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Study On Subgrade Soil Using Jute Geotextile In Prakasam District Of Andhra Pradesh

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Abstract— **The performance of any type of pavements is more contributed on sub-grade soil strength. Many stabilizing techniques and materials were used to increase the strength of sub-grade soil among different natural and artificial geotextile material. Jute is one of the natural abundant resource materials many studies were carried out on jute geotextile on embankment slope protection and embankment construction and drainage design. Jute material is used in reinforcement of soil layer in pavement design. Several case studies in field showed that the strength of Jute Geotextile typically reduced about 60 to 70 percent after lying embedded in estuarine soil for around 18 months. Jute is bio-degradation material in this studies the span of JGT can be increased by spraying bitumen on the jute and reinforcing the soil layer and structurally evaluating the stresses and strains under standard axle load condition 8T another method can adopt by using the polythene sheets like sandwich layer to increase the span and strength of jute fiber and sub-grade strength of CBR value. Research studies will carried on sub-grade soil to increase the CBR value by using jute with bitumen coated/polythene sheets. Some experimental studies had been conducted on clay soil (CI) and results were not reliable for heavy compaction. Principal application of JGT is to reduce the pavement thickness layers and Appropriately designed woven JGT when placed on a road sub-grade enhances its bearing capacity (expressed as CBR %).The phenomenon is the result of the functions of separation and filtration performed by an appropriately designed woven JGT laid on the sub-grade. Consolidation of soil is a protracted process. Normally the range of enhancement of CBR of a sub-grade treated with JGT is 150% to 300% of the control value.**

Index Terms—**Bearing capacity, CBR, Compaction, JGT, Subgrade Soil**

I. INTRODUCTION

Generally strength of the sub-grade soil is expressed as California Bearing Ratio (CBR) value. Increase in the CBR value of sub-grade soil will considerably decreases the thickness of the pavement, thereby reducing the cost of construction of the pavement. During last 25 years lot of work has been done on strength deformation behaviour of reinforced soil and it has been established that addition of reinforcement in soil improves the overall engineering performance of soil. To increase the CBR value so many methods are available such as replacement of existing soil, controlled compaction, pre-wetting, moisture barriers, stabilization and using geo-synthetics. Among all the above mentioned methods stabilization and geo-synthetics are best methods. Stabilization can be done by using chemicals like lime, Portland cement, bitumen etc. The strength attained by the chemical stabilization may not be constant throughout the life of the project. The effect of chemicals may be reduced by the presence of water during rains.

Use of man-made geo-synthetics made of polymeric materials like polypropylene, polyester and polyamide to improve the performance of soil is a well tried and accepted concept all over the world. Application of jute-geo-textile (JGT) was started in 1980's. JGT has been used in many road projects successfully with the aim to construct durable roads and to reduce maintenance cost. JGT has also been used for protection of river banks, in managing slopes including hill slopes, control of surface soil erosion, stabilization of embankments, prevention of reflection cracks in bituminous pavements and consolidation of soft soils etc. The durability of JGT can be improved by coating with phenol and bitumen whichever is easily available.

II. STUDY AREA

Another soil is taken the laboratory to compare the results obtained from both soils. The locally available jute is taken to improve the engineering properties of the soils. T he jute properties are determined based on the weight and diameter of the jute fibers.

Index properties like liquid limit, plastic limit, plasticity index and shrinkage limit etc, for both soils are determined. Based on the results obtained the soils are classified. Optimum Moisture Content (OMC), Maximum Dry Density (determined by using Standard Proctor Test for both soils. Strength tests i.e.
Unconfined Compressive Strength (UCS) and California Bearing Ratio (CBR) are carried out for both soils and results are noted.
The jute was cut according to the diameters of the UCS mould (3.8 cm) and CBR mould (15 cm). These jute layers are placed at different depths 1/3, 1/2 and 2/3 of the moulds and UCS and SOAKED CBR tests are carried out for both soils. To increase the durability of the jute, it is coated with bitumen and is kept in air for 4 days at room temperature. The jute coated with bitumen is also placed at different depths 1/3, 1/2 and 2/3 of the UCS and SOAKED CBR moulds and the tests are carried out for both soils.
Because of plastic is a non-biodegradable material, polythene sheets are also used to increase the durability of jute in this project. Polythene sheets are cut according to diameters of UCS and CBR moulds and is placed above and below the jute and this combination is placed in the UCS and CBR moulds at different depths 1/3, 1/2 and 2/3 of the moulds and the tests are carried out according to IS 2720 for both soils. While doing CBR tests for both soils soaked for 4 days some distortions are occurred in the initial readings of the tests. So correction factors are applied and corrected SOAKED CBR values are determined. A comparison table is made to analysis the results for both soils reinforced with jute, jute+bitumen and jute+polythene Sheet.

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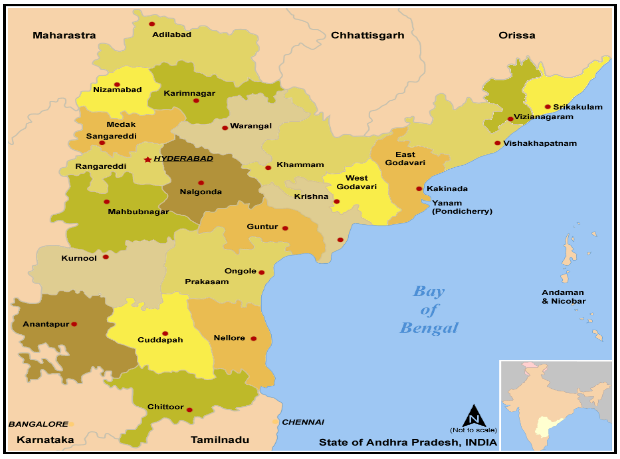
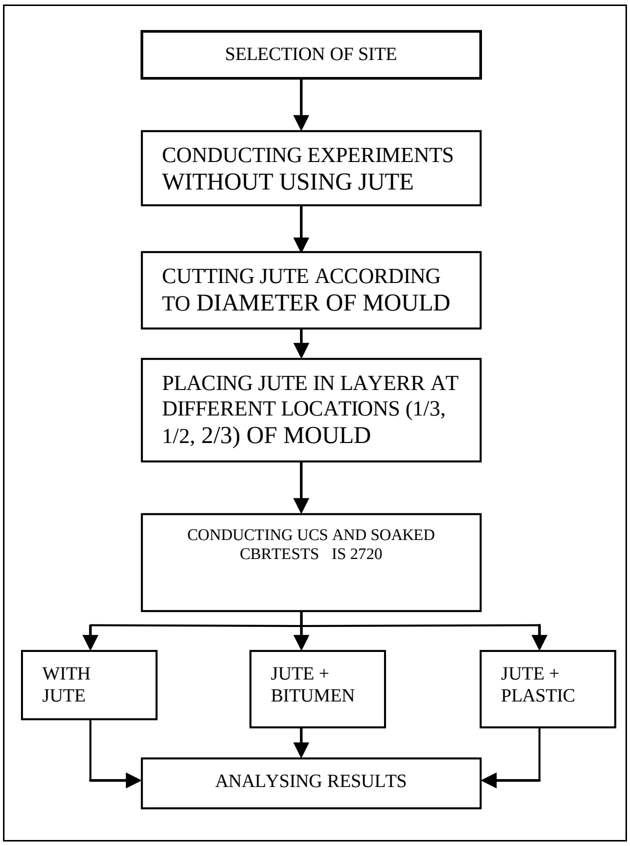




III. LITERATURE REVIEW

Various types of randomly distributed elements such as polymeric mesh elements (Andrews et.al, 1986), synthetic fiber (Gray and Al Refrain 1986, Maher and Gray 1990, Raman et. al, 1996, Char an 1995, Console et al., 2002, Michalowski and Cermak , 2003, Gosavi et al., 2004, Yetimoglu and Inaner 2005, Rao et al., 2006, Chandra et al. 2008 and Singh 2011) metallic fiber (Fatani et al.1999) and discontinuous multi oriented polypropylene elements (Lawton et.al, 1993) have been used to reinforce soil and it has been shown that the addition of randomly distributed elements to soils contributes to the increase in strength and stiffness. Lekha (2004) and Vishnudas et al. (2006) have presented a few case studies of construction and performance monitoring of coir geotextile reinforced bunds and suggested that the use of coir is a cost effective eco hydrological measure compared to stone-pitching and other stabilization measures used in the protection of slopes and bunds in rural areas.

Use of natural fiber in civil engineering for improving soil properties is advantageous because they are cheap, locally available, biodegradable and eco-friendly. The natural fiber reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Over the last decade the use of randomly distributed natural and synthetic fiber has recorded a tremendous increase. Keeping this in view an experimental study was conducted on locally available (Doimukh, Tanager, Arunachal Pradesh, India) soil reinforced with Jute fiber. In this study the soil samples were prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould with and without reinforcement. The percentage of Jute fiber by dry weight of soil was taken as 0.25%, 0.5%, 0.75% and 1%. In the present investigation the lengths of fiber was taken as 30 mm, 60 mm and 90 mm and two different diameters, 1 mm and 2 mm were considered for each fiber length. The laboratory CBR values of soil and soil reinforced with Jute fiber were determined. The effects of lengths and diameters of fiber on CBR value of soil were also investigated. Tests result indicates that CBR value of soil increases with the increase in fiber content. It was also observed that increasing the length and diameter of fiber further increases the CBR value of reinforced soil and this increase is substantial at fiber content of 1 % for 90 mm fiber length having diameter 2 mm.

IV. PROPERTIES OF MATERIALS

Soil:

Index properties of the soil are determined (Table –1) and classification of soil is done as per Indian standard i.e. IS: 1498 & IS: 2720. The soil is classified as inorganic clay with low plasticity i.e. CI & has very intermediate consistency.

Table 1 Index Properties of Soils

S.No	Description	Sample-1	Sample-2
1	Specific Gravity	2.43	2.52
2	Liquid Limit	42.50%	36%
3	Plastic Limit	18.11%	20.56%
4	Plastic Index	24%	15%
5	Maximum Dry Density	17.93 KN/m^3	18.42%
6	Optimum Moisture Content	16%	8%
7	IS Classification	CI	MI

Jute:

Jute fibres constitute about 7-9% by weight of green plant. It has a multi-cellular structure which helps to get mixed with the soil and strengthen it. The properties of jute geo-textile used are given in (Table 2).

Table 2 Properties of Jute

S.No	Properties	Values
1	Thickness	3mm
2	Weight	400g/m^2
3	Tensile strength	2.81kN/m
4	Punching strength	0.5kN
5	Failure strain	30%
6	Permittivity	3.36x10^{-3}per sec
7	Transmissivity	4x10^{-6}m^2/sec
8	Apparent opening size (A.O.S)	0.05mm
9	Tenacity	4.2gm/denier

(Source: Special Report 21- Use of Jute Geotextiles in Road Construction and Prevention of Soil Erosion/Land Slides)

Fig 2 Jute Geo-Textiles

Fig 3 Jute coated with bitumen

Bitumen:

Bitumen is used for coating the jute fiber to protect them from microbial attack & degradation. Bitumen coating is done in the hot state at a temperature of 160°C. Grade and some of the other properties of bitumen are tabulated in (Table-3).

Table 3 Properties of Bitumen

S.No	Properties	Values
1	Grade of bitumen	80/100
2	Softening point	45ºc
3	Flash point	185ºc

Polythene Sheet:

A plastic material of 40 microns is used in a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. The jute geotextile is placed between the two polythene sheets and placed in mould.

Fig 4 Jute covered With Polythene sheets

UNCONFINED COMPRESSION TEST:

The Table 4 shows that the ultimate stress of CI soil increases from 82.35 KN/m^2 to 300 KN/m^2 when 3 layers of jute geotextiles are placed in specimen in layers.

Table 4 UCS test values for CI soil

UCS Test	q(ultimate stress) KN/m^2		
Without reinforcement	82.35		
With reinforcement	1 Layer	2 Layers	3 Layers
	89.84	153.4	300

Table 5 Soaked CBR Test Results for CI Soil

No of layers	0%	1layer	2layers	3 layers
Jute	2.5	2.78	6.36	6.49
jute+bitumen	2.5	3.97	7.16	7.36
jute +plastic	2.5	6.16	6.36	6.96

V. FLEXIBLE PAVEMENT DESIGN USING SOAKED CBRVALUE OF SUB-GRADE SOIL:

California State Highways Department Method:

The Required data for design of flexible pavement are:

1. Design Traffic in terms of cumulative number of standard axles (CSA).
2. CBR value of sub grade.

1. Traffic Data:

a) Initial data in terms of number of commercial vehicles per day (CVPD).
b) Traffic growth rate during design life in %
c) Design life in number of years.
d) Distribution of commercial vehicles over the carriage way

a) Initial Traffic

In terms of Cumulative Vehicles/day, based on 7 days 24 hours Classified Traffic volume data for our pavement it is taken as 320 cumulative vehicles/day.

b) Traffic Growth Rate

Establishing Models Based on Anticipated Future Development or based on past trends Growth Rate of LCVs, Bus, 2 Axle, 3 Axle, Multi axle, HCVs is different. From IRC-37 it is taken as 7.5%.

c) Vehicle Damage Factor (VDF)

Multiplier to Convert No. of Commercial Vehicles of Different Axle Loads and Axle Configurations to the Number of Standard Axle Load Repetitions indicate VDF Values.

Table7 Indicative VDF Values

Initial Traffic in terms of CV/PD	Terrain	
	Plain/Rolling	Hilly
0 – 150	1.5	0.5
150 – 1500	3.5	1.5
> 1500	4.5	2.5

The present terrain is plain with initial traffic of 447CV/Day hence VDF is 3.5.

d) Distribution of Traffic:

Single Lane Roads

Total No. of Commercial Vehicles in both Directions

Two-lane Single Carriageway Roads

75% of total No. of Commercial Vehicles in both Directions

Four-lane Single Carriageway Roads

40% of the total No. of Commercial Vehicles in both Directions

Dual Carriageway Roads

75% of the No. of Commercial Vehicles in each Direction

The distribution factor for present design is taken as

75% of total No of Commercial vehicles/day.

Computation of Traffic for Use of Pavement Thickness Design Chart

$$N = \frac{365 \times A\,[(1+r)^{n} - 1]}{r} \times D \times F$$

N = Cumulative No. of standard axles to be catered for the design in terms of msa

D = Lane distribution factor =0.75

A = Initial traffic, in the year of completion of construction, in terms of number of commercial vehicles per day=320cv/day

F = Vehicle Damage Factor=3.5

n = Design life in years=15

r = Annual growth rate of commercial vehicles=0.075

Therefore

$$N = \frac{365 \times [(1+0.075)^{15} - 1]}{0.075} \times 320 \times 0.75 \times 3.5$$

=8000000 = 8msa

Pavement Design:

The pavement is designed for SOAKED CBR tests results given in Table 5 and Table 6 and Traffic of 8 msa as per IRC-37.

For Soaked CBR value of 2.5%:

From the design catalogue of SOAKED CBR values of 2% and 3% by interpolation the total thickness of pavement for 2.5% is given by

Total Thickness for 8msa and 2% SOAKED CBR value= 795 + (850-795)*(8-5) =828mm

Total Thickness for 8msa and 3% Soaked CBR value=690 + (760-690)*(8-5) = 732mm

Therefore Total Thickness for 2.5% Soaked CBR value=828 - (828-732)*(2.5-2) =779mm

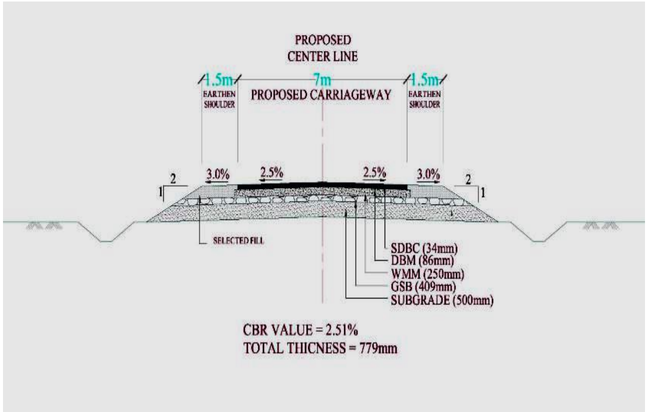
Similarly by doing interpolation for finding individual layer thicknesses the pavement composition is

SDBC (Semi Dense Bituminous Course) =34mm

DBM (Dense Bituminous Macadam) =86mm

Granular base course =250mm

Granular sub base = 409mm



VI. RESULTS AND DISCUSSION

EFFECT OF SHEAR STRENGTH:

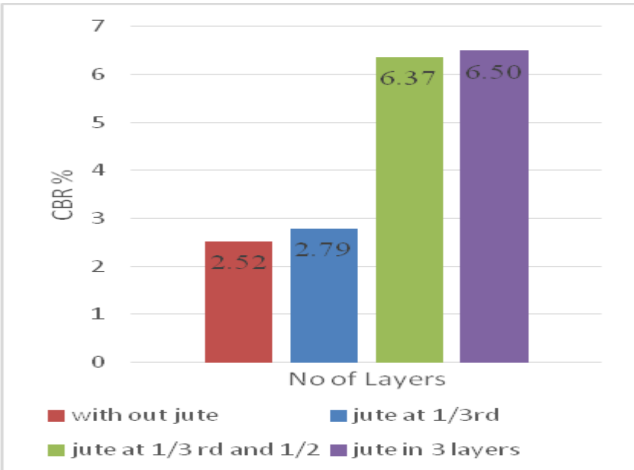
From the results of unconfined compressive strength of CI soil it is found that the ultimate stress increases with increase in number of jute layers that is up to 300% as shown in fig15. As the ultimate stress increases the shear strength of soil also increases due to increase in resistance to compressibility. The stress and strain varies with increase in number of Jute layers. When 3 layers of Jute geotextiles are placed in mould even the strain rate increased to maximum value the specimen does not fail hence in this case the ultimate stress is considered at 15% of axial strain.

EFFECT OF CBR VALUE:

for CI SOIL:

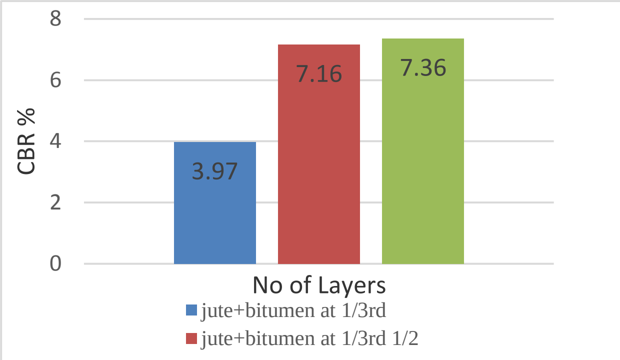
It is observed from the results that there is a significant effect of Jute Geotextile sheet on CBR value of soil.

With Jute Geotextile:



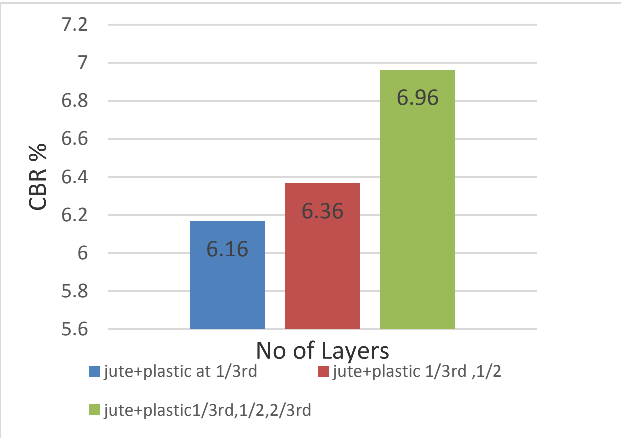
Variation of Soaked CBR value load penetration curve with jute geotextile in different layers

CBR value of soil increases from 2.52% to2.79% as the Jute Geotextile sheet is placed in the soil at 1/3rd depth of mould from top. As the number of JGT sheet increases, the CBR value increases further from 2.79% to 6.5% and load taken by soil for same penetration of plunger increases due to increase in resistance of soil because of JGT as shown in Fig 16. But this increase is significant when 2 layers of jute are used.



The Soaked CBR value of soil increases from 2.52% to 7.36% when three layers of jute coated with bitumen is used due to increase in tensile strength of jute when coated with bitumen. As there is no significant increase in Soaked CBR value and penetration resistance of plunger as shown in fig 17 it is economical to use 2 layers of JGT.

Jute Geotextile between Two Polythene Sheets:



The Soaked CBR value increases from 6.17% when 1 sandwich layer of polythene and jute are placed to 6.96% when 3 layers are used as shown in Fig 18, also the increase in Soaked CBR value of treated jute placed in single layer is equal to that of using 3layers of untreated Jute Geotextile.

VII. SCOPE FOR FUTURE STUDY:

In the past jute geotextiles have been used in slope stabilization techniques and erosion control. After that JGT is used as a separator between two layers (subgrade and sub base course). In this project we use JGT as a reinforcing material in different layers. JGT is also acts as a good drainage material. To increase the durability of JGT we adopted two methods. One is coating with bitumen and other is use of polythene sheet to protect against degradability. We have tested this technique for clay of intermediate compressibility and intermediate silty soils and succeeded.

Further it may also extend to other types of soils. It may also be used as reinforcing material in foundation, to reduce capillary rise in water lagged areas and to reduce the seepage and permeability in water bodies.

VIII. CONCLUSION

On the basis of the experimental results obtained from present investigation and discussions made in previous sections the following conclusions may be drawn:

1. CBR value of soil increases as the number of jute geotextile layers is incorporated into the soil. The CBR value of clay of intermediate compressibility soil is maximum when reinforced with 3 layers of JGT but it is more significant to adopt 2 layers as there is no appreciable difference in CBR value, and for silty clay it is maximum for 2 layers of JGT and decreases with increase in reinforcement due to decrease in density.
2. The maximum improvement in CBR is 300% for jute sprayed with bitumen and jute with polythene sheet.
3. Jute Geotextile can be suitable for use as a separation layer as well as reinforcing material for construction of medium traffic volume roads.
4. By using bitumen sprayed jute and polythene sheets the durability of jute increases.
5. Pavement thickness reduced by 234mm when jute coated with bitumen is used and by 208mm when jute with polythene sheets are used.
6. Percentage Savings of Cost of Different Fabric as compared to Jute Geotextile

IX. RECOMMENDATIONS

Jute geotextile is very effective in weak subgrade soils in reducing their compressibility and increasing their strength.
Acts as a drainage layer along its plain.
The requirements of porometry, permittivity and transmittivity can be attained by using Jute Geotextile.
When used in asphaltic overlays control reflective cracking of pavements and prolong their fatigue life.

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