (California Bearing Ratio). The tests were performed as per Indian standard specification. The results obtained are compared and inferences are drawn towards their usability and effectiveness to make these waste fibre materials for different geotechnical applicationas as a cost effective approach.

The samples are prepared at their respective maximum dry density and optimum moisture content. From the study, it is observed that the friction angle increases by 26% at fiber content of 0.5% and fiber length of 6mm. The fiber-reinforced low plasticity clay exhibited crack fracture and surface shear fracture failure modes, implying that polyester fiber is good earth reinforcement material with potential applications in civil engineering.

Keyword : - *Optimum Moisture Content* **,** *Maximum Dry Density , tri axial test, California Bearing Ratio.*

I. INTRODUCTION

Soil stabilization refers to the any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. In order to work with soil, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

Here in this project, soil stabilization has been done with the help of randomly distributed polyester fibers. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using triaxial shear tests for shear strength measurement.

1.1 Soil Stabilization

Soil Stabilization is the process of altering some properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying on the field.

1.2 Principles Of Soil Stabilization

• Evaluating the soil properties of the area under consideration.

•Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.

•Designing the stabilized soil mix sample and testing it in the for intended stability and durability vaiues.

1.3 Methods Of Soil Stabilization

The different methods of soil stabilization are given below

1.3.1 Mechanical Method of Stabilization

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

1.3.2 Hydraulic Method Of Modification

Free- pore water is forced out of the soil via drains or wells. In coarse grained soils this is achieved by lowering the ground water level through pumping from boreholes or trenches; in fine grained soils the long term application of external loads (preloading) or electrical forces is required .Traditional techniques have benefited from the development of geosynthetics, as in the case of vertical drains.

1.3.3 Chemical or Additive Method Of Stabilization

It refers to the addition of manufactured products into soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. When additives are injected via boreholes under pressure into the voids within the ground or between it and a structure, the process is called grouting .Soil stabilization by heating the ground and by freezing the ground are both considered thermal methods of modification. Heating evaporates water and causes permanent changes in the mineral structure of soils; freezing solidifies part or all of the water and bonds individual particles together.

1.3.4 Modification By Inclusion And Confinement

Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two methods.

a) Oriented fiber reinforcement

b) Random fiber reinforcement

a) Oriented fiber reinforcement

The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation. Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

b) Random fiber reinforcement

This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties.

Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc .Besides easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

1.4 Uses & Advantages Of Soil Stabilization

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil. Stabilization of soil improves load bearing capacity of the soil.

•It improves the strength of the soil, thus, increasing the soil bearing capacity.

•It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation

•It is also used to provide more stability to the soil in slopes or other such places

•Sometimes soil stabilization is also used to prevent soil erosion or formation of dust which is very useful especially in dry and arid weather.

•Stabilization is also done for soil water-proofing. This prevents water from entering into the soil and hence helps the soil from losing its strength.

•It helps in reducing the soil volume change due to change in temperature.

1.5 Applications

Soil stabilization has many applications in earthwork construction, such as soil modification, roadway embankment reinforcement and earth slopes, landfills and embankments.

II. Materials and their Properties

2.1 SOIL

The soil sample was brought from a place near government hospital RIMS, Srikakulam at a depth of 2m below the ground surface. The soil is initially allowed to dry for 2days and the dried soil is thoroughly grinded. The grinded soil is allowed to pass through 4.75mm IS sieve and this soil is used for the present study.

Plate 2.1 Soil sample

2.2 COIR

Coir is brought from Srikakulam market. The diameter of coir is 0.2-0.3mm. The length of coir used for work is 1cm.

Plate 2.2 showing coir

2.2.1 PROPERTIES OF COIR

The following are the different physical and chemical properties of coir.

P^H : 5.4-6.8.

Perfect for use as a growing medium.

2.2.1.1 Air filled porosity (AFP)

10-11% perfect for use as a growing medium.

The Air Filled Porosity (AFT) of a growing medium defines the air spaces in the pot needed for good water dispersal and drainage, and to allow good healthy root growth.

2.2.1.2 Water Absorption time:

Immediate wetting/re-wetting time is immediate.

2.2.1.3 Cat ion Exchange Capacity

In excess of 120 meq/1000g of dry soil combined with a good conductivity figure allowing holding and dispersal of nutrients.

2.2.1.4 Carbon/Nitrogen

Ratio of b/w 90:1and 110:1.This combined with coir's lignin content makes it a good long term growing medium.

2.2.1.5 Nutrition

Coir contains a useful amount of available potassium and small quantities of:

Nitrogen,
phosphorous,
Calcium,
Magnesium,
Sulphur,
Copper,
Zinc,
Manganese,
Molybdenum,
Boron

2.2.2 APPLICATIONS OF COIR

Geotextiles and related products have many applications and currently support many civil engineering applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, bank protection etc….

Coir can improve soil strength at a lower cost than conventional soil nailing. In addition, coir allows planting on steep slopes, further securing the slope.

Coir (coconut fiber) geotextiles are popular for erosion control, slope stabilization and bioengineering, due to the fabric's substantial mechanical strength. Coir geotextiles last approximately 3 to 5 years depending on the fabric weight. The product degrades into humus, enriching the soil.

2.3 RUBBER TYRE

The diameter of the tyre is upto 3mm and length is 1-2cm. The following are the different properties of waste rubber tyre.

Plate 2.3 Figure showing rubber tyre

2.3.1 Chemical Composition

Approximately 80% of the weight of car tyres and 75% of truck tyres is rubber compound. The compositions of tyres produced by different manufactures are reported to be similar. Table shows the material composition of passenger car and truck tyres from the European Union (EU) as well as the composition of tyre rubber from Canada.

Material	Car tyre	Truck tyre
Rubber/elastomers	47%	45%
Carbon black	21.5%	22%
Metal	16.5%	25%
Textile	5.5%	-
Zink oxide	1%	2%
Sulphur	1%	1%
Additives	7.5%	5%

Table: 2.1 Composition of tyre by different manufacturers

2.3.2 APPLICATIONS OF TYRE WASTE

1.Sub grade fill and Embankment.
2.Backfill for wall and Bridge Abutments.
3.Sub grade insulation for roads.
4.Landfills.
5.Septic system drain fields.

III. TEST RESULTS
3.1 MIXING PROCEDURE

Soil passing through 4.75mm IS sieve is used for the present study. To this soil sample required percentage of stabilizer by weight is added and a uniform mixture is made. For this mixture water is added and properly mixed in order to ensure the bonding of fiber and soil. The prepared sample is tested for maximum dry density, optimum moisture content, unconfined compressive strength, direct shear test and CBR value. This procedure is repeated for 0.25%, 0.5%, 0.75% and 1% of coir and for 1%, 2%, 4%, 6%, And 8% of tyre waste.

Index and Engineering properties of the soil used for the present study are given below.

3.2 INDEX PROPERTIES OF SOIL

Property of soil	Values
Liquid limit	49%
plastic limit	25%
Plasticity index	24%

Table: 3.1 Index properties of soil

3.3 ENGINEERING PROPERTIES OF SOIL

Property of soil	Values
Field water content	25%
Field density	1.99 gm/cc
Dry density	1.6gm/cc
OMC	20 %
MDD	1.67 gm/cc
CBR	1.95%
UCS	0.36 kg/cm^2
Undrained cohesion	0.18 kg/cm^2

Table: 3.2 Engineering properties of soil

3.4 SIEVE ANALYSIS

IS SIEVE (mm)	PERCENTAGE FINER (%)
4.75	98.6
2.36	94.43
1.18	89.63
0.6	85.06
0.475	79.52
0.3	75.58
0.15	70.47
0.075	66.65

Table: 3.3 Grain size analysis results

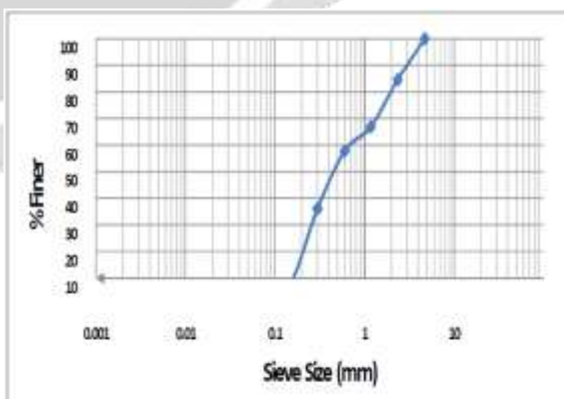

Fig3.1 Grain size distribution for unmodified soil

3.5 TEST RESULTS FOR ATTERBERG'S LIMITS

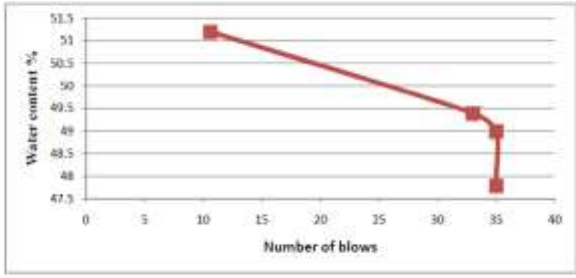

Fig 3.2 Liquid limit curve for unmodified soil

From graph liquid limit = 49%

Plastic limit = 25%

Plasticity index = 24%

3.6 OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY

Proctor test is conducted on the soil sample as per IS 2727(par 7)-1980 (reaffirmed).

COMPACTION TEST RESULTS

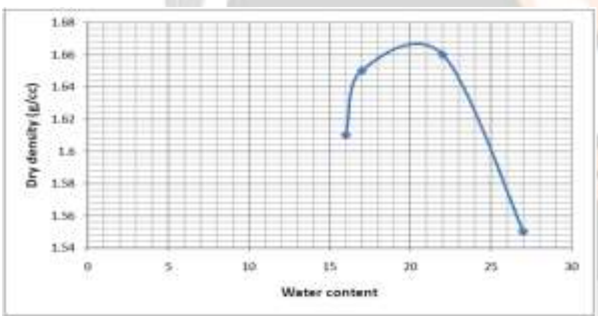

Fig 3.3 Compaction curve for unmodified soil

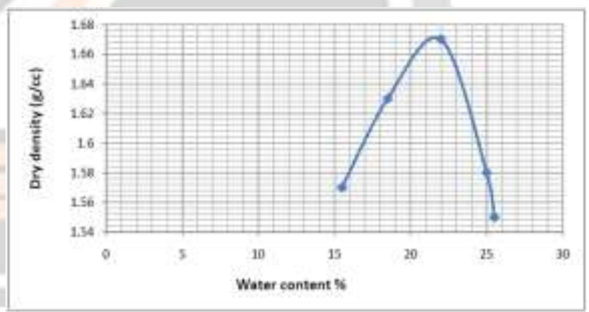

Fig 3.4 Compaction curve for soil+1.0% tyre

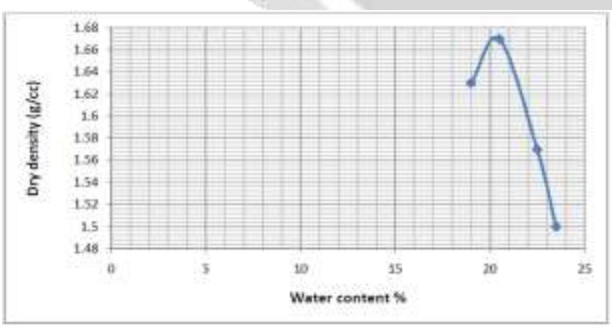

Fig 3.5 Compaction curve for soil +2.0% tyre

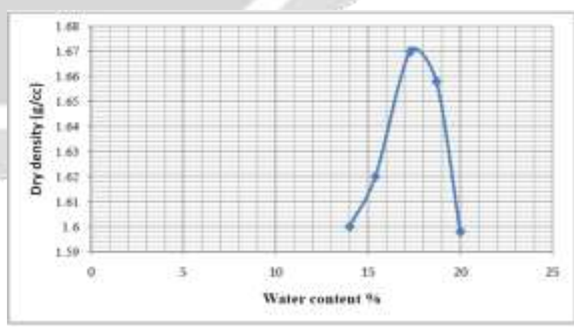

Fig 3.6 Compaction curve for soil + 4.0% tyre

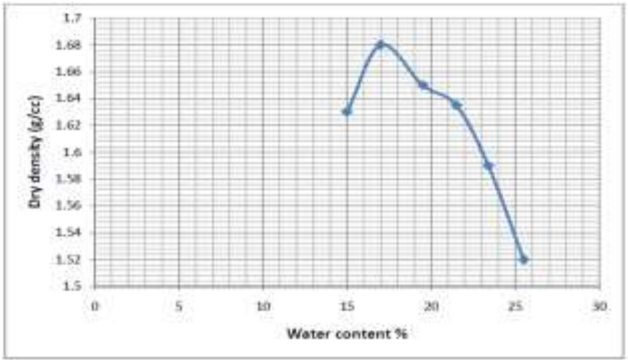

Fig 3.7 compaction curve for soil +6.0% tyre

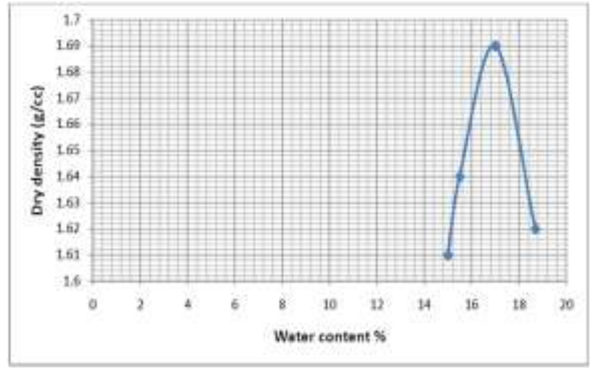

Fig 3.8 Compaction curve for soil + 8.0% tyre

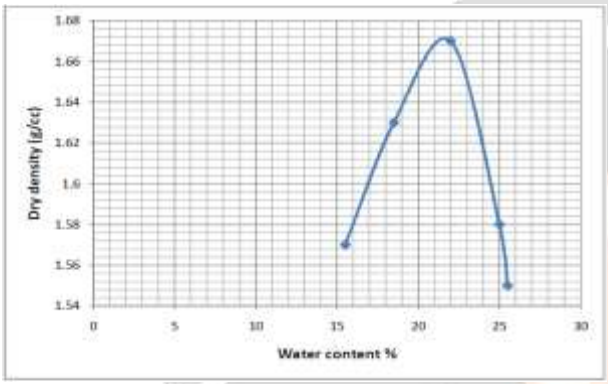

Fig 3.9 Compaction curve for soil + 0.25% coir

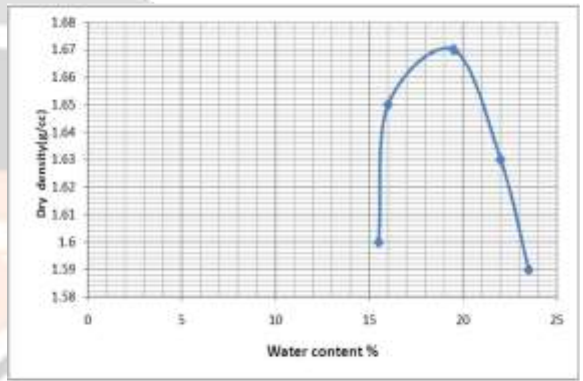

Fig 3.10 Compaction curve for soil + 0.5% coir

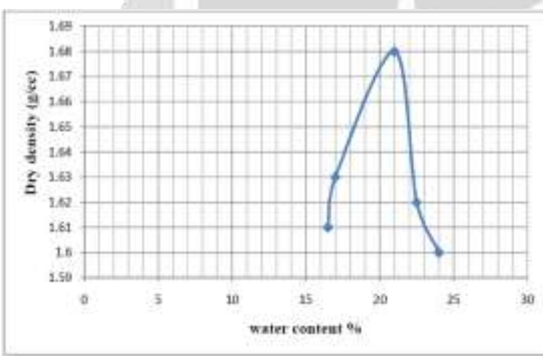

Fig 3.11 Compaction curve for soil + 0.75% coir

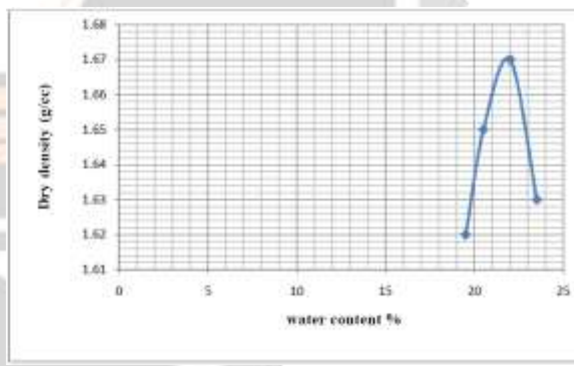

Fig 3.12 Compaction curve for soil + 1% coir

3.6 TRIAXIAL TEST

Triaxial test is determined for soil samples as per IS 2720(part 10)-1973

try axial curve for soil

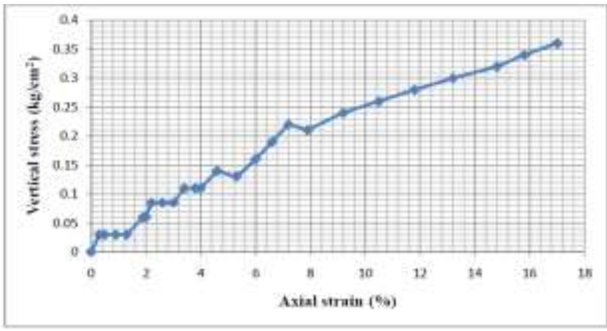

Fig 3.13 try axial curve for soil

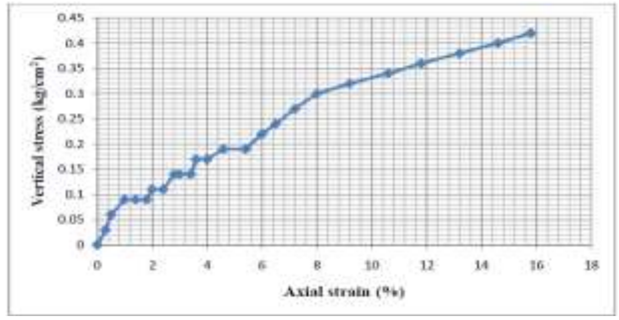

Fig 3.14 try axial curve for soil + 1% tyre

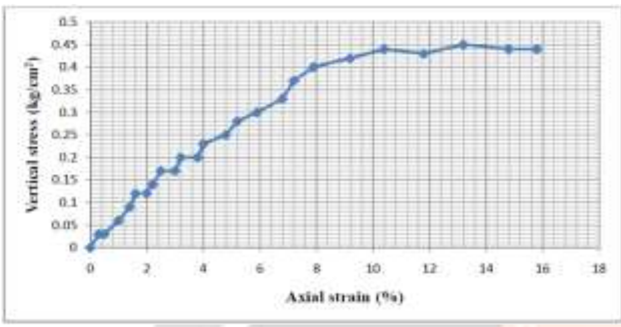

Fig 3.15 try axial curve for soil + 2% tyre

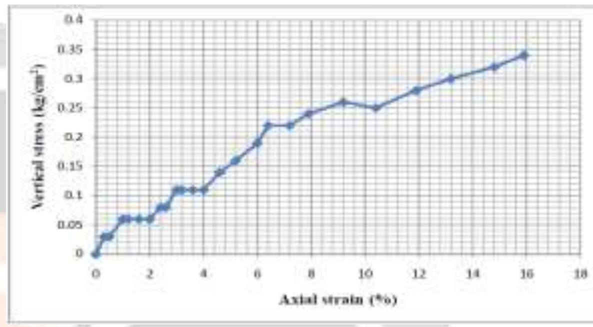

Fig 3.16 try axial curve for soil + 4% tyre

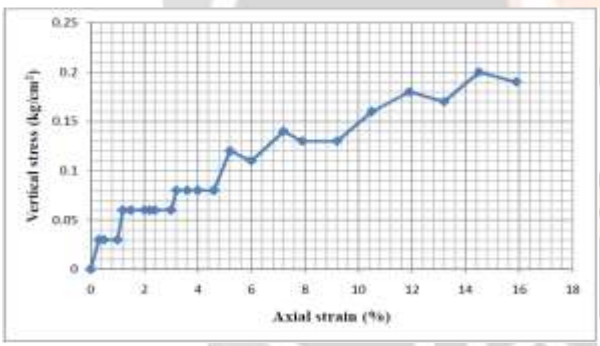

Fig 3.17 try axial curve for soil + 6% tyre

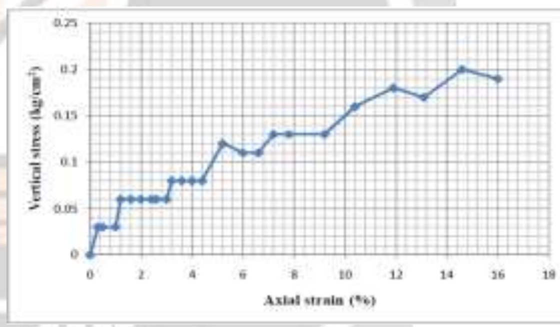

Fig 3.18 try axial curve for soil + 8% tyre

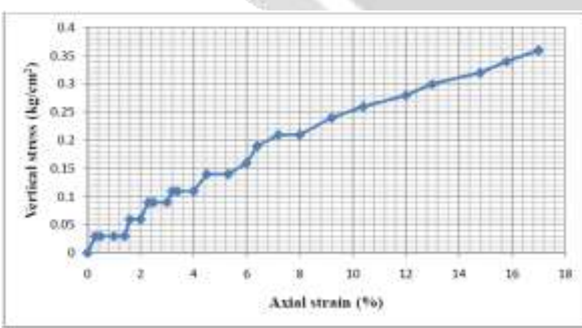

Fig 3.19 try axial curve for soil + 0.25% Coir

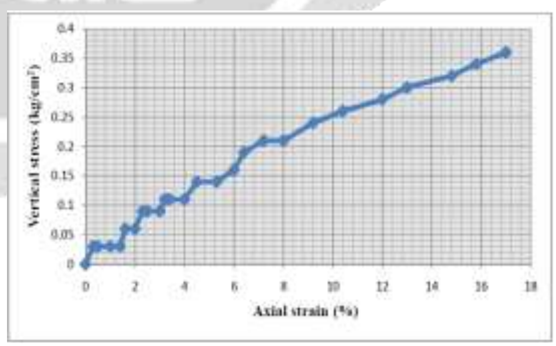

Fig 3.20 try axial curve for soil + 0.50% Coir

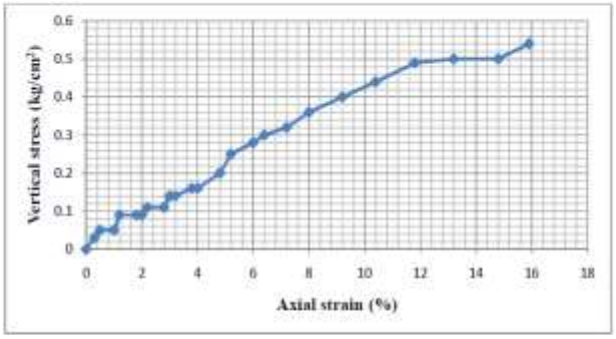

Fig 3.21 try axial curve for soil + 0.75% Coir

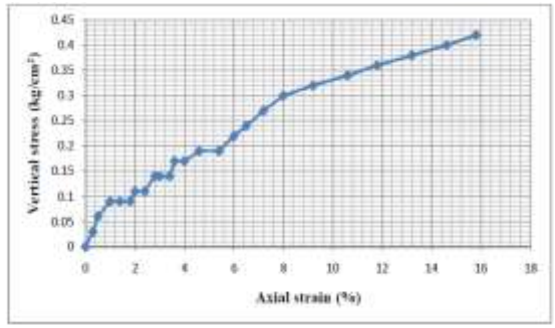

Fig 3.22 try axial curve for soil + 1% Coir

3.7 CALIFORNIA BEARING RATIO (CBR) TEST California bearing ratio is determined for the soil samples as per IS 2720 (part 8) 1973.

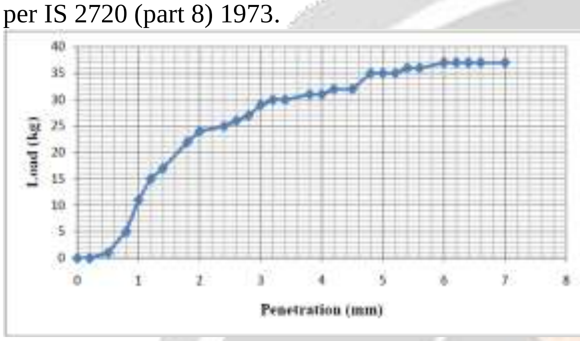

Fig 3.23 CBR Curve for soil

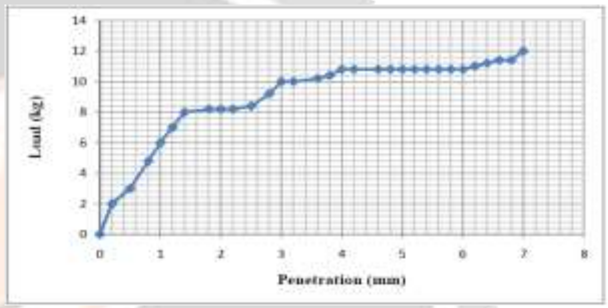

Fig 3.24 CBR Curve for soil + 1% tyre

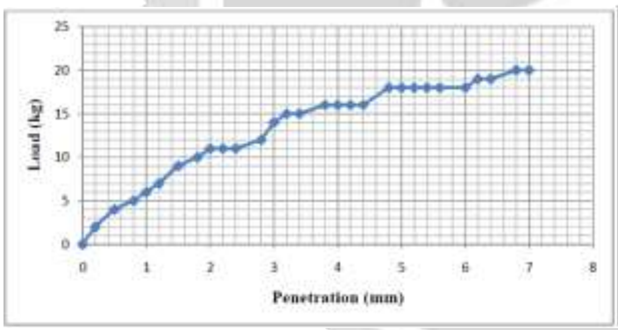

Fig 3.25 CBR Curve for soil + 2% tyre

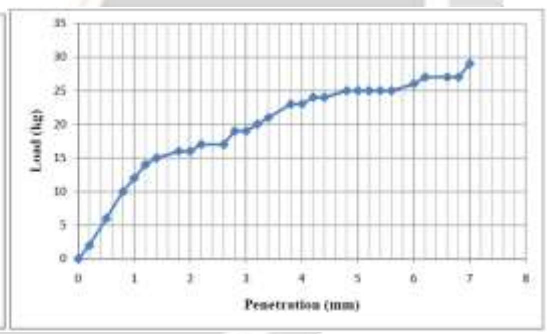

Fig 3.26 CBR Curve for soil + 4% tyre

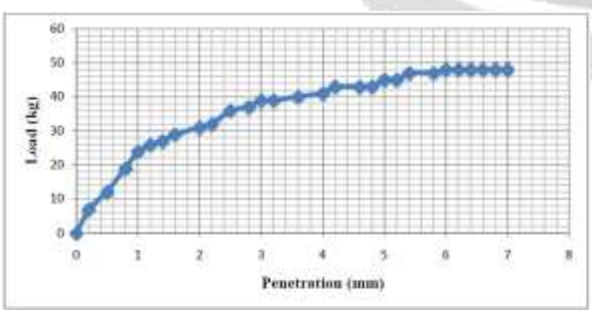

Fig 3.27 CBR Curve for soil + 6% tyre

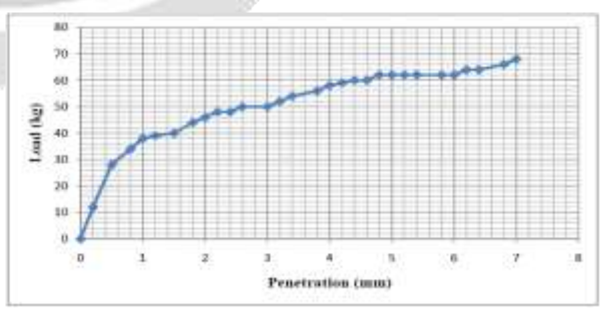

Fig 3.28 CBR Curve for soil + 8% tyre

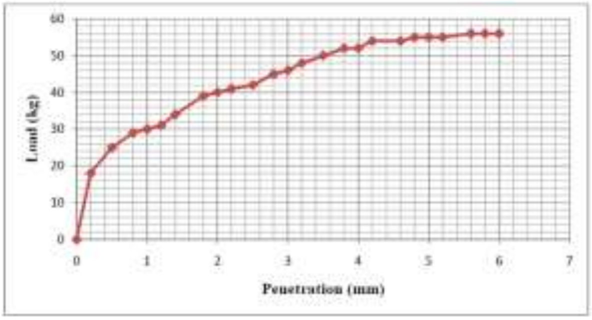

Fig 3.29 CBR Curve for soil + 0.25% coir

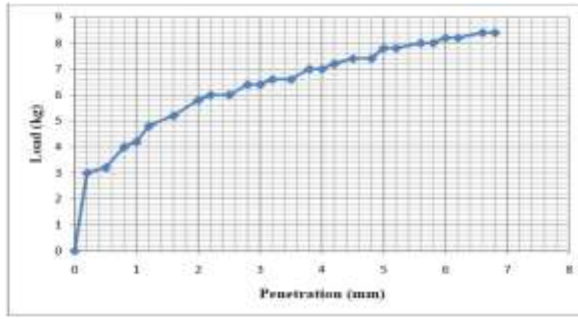

Fig 3.30 CBR Curve for soil + 0.5% coir

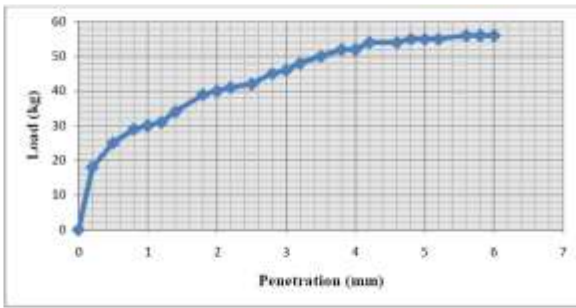

Fig 3.31 CBR Curve for soil + 0.75% coir

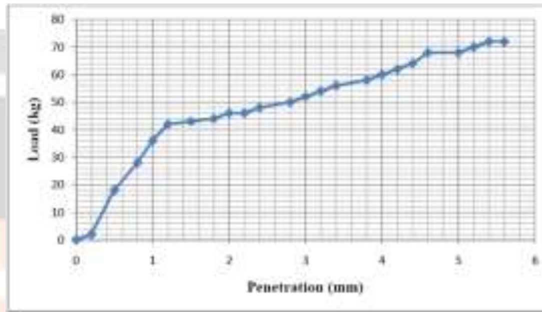

Fig 3.32 CBR Curve for soil + 1% coir

3.8 COMPARISION GRAPHS

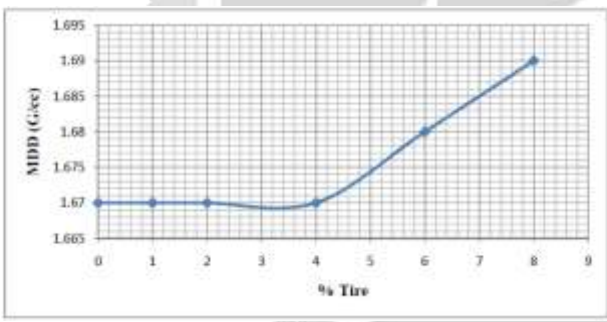

Fig 3.33 Compaction Graph for Compaction with TYRE

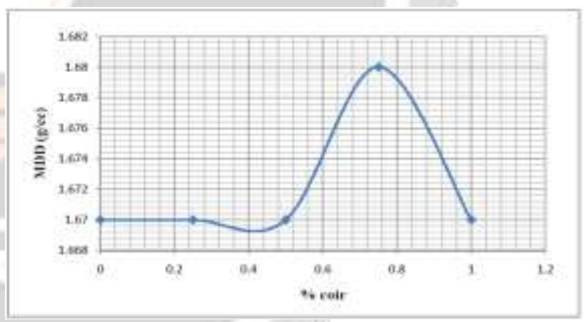

Fig 3.34 Compaction Graph for Compaction with COIR

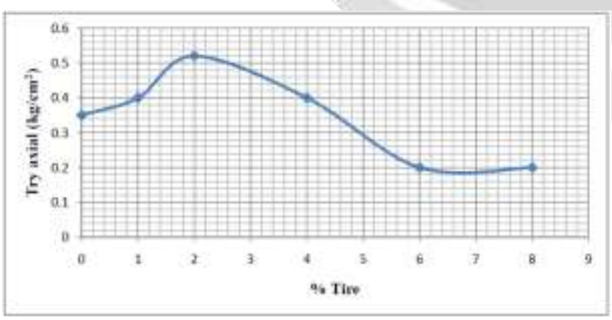

Fig 3.35 Compaction Graph for TRY with TYRE

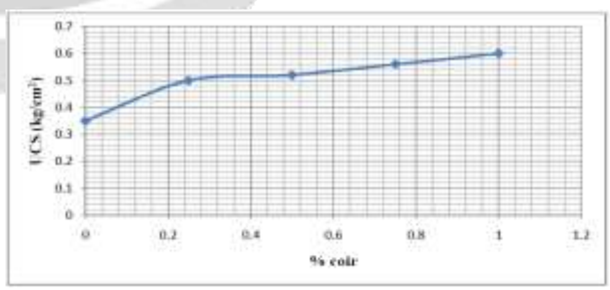

Fig 3.36 Compaction Graph for TRY with COIR

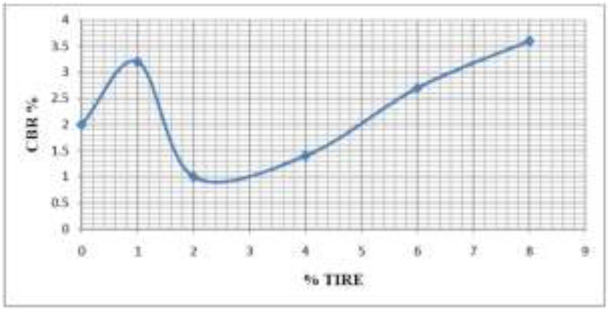

Fig 3.37 Compaction Graph for CBR with TYRE

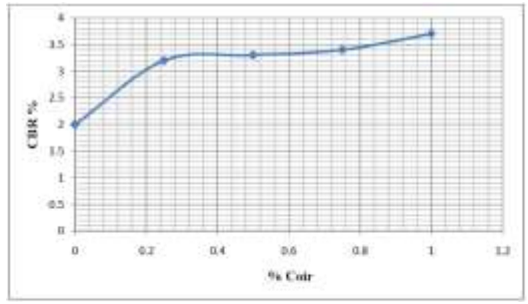

Fig 3.38 Compaction Graph for CBR with COIR

5.9 RESULTS

% coir	MDD (gm/cc)	OMC %	TRI (kg/cm²)	C_u (kg/cm²)	CBR%
0	1.67	20	0.36	0.18	1.95
1	1.67	22	0.41	0.21	3.19
2	1.67	20	0.52	0.26	1.1
4	1.67	17.5	0.4	0.2	1.27
6	1.68	17	0.2	0.1	2.65
8	1.69	17	0.2	0.1	3.55

Table: 3.4 Table of results (tyre)

%coir	MDD(gm/cc)	OMC %	TRI (kg/cm²)	C_U (kg/cm²)	CBR%
0	1.67	20	0.36	0.18	1.95
0.25	1.67	22	0.48	0.24	3.1
0.5	1.67	20	0.54	0.27	3.2
0.75	1.68	21	0.55	0.28	3.35
1	1.67	22	0.6	0.3	3.8

Table: 3.5 Table of test results (coir)

VI. DISCUSSION ON RESULTS

4.1 COMPACTION TEST

4.1.1 WITH INCREASE IN PERCENTAGE OF TYRE WASTE

The MDD value for natural soil is 1.67 gm/cc. By increasing the reinforcement with tyre up to 4% there is no change in the MDD value. By further increasing the percentage up to 8%, MDD value is increased to 1.69gm/cc, which shows an increment of 1.2%.

When compared to natural soil sample, the results of 6% tyre and 8% tyre are greater than natural soil by 0.6% and 1.2%.

The optimum moisture content value for natural soil is 20% and increased to 22% at 1% tyre waste. By further increasing the reinforcement up to 8%, OMC decreased to 17%, which shows a decrement of 33.3%.

When compared to natural soil sample, all the results of blended soils are less than or equal to the OMC of natural soil by 12.5%, 15%,15% and equal to OMC at 2% tyre waste. Whereas for 1 % tyre, there is an increase of 10%.

4.1.2 WITH INCREASE IN PERCENTAGE OF COIR

The MDD value for natural soil is 1.67 gm/c. By increasing the percentage of coir there is no change in MDD value upto 0.5% coir. By further increasing the percentage to 0.75% the MDD value increased to 1.68 gm/cc and again decreased to 1.67gm/cc for 1% coir.

The OMC value for natural soil is 20% and is increased to 22% for 0.25% coir and decreases by 10% and reaches a value of 20% at 0.5% coir. By further increasing the percentage of coir up to 1% the OMC is increased to 22%, which is an increment of 10%.

When compared to natural soil sample, all the results of blended soils are greater than OMC of natural soil by 10%, 5% and 10% for 0.25%, 0.75% and 1% coir respectively.

4.2 TRIAXIAL TEST

4.2.1 WITH INCREASE IN PERCENTAGE OF TYRE WASTE

The unconfined compression strength for natural soil is 0.36 kg/cm^2. By increasing the percentage of tyre up to 2% the value of UCS is increased by 44.44% and reaches a value of 0.52 kg/cm^2. By further increasing the percentage of tyre up to 8% the UCS value is decreased by 62.6% and reaches a value of 0.2 kg/cm^2.

4.2.2 WITH INCREASE IN PERCENTAGE OF COIR

The unconfined compression strength for natural soil is 0.36 kg/cm^2. By addition of coir the UCS value has increased to 0.6 kg/cm^2 up to 1% coir, which is showing an increment of 66.66%.

When compared with natural soil, all the results of reinforced soils are greater than unconfined compression strength of natural soil by 33.33%, 50%, 52.77% and 66.66% for 0.25%, 0.5%, 0.75% and 1% coir respectively.

4.3 CBR TEST

4.3.1 WITH INCREASE IN PERCENTAGE OF TYRE WASTE

The CBR value for natural soil is 1.95% and increased to 3.19% for 1% tyre waste. By increasing the percentage of tyre to 2% the CBR value is decreased to 1.1%. upon increasing the percentage of tyre waste up to 8% the value of CBR increase to 3.55%.

When compared to natural soil, all the values of blended soil samples are higher than the natural soil samples by 63.58%, 35.9%, and 82.05% for 1%, 6% and 8% respectively. Whereas there is a decrease in value of CBR for 2% and 4% tyre by 51.79% and 44.2%.

4.3.2 WITH INCREASE IN PERCENTAGE OF COIR

The CBR value for natural soil is 1.95%. By addition of coir, the CBR value has increased up to 1% coir and reached to 3.83%, which shows an increment of 96.4%.

When compared to natural soil, all the values of reinforced soils are greater than natural soil by 58.97%, 68.2%, 74.35% and 96.4% for 0.25%, 0.5%, 0.75% and 1% coir respectively.

V. CONCLUSIONS

1. MDD of modified soil is maximum at 0.75% coir, which shows an increment of 0.6% and OMC is maximum at 0.25%, which shows an increment of 10%.
2. The UCS value of modified soil gets increased with increase in coir content with an increase of 66.66%.
3. The CBR value of modified soil increases with increase in coir content with an increase of 94.8% at 1% coir.
4. MDD increases with increase in percentage of tyre and the OMC gets decreased with increase in percentage of tyre.
5. The use of shredded rubber tyres since reduces the amount of water required for the compaction effort while maintaining a reasonably good maximum dry density.
6. The UCS value of modified soil is maximum at 2% tyre, which shows an increment of 44.4%.
7. The CBR value of modified soil is maximum at 8% tyre, which shows an increment of 82.05%.
8. The CBR and UCS values of coir at 1% are higher compared to that of tyre. Hence coir is more reliable than tyre.

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