Studies on Coir Geotextile over Weak Subgrade for Betterment of Service Life of Low Volume Roads

Harinder.D[1], S. Shankar[2]

[1]Ph.D. Research Scholar, [2]Assistant Professor, Department of Civil Engineering, Transportation Division, National Institute of Technology, Warangal, Telangana (India)

ABSTRACT

The performances of the Low-Volume Roads (LVRs) largely depend on the properties of the subgrade and sub-base soil. The construction of LVRs over the weak subgrade poses several problems to the pavement, the Block cotton soil is encountered as the weak subgrade soil. The BC soil is associated with the inorganic clay of medium to high compressibility, high swelling and shrinkage. It's poses high strength in dry and loses its strength in wet condition. Due to this problem, the vertical movement takes place in the subgrade soil leading to failure causes to the pavement. The failures of pavement occur in the form of rutting, fatigue cracking and uneven surface. In order to improve the performance of the roads on such soil many of the conventional technique were adopted and reported their benefits. In the present study on attempt is made in the laboratory to improve the performance of the LVRs on such soil by using the coir geotextile mats as reinforcement and separation material. The study was conducted in the form of two-layer system with the help of Wheel Tracking Test (WTT) apparatus. The study conclude that the inclusion of coir mats between the subgrade and sub-base layer helpful in restricting the movement of sub-base layer, reduce the vertical depression or settlement and improves the service life of the LVRs.

Keywords: Coir geotextile, Reinforcement, Subgrade, Sub-base, Separation and WTT.

I. INTRODUCTION

The reinforcement of weak subgrade soil has become necessary in engineering application. One way to improve the weak soil properties by using the conventional techniques such as lime cement fly ash etc. many of the conventional techniques were adopted to improve the properties of the BC soil. But these methods are not eco-friendly neither economical, and also having the difficulties in the field during the construction. Latter, geosynthetics are chosen as alternate materials to improve the performance of the LVRs on such soil (BC). Forms the past few decades, the geosynthetics have been gained universal promises to use in the pavement and geotechnical engineering aspects. The many of the studies were conducted in the laboratory as well as in the field using the fabrics geosynthetics and few of the studies were conducted using the natural geotextile. Form the natural geotextile, the coir geotextile have been used widely in pavement application. It is revealed that the coir geotextile are improved the performance of the

LVRs. In the present study, an attempt is made in the laboratory to evaluate the potential ability to reduce the vertical load over the subgrade, appropriate placement position of coir geotextile mats with reduced thickness of the sub-base and performance of the coir mats.

The LVRs are needs to stable in excessive deformation with increasing the traffic load under the moving load condition. The present study is conducted in the laboratory by using the three types of coir geotextile mats with help of fabricated mould. The two types of fabricated mould of size 300mmx300mmx300mm and 300mmx300mmx400mm were used. The moulds are prepared in the form of two-layer system such as subgrade and sub-base with inclusion of three types of coir geotextile mats (coir composite (CC), Woven coir mat (WCM) and non-woven coir mat (NWCM)) at H/2, H/3 and H/4 position. The moulds are prepared as per the modified CBR standards and tested by using the Wheel Tracking Test (WTT) apparatus.

II. LITERATURE REVIEW

The geosynthetic have been used in pavement to poses the functions of reinforcement, separation and drainage etc. the geosynthetic and the geotextiles are used to prevent the interruption of subgrade and sub-base material and reinforcement the pavement on weak subgrade.

The expansive soil poses the sevaral problems to the pavement in the form of rutting, fatigue and reflection due its high swelling, shrinkage and volume change behavior upon wetting and drying condition [1, 2, 3] to prevent these problem many of the conventional technics were adopted and reported their benefits, due its high cost and the difficulties in application in field. The geosynthetics are chosen as alternate material in pavements. In addition strength to the pavement, the geosynthetics are gaining importance in pavement in term of Reinforcement, separation and drainage, they proved to be cost effective especially for low volume roads [4, 5]. To investigate the effectiveness of geosynthetics in term of reflecting cracking, and conclude that the reduction of cracking proportion depends on the suitable position of the Geosynthetic [6]. The degradation of coir depends on the medium of embedment and climatic conditions and is found to retain 80% of its tensile strength after 6 months of embedment in clay [7, 8] an attempt is made in the laboratory with 3 type of clay soil to conduct the hydraulic conductivity test, at wet off optimum of to reduce the volumetric shrinkage strain of the sample at drying and wetting condition. To evaluated the desiccation characteristics under the cyclic loading at wet and dry condition. The study indicate the compaction effects decrease the volumetric shrinkage strain, the large the volumetric shrinkage strain showed the more cracks in the sample [9] . To describe the shear strength of clay soil reinforced with the randomly distributed coir fiber by using the Tri-axil test [10]. This study concluded that the incorporation of the coir fiber improves the shear strength of the clay soil.

III. MATERILAS

Black Cotton Soil (subgrade): The laboratory study is conducted with BC soil as subgrade soil. This is collected from the lake which is near to the NIT Warangal and used as a subgrade soil. The basic properties of subgrade (BC) soils are given in Table 1.

Table 1 the basic properties of BC soil

The Property of BC soil	**Value**
Classification	CH
Liquid limit (%)	58
Plastic limit (%)	27
Plasticity index (%)	34
Specific gravity	2.62
Optimum Moisture Content (%)	17
Max dry density (gm./cc)	1.7
Free Swelling Index (%)	77
Un-soaked CBR value (%)	9.0
Soaked CBR value (%)	1.0

Morrum Soil (Sub-base): The sandy gravel (SG) soil is chosen as sub-base soil. Generally morrum soil is commonly used materials in roads construction. The sub-base soil having the higher sandy particle associated with poor cohesive strength. The properties of the sub-base soil are OMC (8%), MDD (1.87%), shear strength parameter C and ω (0, 31^{o}) and soaked and unsoaked CBR value are 6% and 13 % respectively.

Table 2 the basic properties of coir geotextile

Basic Properties of the coir	Values
Length (mm)	15-20
Density (g/cc)	1.15-1.4
Breaking elongation (%)	30
Diameter (mm)	0.1-1.5
Specific Gravity	1.15
Swelling in water (%)	5.0
Young's modulus (GN/m²)	4.5
Specific heat	0.27

The coir geotextile is naturally available material extracted from the husk of coconuts. It is strong in the nature and high durability as compared with other natural material, it can spun and woven into matting. The basic properties of coir geotextile are presented in Table 2.

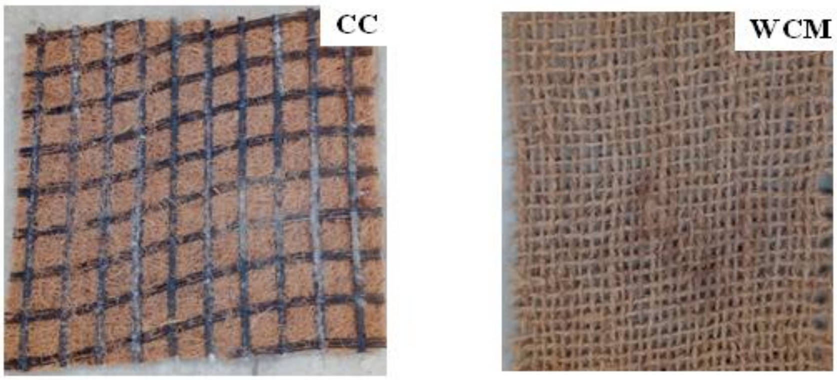

Fig.1 types of coir mats used for the study

In the present study, three types of coir geotextile mats are used which are shown in Fig.1. Namely, CC=Coir Composite, WCM= Woven Coir Mat and NWCM= Non-Woven Coir Mat.

IV. EXPERIMENTAL SETUP

The Wheel Tracking Test apparatus (WTT) are used for this investigation with varying contact pressure of moving load to simulate the filed condition. It was developed by British National Rail Road Research Institute (Generally used for measuring the plastic deformation of bituminous asphalt concrete). The WTT apparatus height of the loading lever has been raised using the fabricated angle sections. The fabricated angles are controlling the enable to the loading onto pavement model section. The maximum load applied on to the pavement has 55 Kg, through the moving wheel of diameter 200mm, width of 50mm made of solid rubber. To run the wheel over the model section three phase motor with 75kw, 400v power motor is used. The experimental setup is show in Fig.2.

Fig.2 Wheel tracking test apparatus with 400mm mould setup

V. RESULTS AND DISCUSSIONS

The laboratory study is conducted using the fabricated mould of size 300mmx300mmx300mm. The fabricated mould was prepared as a two-layer model system subgrade and sub-base with reinforcement and un-reinforcement of coir geotextile mats. The two types of the coir mats were used as reinforcement material. The subgrade is prepared and compacted as (BC soil and the sub-base is sandy gravel soil) CBR protocol. The coir geotextile mats are placed at a different position such as H/2, H/3, and H/4 from the bottom of height.

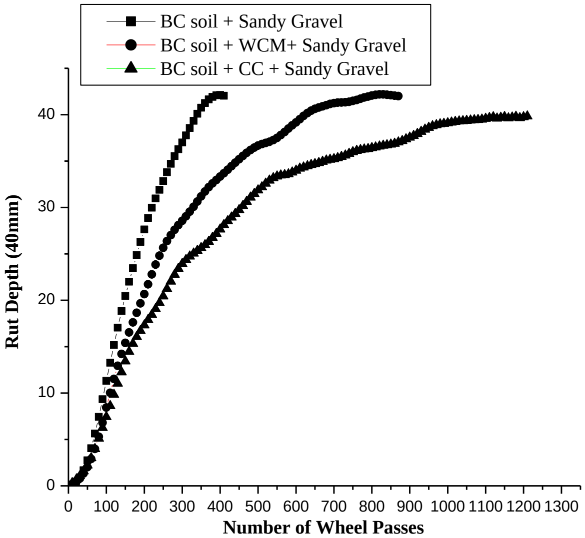

Fig.3 Rut depth along with number of wheel passes at H/2 position coir mats.

The fabricated mould were prepared has two-layer pavement system with and without provision of coir mats. The reinforcement model layer is shown the higher repetition (number of wheel pass) than the un-reinforcement layer due to its higher thickness of sub-base soil. In this case the higher repetition was obtained at a position of H/2 with coir composite mats and with the provision of higher thickness of the sub-base soil. The un-reinforcement pavement layer showed the 350 repetition. The rut depth and number of wheel passes at H/4 is shown in Fig.3.

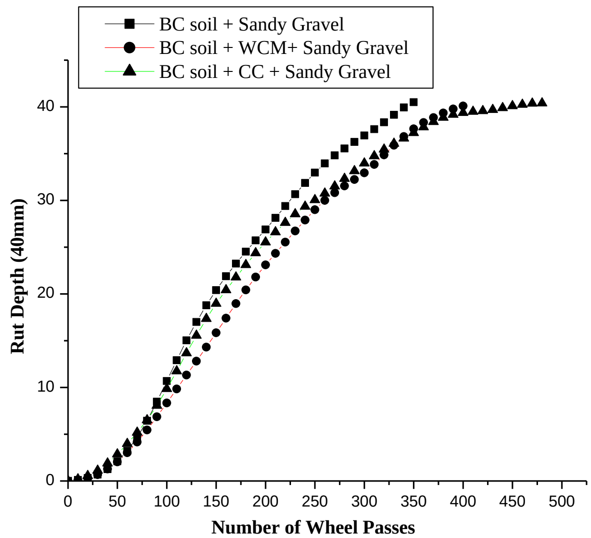

Fig.4 Rut depth along with number of wheel passes at H/3 position coir mats.

In case of sandy gravel sub-base soil, the provisions of coir mats decrease the number of repetitions. The failure is occurred in the sub-base soil due to its strength, even though the maximum load was take place by the coir mats. It is observed the performance of the coir mat depends on the strength and thickness of the sub-base soil. In this case, the provision of coir mats at H/3 position does not satisfactory performance. The rut depth and number of wheel passes at H/2 position shown in Fig 4.

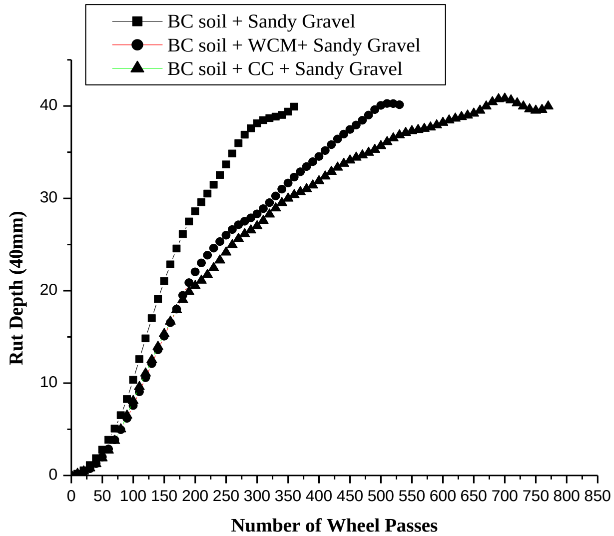

Fig.5 Rut depth along with number of wheel passes at H/4 position coir mats.

The inclusion of coir mats in a fabricated mould at H/4 position will show the similar rut depth in both cases (300mm and 400mm thickness). In both the cases, the maximum number of repetition 780 and 560 is occurred with CC and WCM respectively. The rut depth and number of wheel passes at H/4 position given in Fig 5. The thickness of the coir mats is showed the large effect to reduce the deformation, higher repletion with CC materials. Due to the thickness of the coir mats.

In The laboratory, a study is attempt in the form of two layer pavement model system using the fabricated mould of size 300mmx300mmx400mm. The fabricated mould was prepared as a two-layer model system as subgrade and sub-base with reinforcement and un-reinforcement of coir geotextile mats. The fabricated mould was prepared and compacted as per the CBR protocol. The pavement model sample was test by the WTT apparatus. The coir geotextile mats are incorporated in the fabricated mould at a different position such as H/2, H/3, and H/4 from the bottom of height.

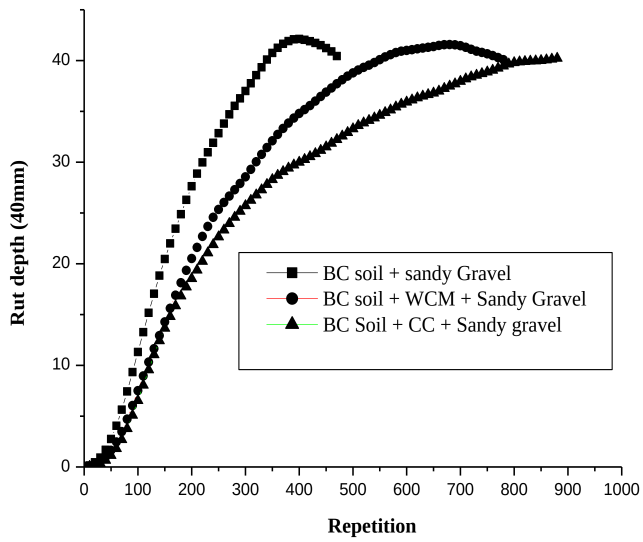

Fig.6 Rut depth along with number of wheel passes at H/2 position coir mats.

The laboratory study was performed with increasing thickness of mould such as 300mm to 400mm thickness with the same phenomena. The rut depth and the number of wheel passes were noted and given in Fig.6 at a position of H/2. The higher number of wheel passes is occurs at H/3 position with provision of the coir composite mats along with the higher thickness f the sub-base soil. The un-reinforced model layer having the lower number of wheel passes.

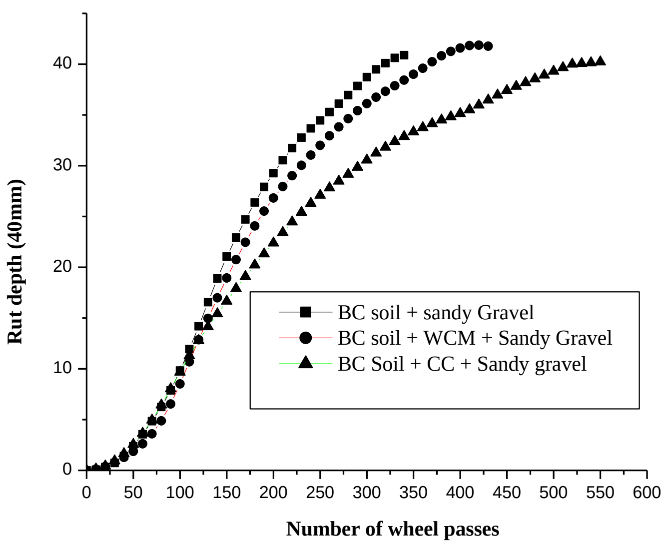

Fig.7 Rut depth along with number of wheel passes at H/3 position coir mats.

The placement of coir mats at H/3 position with sandy gravel soil having the lower repetition than the H/2 and H/3 position. The maximum number of wheel passes at H/3 position obtained was580 repetition and minimum of 350 repetitions with reinforcement and un-reinforcement model layer respectively. The rut depth and the number of wheel passes at H/3 position are showed in Fig. 7.

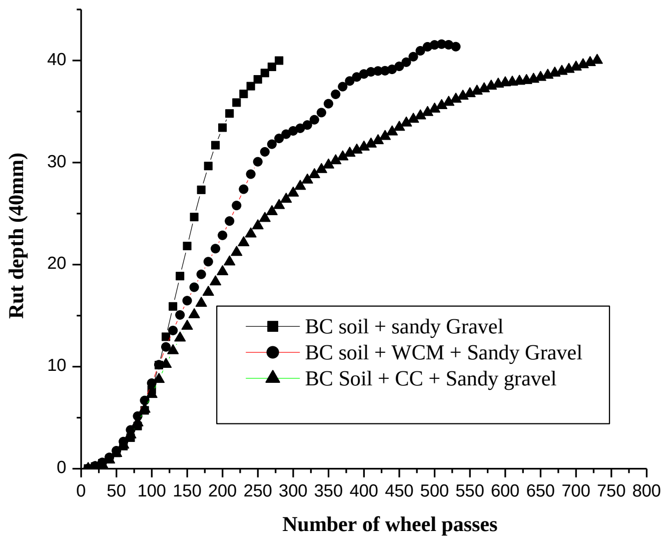

Fig.8 Rut depth along with number of wheel passes at H/4 position coir mats.

In the laboratory the un-reinforcement and the reinforcement model layer were prepared with provision of coir mats at H/4 position in the fabricated mould. In this case, the thickness of sub-base material 130mm is placed over the coir mat which is lower than the H/2 and H/3 position. The numbers of wheel passes are 780 and 560 with CC and WCM respectively. The rut depth and number of wheel passes at H/4 position shown in Fig.8. It was observed the placement of coir mats at H/4 position acts as a tension member and consume the maximum load from the top of the layer (sub-base) immediately transformed towards the edge of the pavement and increased the repetition. It was revealed that the coir geotextile mats needs to provide at a position to take the maximum load and transformed toward the edge of the pavement irrespective the thickness of pavement layer thickness.

VI. CONCLUSION

In this paper, the current study an attempt is made in the laboratory to use of coir mats and its application to enhance the weak subgrade soil under the repeated loading condition with two types of coir mats. The following conclusions are made from the study:

- The provision of coir mats at H/4 position increase the repetition (780) with reduced deformation with same rut depth. The CC mats possess the multi-function to the pavement in term of reinforcement and separation. Due to this properties of coir mats it's improve the service life of the pavement.
- The maximum repetition were obtained at H/2 position with higher thickness of sub-base soil, the failure is obtained in sub-base soil. Due to its lower shear strength. In this case the coir mats act as tension member showed the better performance.
- The performance of the geotextile depends on the properties of sub-base soil and the types of coir mats. The performance of the coir mats at H/3 position does not shown the better performance in both case with sandy gravel sub-base soil.

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