Construction of Blanket and Subgrade for Railway with Sand- Moorum- Natural Fiber Mixed Composites

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Abstract- Huge amount of alternate materials have become necessary in construction of railway subgrade and blanket due to large scale development of Indian Railway through lying of new tracks, modernizing of old tracks to accommodate high speed trains and conversion of single tracks to double or more ones,. It has also become essential to make sure that quality of such construction reaches the standard needed for the safe, comfortable and cost effective passage of trains at designed conditions. An experimental programme has been undertaken by the authors to investigate the possibility of using natural fiber randomly mixed with locally available sand-moorum composite system as alternative materials in construction in such cases. California Bearing Ratio (CBR) tests both in unsoaked and soaked condition have been conducted to observe the maximum improvisation of different mix proportion of sand-moorum-natural fiber composites. Results of the experimental study made with various proportion of sand-moorum composite mixed with natural fiber like jute and coir fiber to attaining desired CBR values with special reference, are reported in this paper.

Keywords – Railway subgrade and blanket, Cost effective, Random mixing, Alternative materials.

I. INTRODUCTION

In the recent years, due to large scale development of Railway through laying of new tracks, modernizing of old tracks to accommodate high speed trains and conversion of single tracks to double or more ones, huge amount of alternate materials have become necessary in India. It has also become important to make sure that quality of such construction reaches the standard necessary for the safe, comfortable and cost effective passage of trains at designed conditions. Further for such huge construction volume, availability of good quality materials in cost effective manner is a challenging problem. Use of local available cheap material with proper engineering to make them suitable functionally and cost effective manner may be a welcome solution. Railway authorities are making serious and sincere efforts to further passenger comfort. In that direction efforts have to be made from improving the railway tracks and many problem appear for the tracks due to deformation and malfunctioning of the blanket and the subgrade below rather than from the track itself. Main functions of the blanket lies in spreading the load on formation, limiting the subgrade stress within the subgrade strength, eliminating the mud pumping and containing the seasonal moisture content variation in the subgrade [1]. Similarly function of subgrade can be achieved by restraining settlements of the original ground and of the embankment filling, and providing steady mechanical behaviour under design train loads and velocity in a time-independent manner.

Specification for Blanket Material:

The blanket should cover the entire width of the formation from shoulder to shoulder. The blanket material should be well graded coarse grained material and the particle size distribution curve should fall within two enveloping curves shown in Fig. 1. If the material contains plastic fines, the percentage of fines i.e. percentage finer the 75µ sieve shall not exceed 5%. If fines are non-plastic, then the above percentage may be allowed up to 12%. The Uniformity coefficient (C_u) should not be less than 4, preferably be more than 7. The coefficient of curvature (C_c) should be within 1 and 3. Also, no skip grading is allowed.

Classification of the Railway sub-grade:

According to International Union of Railways (UIC) as well as European Standardization (CEN), the behaviour of the sub-grade may macroscopically be described by and classified as follows:

(A) S_3 - Low settlements and very good support of train loads.
(B) S_2- Medium behaviour in settlements and in withstanding train loads.
(C) S_1- Large settlements and non-satisfactory support of loads.
(D) S_0- Extensive settlements and a very bad performance in withstanding loads.

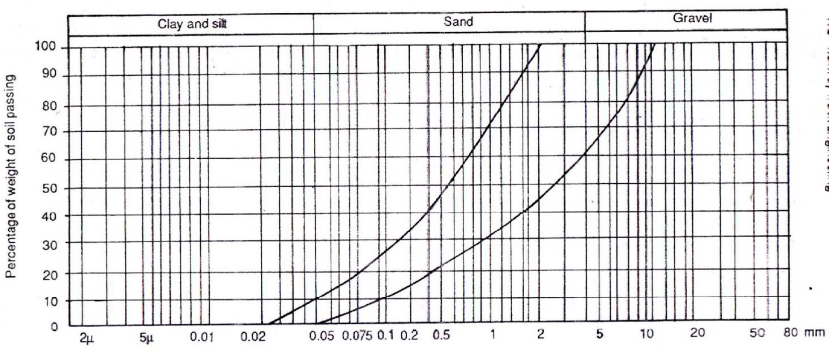

Fig. 1: Enveloping curves for blanket material (After Mundrey, 1993)

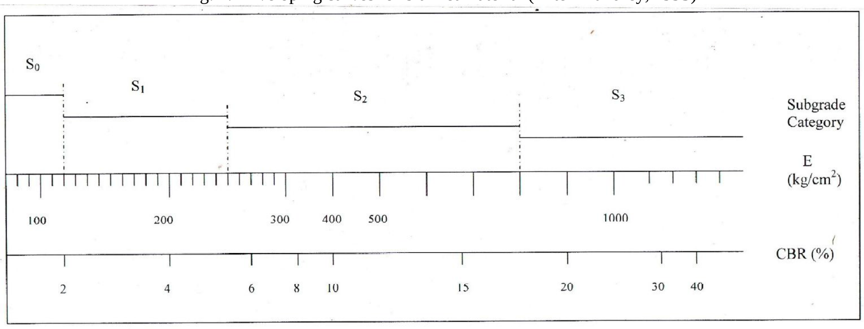

Fig. 2: Modulus of elasticity and CBR index for various subgrade categories (After Profillidis 2006)

In addition to the modulus of elasticity, the characterization of the subgrade also requires the determination of its carrying capacity. Figure 2 illustrates the respective values of the CBR index corresponding to the various sub-grade soil categories [2].

Laying of formation layer in new tracks:

If the subgrade soil used is classified as S_1 or S_2, it advisable to place an additional layer to composed of a better quality soil material. This layer is often termed the formation layer. The formation layer should be more compact than the soil of the base. Accordingly, most railways require the formation layer to have a coefficient of 100% by the normal Proctor test, while this value is routinely 95% for base layers (in the case of embankments). Use of the formation layer leads to substantial improvement in the subgrade behaviour only if the following two requirements are meet,

(A) The soil of the base of the subgrade has a low water content, otherwise grains of the base may enter the formation layer, thus deteriorating the transverse slope,
(B) The formation layer should be homogeneous and free of local concentrations of fine-grained material.

Improvement of formation layer in existing tracks:

Many tracks have been constructed in the past without a formation layer. In some of these old tracks, it is necessary to increase speed and per axle load, which result in increased stresses in the subgrade. The most practical solution is to increase, during maintenance works, thickness of track bed structures, which, however, will be difficult in cases of limitation in the height above the track or may not lead to the desired decrease in values of stresses in the subgrade. In such cases, it will be necessary to improve or install a formation layer in an existing track.

In many cases subsidence of earthen embankments may damage the railway track. This can be effectively prevented by the application of Geotextiles from natural fibre, having large initial strength and great accelerating capacity for consolidating subgrade soil and draining facility which improve the quality of subgrade in short duration and after some initial period the decrease in strength of this applied natural fiber does not cause concern as strength of the subgrade itself would be improved by that time [3]. For the subgrade materials consisting of cohesive soils, moorum can be used as blanket or sub-ballast placed between ballast and formation of railway track [4].

II. PROPOSED INVESTIGATION

A. Scope of Work –

An experimental programme has been undertaken by the authors to investigate the possibility of using natural fiber with locally available sand-moorum composite system by random mixing. This program was aimed at searching different alternate materials for subbase in roads where conventional constructional materials like brick bats are being discourged for use due to dearness of fuel and scarcity of good clays for making bricks. Availability of similar alternate materials in construction of railway subgrade and blanket has also being studied in this regard. Results of the experimental study made with various proportion of sand-moorum composite mixed with Jute fiber and Coir fiber with special reference to attaining desired CBR values, are studied here.

B. Materials Used –

Sand: Locally available Fine sand, Medium sand and Silver sand were used in this experimental study. The reason for choice of these types of sand was mainly for their easy availability in many parts of the country for possible use in practice. The physical properties of different sands used are given in Table 1.

Moorum: Moorum can be easily available in different parts of Indian country sides. However the quality of Moorum varies with locations of the quarry. Moorum is generally a residual soil decomposed from Laterite rock is red to reddish brown in colour. It is widely used material in different civil engineering construction works in highways and railways. It is considered to be locally available good materials for blanket [4]. In this experimental study the moorum was collected from a location in the western part of West Midnapur in West Midnapur. The moorum contents about 42.5% of gravel with negligible percentage of fines. The physical properties of moorum used are given in Table 2.

Natural fiber: Natural fibers like Jute fiber and Coir fiber were collected from local market and processed by cutting into small pieces of length 5mm for use as fiber material. Fibers were randomly mixed in sand and moorum composite to form homogeneous mixture. The physical properties of different fibers used are given in Table 3.

Table 1: Physical Properties of Different Sand

Properties	Fine Sand	Medium Sand	Silver Sand
Classification (IS)	SP	SP	SP
Specific gravity	2.63	2.65	2.54
Coefficient of uniformity, C_u	2.08	3.51	2.45
Maximum dry density (gm/cc)	1.62	1.625	1.588
Optimum moisture content (%)	15.3	14.5	15.5
Unsoaked California bearing ratio (%)	8.1	9.2	7.2
Soaked California bearing ratio (%)	7.2	8.1	6.3

Table 2: Physical Properties of Moorum

Properties	Moorum
Coefficient of uniformity, C_u	27.8
Gravel Content	47.1%
Sand Content	52.2%
Fine Content (Less than 75µ)	0.7%

Table 3: Physical Properties of Fibers

Property	Jute spoil	Coir
Density (g/cc)	1.47	1.40
Diameter (mm)	0.03-0.14	0.1-0.45

C. Test Programme –

In a previous study to investigate the effect of inclusion of natural fibers on CBR values of various locally available sands, the CBR tests were conducted for above three different types of sand mixed with various percentage of the Jute and Coir fiber by weight of different length of fiber in Unsoaked condition at corresponding optimum moisture contents. All the tests were conducted as per relevant I.S. codal provision [7].

From these experiments, it was evident that there is a significant increase in the CBR value for such sands when discrete natural fibers were mixed randomly in those sands. CBR value is found to be maximum for fiber length of 5mm for all natural fibers used. Optimum percentages of fiber inclusion for both jute spoil and coir fiber were 1.5% of the dry weight of Fine and Silver sand. But for medium sand highest CBR value can be obtain for 1% of fiber inclusion [5,6]. In this experimental study, moorum with varing percentage were mixed with each of sand-fiber composite mixed at above fiber inclusions causing maximum CBR.

With optimum length (5mm) and percentage of jute and coir fiber (1.5% of the dry weight of Fine and Silver sand and 1% of the dry weight of Medium sand), the fibers were randomly mixed with three different types of sand for different combination of mix at their corresponding OMC. The mixing of fibers and sand was done manually with proper care for preparing homogeneous mixture. Then moorum with various percentage 5%, 10%, 15%, 20%, 25%, were mixed in sand-fiber composite uniformly. Moorum-sand-fiber composite were compacted at OMC and CBR tests were conducted in the sand-moorum-fiber composite for all the series.

A typical grain size distribution curve for the sand-mooram composits is plotted in Fig. 3 over which specified enveloping curves are also shown. From these curve it is observed that the only Moorum (25%) and Medium sand (75%) composite is well within the two enveloping curves, is suitable as blanket material. Other two combinations of sand and moorum though donot fulfil the specification of blanket material, can considered for use as subgrade material as per classification given in fig.2 for their high CBR values.

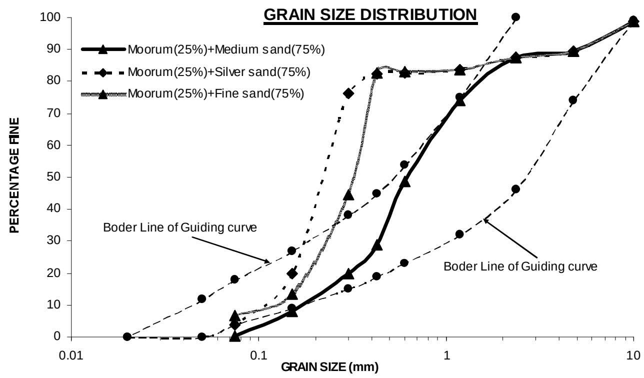

Fig. 3: Typical Grain Size Distribution curves for Sand-Moorum composite

III. EXPERIMENT AND RESULT

Unsoaked and Soaked CBR tests have been conducted in the Laboratory as per I. S. Code 2720, Part- IV, 1963, for different series of moorum-sand-fiber composite. The results of these tests are given in the table 4.

Table 4: Summary of Results of Soaked and Unsoaked CBR tests

Description of Mix	Unsoaked CBR		Soaked CBR	
	Coir	Jute	Coir	Jute
Fine sand	8.1		7.2	
Fine sand + 1.5% Fiber	12.5	12.1	11.3	11.0
Fine sand + 5% Moorum + 1.5% Fiber	13.0	12.7	11.7	11.7
Fine sand + 10% Moorum + 1.5% Fiber	14.1	13.3	12.5	12.0
Fine sand + 15% Moorum + 1.5% Fiber	17.4	16.0	16.1	15.2
Fine sand + 20% Moorum + 1.5% Fiber	20.0	18.8	19.3	18.5
Fine sand + 25% Moorum + 1.5% Fiber	23.3	22.2	22.0	20.4
Medium sand	9.2		8.1	
Medium sand + 1% Fiber	10.5	10.4	9.7	9.5
Medium sand + 5% Moorum + 1% Fiber	11.8	11.0	10.5	10.2
Medium sand + 10% Moorum + 1% Fiber	14.3	13.1	12.7	12.8
Medium sand + 15% Moorum + 1% Fiber	17.6	16.1	15.5	15.0
Medium sand + 20% Moorum + 1% Fiber	20.6	18.7	19.0	18.0
Medium sand + 25% Moorum + 1% Fiber	23.7	21.6	22.1	20.5
Silver sand	7.2		6.3	
Silver sand + 1.5% Fiber	12.4	12.7	10.2	10.1
Silver sand + 5% Moorum + 1.5% Fiber	12.8	13.1	11.0	10.8
Silver sand + 10% Moorum + 1.5% Fiber	13.8	13.6	12.2	11.2
Silver sand + 15% Moorum + 1.5% Fiber	16.7	15.5	15.1	14.6
Silver sand + 20% Moorum + 1.5% Fiber	19.3	18.7	17.5	17.1
Silver sand + 25% Moorum + 1.5% Fiber	22.8	21.2	21.7	20.1

From the CBR results, it can be observed that the CBR values increases with the inclusion of moorum for the various Sand-fiber mix within the range of the testing programme. For fine sand–coir–moorum composite, gives maximum soaked CBR value of 22.0%. But for fine sand–Jute–moorum composite, gives maximum soaked CBR value of 20.4%. On the other hand, for medium sand, the highest soaked CBR value of the composite for coir and jute fiber are 22.1% and 20.5% respectively. However, for silver sand, the soaked CBR value of the composite for coir and jute fiber are 21.7% and 20.1% respectively. The Soaked CBR vs % of Moorum curve for different three types of sand for Jute and Coir fiber are shown in Fig. 4 and Fig. 5 respectively.

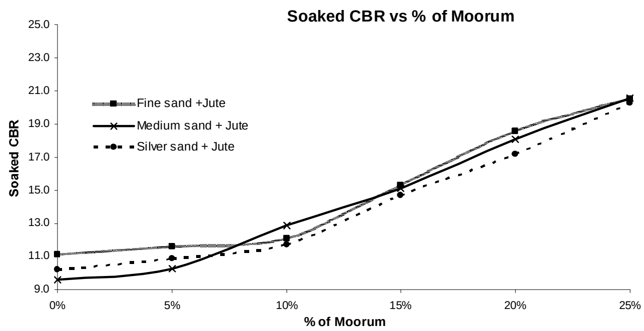

Fig. 4: Effect of Moorum content mixed with different sand on soaked CBR for Jute fiber.

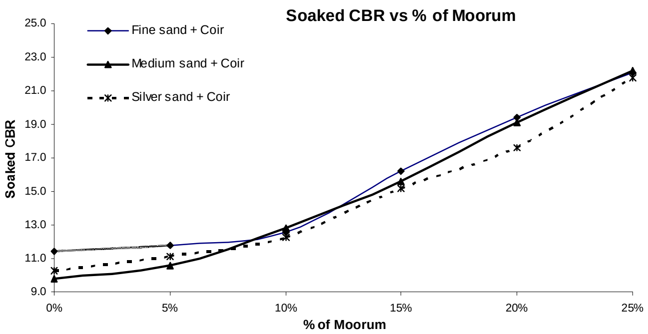

Fig. 5: Effect of Moorum content mixed with different sand on soaked CBR for Coir fiber.

For both the cases it is observed that when moorum content reaches a value of 10%, CBR of the moorum mixed with sand and Jute or sand and Coir start increasing at a faster rates. Thus moorum can be used in any condition of requirement of needed CBR for design. Jute or coir fibers impart more or less similar effect in increasing CBR (soaked) value of the composite.

IV.CONCLUSION

From the experimental investigation reported above, following conclusions may be drawn.

1. For all three types of sand used in this investigation remarkable increase in the CBR values was observed with the increase of moorum mixed for various percentage (%) by weight of the sand-fiber mix. These sand-fiber composite mixed with 25% of moorum by weight of sand may suit best as subgrade material for Railway track having CBR greater than 20%.
2. It can also be noticed that Moorum (25%) and Medium sand (75%) composite is well within the two enveloping curves given in fig. 3, and thus is suitable as blanket material. For other combination of sand and moorum donot fulfil the specification of blanket material but can be used as subgrade material.

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Experimental Analysis of Epoxy- Glass Fiber Composite Leaf Spring for Natural Frequency of Leaf Spring to Reduce the Vibration

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Abstract: The study of composite materials involves many topics for example manufacturing processes, anisotropy, elasticity strength of anisotropic materials and micromechanics. Composite materials are ideal for structural application where high strength to weight and stiffness to weight ratio are required. Aircraft and spacecraft are typical weight sensitive structures in which composite materials are cost effective. The key material properties for usual engineering mechanics applications are strength and stiffness. The fibers are stiff and have high strength and they are expected to carry the load to which the structure is submitted. The matrix has low strength and low stiffness and it gives the shape to the component and transfers the loads to fibers and between them. The applications of composite materials especially long fiber polymers has experienced a great increase and now days are widely used in industries like aircraft and wind turbine components. The objective of this paper is to analyze theoretically, experimentally and by finite element method the mechanical behavior of glass epoxy composite material used for leaf spring.

Keywords: Composite, Modal analysis, Leaf spring

I. INTRODUCTION

The usual design criterion for composite material is based on trying to align the fibers with most critically loaded directions of mechanical component. A comprehensive and Behaviors of force versus displacement are obtained. Meanwhile, trial mechanical elastic constants are imposed on a four – node shell element with the same size as the unit cell to match the force – displacement curves. The effective nonlinear mechanical stiffness tensor is thus obtained numerically as functions of elemental strains. The procedure is exemplified on a plain weave glass composite and is validated by comparing with 30 degree bias trellising and bi-axial tensile test results. Objective study and laminate failure and related criteria of in unidirectional various loading cases is being extremely tidied.

Many authors have reported that the natural bending frequency of a dive shaft transmitting a torque can be increased without reducing the torque transmission capability, if the shaft is made using both carbon fiber epoxy composite and aluminum. It increases the natural bending frequency and sustains the applied torque. The high natural bending frequency of a shaft makes it possible to manufacture the drive shaft of passenger car in one piece.

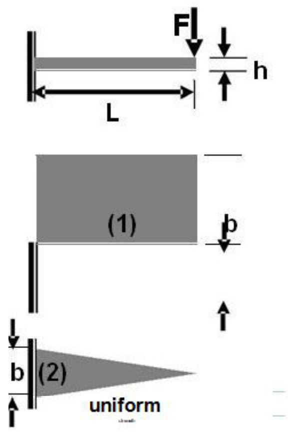
II. LEAF SPRING

In order to have an idea of working principle of a leaf spring, let us think of the diving board in a swimming pool. The diving board is a cantilever with a load, the diver, at its free end. The diver initiates a to and fro swing of the board at the free end and utilizes the spring action of the board for jumping. The diving board basically is a leaf spring. The leaf springs are widely used in suspension system of railway carriages and automobiles. But the form in which it is normally seen is laminated leaf spring.

In the cantilever beam type leaf spring, for the same leaf thickness, h, leaf of uniform width, b (case 1) and, leaf of width, which is uniformly reducing from b (case 2) is considered. From the basic equations of bending stress and deflection, maximum stress, $\sigma_{max,}$ and tip deflection, can be derived. For case 1(uniform width)

$$\delta_{max} = \frac{4FL^3}{Ebh^3}$$

Where, E is the Elastic modulus of the spring material.

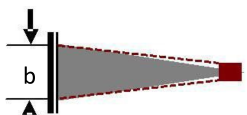


For case 2(non uniform width)

$$\sigma_{max} = \frac{6FL}{bh^2}$$

$$\delta_{max} = \frac{6FL^3}{Ebh^3}$$

In the second case it is observed that instead of uniform width leaf, if a leaf of varying width (triangular one as shown in the figure) is used, the bending stress at any cross section is same and equal to σ_{max}. This is called as leaf of a uniform strength. Moreover, the tip deflection being more, comparatively, it has greater resilience than its uniform width counterpart. Resilience, as we know, is the capacity to absorb potential energy during deformation. However, one should keep in mind that in order to withstand the shear force the tip has to have some width. This is shown as a red zone in the figure. In one way non uniform width leaf is a better design than a uniform width leaf.



Uniform strength

Leaf spring of simply supported beam type is shown in the Fig., for which the stress and deflection equation are also given as in the case of cantilever.