



## APPLICATION OF GEO-TEXTILES TO IMPROVE C.B.R VALUE OF SUB-GRADE

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### ABSTRACT

*A well-developed road network forms an integral part of the development of any nation. The lack of resources available and their ever-increasing cost of materials and energy have motivated highway engineers to explore new alternatives in building new roads and rehabilitating the existing ones. A weak sub-grade has been and still is one of major concerns to pavement design engineers due to its potential contribution to permanent deformation in flexible pavements, particularly in low-volume thin pavements. In such situations, the natural condition of poor sub-grade soils needs to be improved by suitable modification techniques to meet project requirements. Improving the strength of the sub-grade soils using additives is one such alternative. In the present study the performance of nonwoven geo-textile, interfaced between soft sub-grade and unbound gravel in an unpaved flexible pavement system, is carried out experimentally, utilising the California Bearing Ratio (CBR) testing arrangement. In order to evaluate the performance of the reinforcement the CBR load – penetration graphs are drawn. The relation of both soft sub-grade soil and soft sub-grade geo-textile soil separately. Soil properties and variations of load carrying capacity is found using CBR Tests. Optimum percentage of fibres and optimum size of geo-textile is also found using CBR Test.*

**Key words:** sub-grade roads, geo-textiles, CBR value

### 1. INTRODUCTION

The economic development of a country is closely related to its road transport infrastructure facilities available. Especially in an under developing country, the rural roads connecting agricultural villages is vital

in improving the rural economy. It is known that the option of unpaved roads are economical for low traffic volume in such areas, however, when unpaved roads laid on soft sub-grade undergoes large deformations, where the periodical maintenance of the rural road is limited due to cost considerations, which may disrupt the service and affect the function of the road. In such situations, comparing various other methods, geo-synthetics can be utilized to improve not only the performance of the unpaved road by increasing the life time, but also, minimizing the maintenance cost as well as reducing the thickness of the road.

### USE OF GEOTEXTILES

Use of geo textiles has also become very popular in recent years. According to one estimate, about 100 million square kilometres of geo textiles will be used every year as a soil saver, if proper marketing strategy is adopted by the appropriate authorities. With Indian Jute Mill Association and Indian Jute Industries Research Association taking a proactive role. Geo textiles are finding their way into almost every sphere of application in civil engineering. Being produced from natural resources, geo textiles are eco-friendly. Since synthetic geo textiles are expensive in India, cheaper substitutes like Coir have

become more popular. The broad application and uses of geo textiles have been fairly identified (Palit et al, 1988). Kabir et al (1988) have given analysis and design approach for an unpaved road reinforced with jute fabric. The following sections present a case study in which jute geo textile was used to strengthen a weak sub grade in Kakinada port area.

Coir Geo-textile a natural technical textile, was tried long before man-made Geo textile was put to use in roads. Geotextile made of jute was reportedly used in Kingsway at Dundee, Scotland way back in 1920, in Strand Road, Kolkata in 1934 by Bengal PWD and sporadically in other roads long before the use of man-made geotextile as an improver of sub-grade in roads was conceived. The trials unfortunately were not monitored and followed up. As a result, the potential of Geo textile in road construction has remained unexplored.

## **MECHANISM OF FUNCTIONING OF GEO-TEXTILE IN ROAD CONSTRUCTION**

Functionally there is no difference between man-made Geo-textile and Coir Geo-Textile. As a separator it prevents intermixing of sub-grade and sub-base. As filter it ensures “soil-tightness” on the one hand and facilitates dissipation of pore water pressure on the other. Geotextile is an excellent drainage medium and can transmit water efficiently through its own thickness both across and along its plane. On application of repeated dynamic loads on the road-top, entrapped pore water is squeezed out without allowing migration of top soil particles. The process ultimately ensures

natural consolidation of sub-grade. The consolidated soil mass known as “Filter Cake” attains a higher CBR usually 1.5 to 3 times the control value after a lapse of about one season cycle normally.

The principal reason is enhancement of CBR and for that matter, bearing capacity of the sub-grade is separation along with the membrane effect. Due to stretching of the fabric on imposition of load Geo-Textile exerts an upward reaction against it. Low elongation and high initial tensile strength of Geo-Textile help in this process. For designing the right fabric, it is necessary to know the average particle size distribution of the sub-grade, its permeability and the dynamic load the road is expected to sustain.

Soil is a critical element influencing the success of a construction project. For traffic structures like roadway pavements, the sub-grade, which performs as the foundation of the structure is very important and has to be strong enough to support the entire structure. Soil stabilisation is the process of altering the engineering properties of soil by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Stabilisation can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. The most common improvements achieved through stabilisation include better soil gradation, reduction of plasticity index or swelling potential and increase in durability and strength.

The creation of non-decaying waste materials combined with a growing consumer population has resulted in a waste

disposal crisis. Plastic discarded as waste material attribute to complex and adverse environmental problem in all the major cities in the globe. The reasonable way to minimize such waste disposal problem is to utilise the material for engineering applications. This can be done by using them in improving the strength of soil in the field of geotechnical engineering. Plastic wastes can be cut into pieces and mixed with soil and the behaviour of the soil is similar to fibre reinforced soil.

### Literature Review:

1. Full-scale field tests and large scale laboratory tests (Elvidge and Raymond, 1999; Bergado et al., 2001; Hufenus et al., 2006; Bhosale and Kambale, 2008; Subaida et al., 2009; Palmeria and Antunes, 2010) are carried out to investigate the performance of unpaved roads.
2. Laboratory CBR tests are performed to study the use of natural coir and jute geotextile (Michael and Vinod, 2009; Senthil Kumar and Pandiammal Devi, 2011; and Babu et al., 2011).
3. CBR tests are also conducted by introducing geotextiles and geogrid in granular soil (Naeini and Mirzakhani, 2008; DuncanWilliams and Attoh-Okine, 2008; and Dhule et al., 2011).
4. Further, based on CBR test, the influence of geotextile, geogrid and geonet are investigated in clay with low or medium compressibility (Srivastava et al., 1995; Naeini and Moayed, 2009; Nair and Latha, 2010; Moayed and Nazari, 2011; and Nair and Latha 2011) as soft subgrade in an unpaved road system.

5. Mohanachandran.Sayida M.K., Sheela Evangeline Y, use of geo-synthetics is ensured in a given geotechnical application In this study the performance of woven and nonwoven coir geotextiles in unpaved and paved flexible pavement models are carried out experimentally, utilising the California Bearing Ratio (CBR) testing arrangement. Compared with the unreinforced soil, all reinforced soil samples , show a slower increase in rate of penetration.

Hence, in this study the effect of non-woven geotextiles on the CBR strength of the aggregate – soil system is carried out considering the soft subgrade.

## MATERIALS AND METHODS

### Soil selection

A soil survey report typically contains soils data for one county. During a soil survey, soil scientists walk over the landscapes of the county, bore holes with soil augers, and examine cross-sections of soil profiles. They determine soil textures of different soil horizons. Soil color, soil structure, and the relationships and thicknesses of the different soil horizons also are observed. These and many other soil factors are studied in the field, and other properties are determined through laboratory tests. To be proficient in using soil survey data, it is imperative that the user have a basic understanding of the concepts of soil development and of soil-landscape relationships.

### Soil Sample

The soil used in the present study is locally available weak soil taken from a depth of 1m from a reservoir near to Vishakhapatnam. The engineering and index properties such as specific gravity,

Atterberg's limits, compaction characteristics etc. of the particular soil selected for this study were determined in the laboratory as per IS 2720, 1986. The physical properties of the soil obtained are given in Table 1. The particle size distribution curve obtained for soft soil sample.



Fig – 1 Sample

## EXPERIMENT PROCEDURE:

### Specific gravity test

Specific gravity( $G$ ) is the ratio of the weight of a given volume of soil solids at a given temperature to the weight of an equal volume of distilled water at that temperature. In other words, it is the ratio of the unit weight of soil solids to that of water. Specific gravity is a dimensionless quantity. In case of soils it can be defined as the number of times that soil is heavier than water. These specific gravities are different for different types of soil. During time of experiment it should be very careful that the temperature correction and water should be gas-free distilled water. It is defined as a very important physical property used to calculate other engineering properties of soil like, density, void ratio, porosity and saturation condition.

As mentioned previously, the ratio of the weight of a given volume of soil solids to the weight of an equal volume of distilled water is termed as Specific Gravity. This specific gravity of soil solids is determined by a pycnometer in an experimental setup where the volume of the soil is found and its weight is then further divided by the weight of equal volume of water.

### Liquid limit and Plastic Limit Test

The water content at which soil transforms from one state to the next state are known as liquid limit and plastic limit.

Liquid limit is defined as the water content that represents the boundary between the liquid and plastic states of the soil. At liquid limit, the soil possesses a small value of shear strength. The liquid limit is the minimum water content at which the soil tends to flow as a liquid is termed as a liquid limit.

The liquid limit is determined in the laboratory as the water content at which a part of soil, cut by a groove of standard dimensions, will flow together for a distance of 12mm under the impact of 25 blows. The drop of the cup used in this test is 10mm. The compressibility of a soil generally increases with an increase in liquid limit. One of the apparatus used for finding the liquid limit is Casagrande apparatus.

Plastic limit, it is defined as the water content that represents the boundary between the plastic and semi solid states of soil. The plastic limit is the minimum water content at which the change in shape of the soil is accompanied by visible crack.

In the laboratory, the plastic limit is determined as the water content at which a soil will just begin to crumble when rolled



into a thread of approximately 3mm in diameter.

$$\text{Plasticity Index (IP)} = \text{Liquid Limit (WL)} - \text{Plastic Limit (WP)}$$

Conversion from liquid state to plastic state is termed as liquid limit and conversion from plastic state to semi-solid state is termed as plastic limit and difference between these both defines Plasticity Index.

## MATERIALS

### 1. Coir geo textile from coconut

Since the development of coir sector contributes towards the sustainable development agenda in terms of creation of environment friendly products, its application for domestic use along with the usage in housing, building, agriculture, horticulture, and infrastructure production are significant. The world population is becoming more and more conscious about the need of preserving the nature with an increasing number of people opting for environment friendly products. This is the opportune time to promote the case of coir to replace synthetic furnishings and certain wooden building materials. It is therefore extremely important that, a major collective initiative may be taken up to promote the cause of coir by identifying the thrust areas involving a quantum jump in coir sector development.



Figure :Coconut coir

Three different type of coir geo-textiles available were, viz., H2M6, H2M8 and non woven geo-textiles.

Lignin	45.82%
Cellulose	43.25%
Hemi-cellulose	0.23%
Water soluble components	7.7%
Pectin's etc (soluble in boiling water)	3.0%

Coir geo textiles are made from coconut fibre extracted from the husk of coconut. Like other polymeric counterparts, coir geo textiles are developed for specific application in civil engineering like erosion control, ground improvement, filtration, drainage, river bank protection, road pavements, slope stability etc. This biodegradable and environment friendly material is virtually irreplaceable by any of the modern synthetic substitutes. The process involved in obtaining geo textiles from the raw material, husk of coconut is:

1. Retting the coconut husks, which means soaking in water for 8-10 months to remove certain natural chemicals from the husk to enable proper de fibring.
2. Extraction of fibre either manually or with the help of a machine.
3. Spinning of yarn.

4. Weaving to obtain the desired geotextiles.

### METHODOLOGY:

CBR test specimens are prepared by applying modified compaction efforts to unmixed and mixed clayey soil at their respective optimum moisture content (OMC) obtained in the compaction tests. Two types of tests are run, unsoaked and soaked. A surcharge mass of 4.5 kg is placed on the surface of the compacted specimens and then the samples are soaked in water for a period of four days. After four days of soil were determined corresponding to plunger penetration of 2.5 and 5 mm per the standard procedure laid down soaking, the mould assembly was taken out from water and the top surface of water was left exposed to air for half an hour. The CBR mould along with soaked soil sample was brought to a motorized loading frame for testing. The CBR values of the test samples of unreinforced and reinforced in IS:2720 , Part 16.



### RESULTS AND DISCUSSIONS

In these results soil is added with different ratios of coconut coir. The main parameters

that are studied include C.B.R. The numbers of curves are placed from the test results of C.B.R. tests are performed on the soil and soil mix with different percentage of coir fiber. Coir increases the C.B.R values in this investigation. The experimental results are carried out in the following laboratory works.

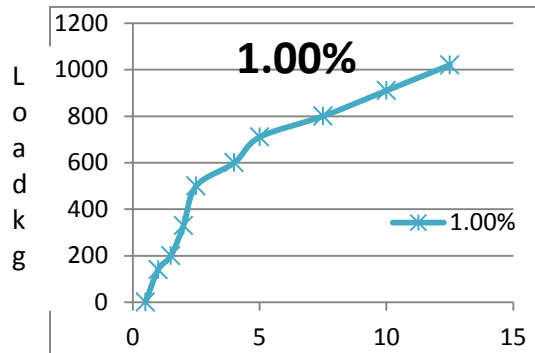
There is considerable improvement in compressive strength in case of all the soils on account of treatment with coconut coir fiber. It is noted that the compressive strength of soil increases when treated with coir (fiber) up to 1%. The increase may be due to the increase in shear parameters. It was difficult to prepare the identical samples (at constant dry density) of reinforced soil beyond 1 % of fiber content and hence in the present study the maximum coir fiber content was considered to be 1 % by dry weight of soil.

### RESULTS FOR UNSOAKED:

Penetration	Percentage of reinforcement added to soil				
	soil	0.25%	0.50%	0.75%	1.00%
0.5	20	20	30	35	0
1	50	60	85	110	140
1.5	90	95	160	180	200
2	130	150	250	320	330
2.5	190	240	340	450	500
4	220	290	420	510	600
5	280	340	505	650	710
7.5	330	405	630	765	800
10	355	450	710	840	910
12.5	380	490	820	900	1020

Graphs showing cbr results for different percentage fibre contents under un soaked conditions

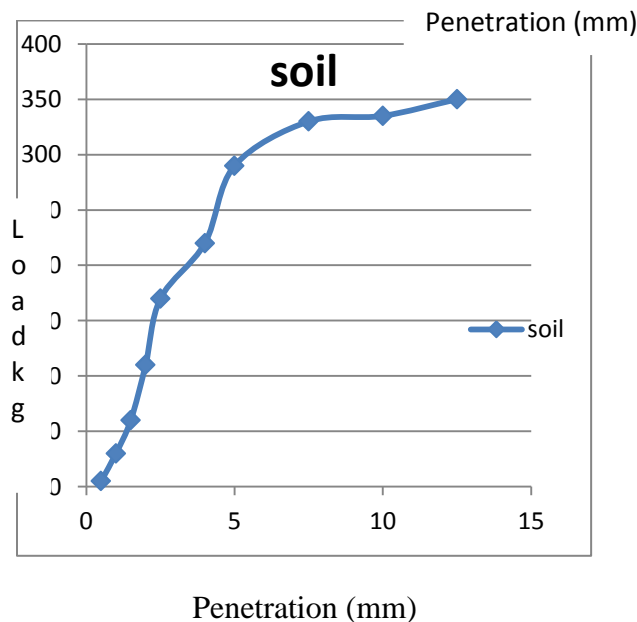
**Load vs Penetration graph when 0.75 % coir is used.**



**Load vs Penetration graph when 1 % GEO-TEXTILE (GT) is used.**

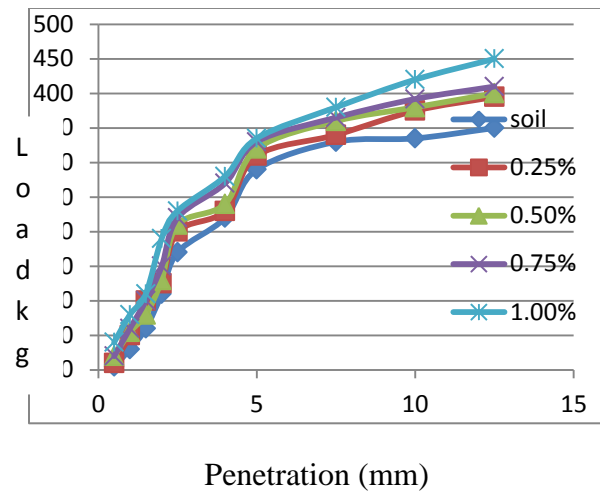
### SOAKED CBR VALUE OF COIR

**Results for soaked for different percentages of Coir used.**



**Load vs Penetration graph when 0 % GEO-TEXTILE (GT) is used.**

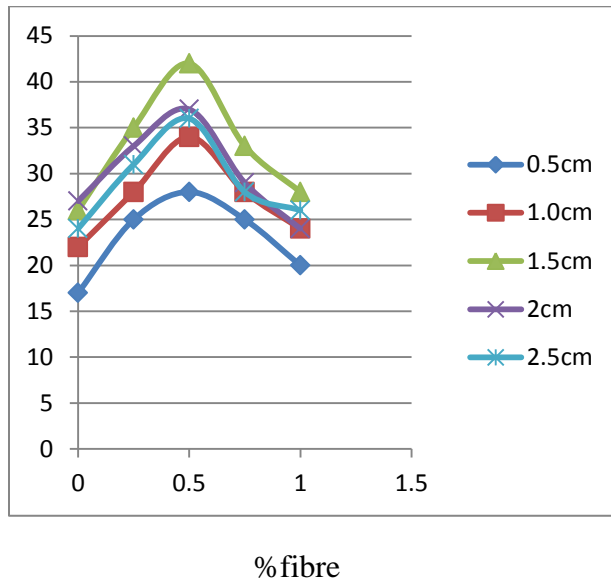
### SOAKED CBR VALUE OF COIR



CBR method of pavement design is the most popular method of pavement design. In this method, the thickness of pavement above a certain layer is based on CBR of that layer. There are charts connecting CBR and thickness of pavement required given by IRC 37-2001. As the CBR of the material increases, the thickness of pavement required reduces. The stabilization of the soil increases its CBR value tremendously and thus helps in reducing the pavement thickness. The experimental study involved performing laboratory CBR tests using coir fibers for three samples each. The sub-grade was prepared in the CBR mould of internal diameter 150mm and height (H) 175mm, by compacting up to 0.8H, to its max dry density and optimum moisture content. The control specimen is the soil sample without coir geo-textiles and reinforced sample is the sample with coir geo-textiles.

The improvement in load carrying capacity of the sub-grade soil was identified by using the CBR test. The coir fibre length varies from 0.5cm to 3cm and the optimum fibre length obtained was 1.5cm. The coir fibre

percentage varies from 0% to 1% and optimum fibre percentage obtained was 1%.



### Load vs Percentage fibre for fibre length comparisons

The influence of varying fibre length of coir was studied. It was found that the test was sensitive to the fibre length variation. For 0.5% fibre content the maximum value of load obtained was 42 kN for 1.5cm fibre length.

### 5. Conclusions

The present and past studies has shown quite encouraging results and following important conclusions can be drawn from the study:

1. Coir fibre is a waste material which could be utilized in a sub base for paved and unpaved roads.
2. From the experimental results it is found that the load taken by the soil sample increases with the increase with increase in percentage of fibre content thereby CBR

values of soil-coir fibre mix increases with increasing percentage of fibre.

3. Maximum improvement in C.B.R. values are observed when 1% of coir is mixed with the soil with length of coir 1.5 cm gives optimum results. The use of coir geo-textiles increases the sub-grade strength and thus improves pavement life.

4. It is concluded that proportion of 1% coir fibre in a soil is optimum percentage of materials having maximum unsoaked CBR value. Hence, this proportion may be economically used in road pavement and embankments.

5. Processing of coir waste in usable form is an employment generation activity in coir fibre manufacturing units and the effective use of coir waste can uplift rural economy and leads to beneficial effects in engineering construction.

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