Application of Natural Fibre with Sand and Moorum for Subbase Construction of Roads

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***Abstract*— In India recently large amount of construction of roads are going on. Such constructions require huge quantity of good brickbats for subbase of road. But the production of bricks is limited due to non-availability of good soils. In view of this there is growing need for use of alternate materials in place of brickbats for making sub base. On the other hand, natural fibers like Jute and Coir fiber are biodegradable, eco-friendly and are available in abundance in India. Randomly distributed fibers is one of the latest techniques in which fibers of desired quality and type are added to the soil. This method is very easy and no special skill is required. Therefore natural fiber can be mixed with sand and moorum in the sub base course to result increase in strength and decrease deformability. Such application will also reduce the cost of pavement. An experimental program has been undertaken here for the improvement of compactibility of sands, and increase in California Bearing Ratio of such laid fiber-sand-moorum composite layers. From this study, remarkable increase in the CBR values was observed with the increase of percentage (%) of moorum mixed for various sand-fiber mix. These sand-fiber composite mixed with 25% of moorum by weight of sand may suit best as subbase material for highway having CBR greater than 20%.**

***Index Terms*— Cost effective, Subbase, Sand-moorum composite, Random mixing, Alternative materials.**

I. INTRODUCTION

In flexible pavement, sub-base is generally constructed with brickbats. However due to scarcity of good clays to make brick, use of brick bats in construction of road subbase is being discouraged. Different locally available alternate materials are being used for subbase construction in the rural areas. But they may not be available in many areas. In this regard, sand and moorum may be used as alternate material for the construction of subbase. Randomly distributed fibers in sand is one of the latest techniques in which fibers of desired quality and type are added to the soil. This method is very easy and no special skill is required.

Varghese et al. (1989) investigated the possibility of increasing the bearing capacity of cohesionless soils by reinforcing with coconut fibres through model studies. It has been observed that the bearing capacity of foundation soil will be maximum when the reinforcement is kept at a depth of 0.41 times the width of the foundation. Inclusion of randomly distributed synthetic fibres in compacted fine grained soils is reported to cause generation of greater strength and toughness (Freitag, 1986). Full scale field test on discrete fibre reinforced sand, conducted by Tingle et al (2002) indicated that fiber stabilized sands are viable as an alternate to traditional road construction materials for low volume roads. Reinforcing the soil with short fiber appears to have great potential for application in roads when alternate materials are also used. Fiber reinforced flyash can be used as subbase in rural roads. Sreedhar et al (2009) reported experimental study on the effect of including geotextile fibres in dry sand as random distributed. They observed phenomenal improvement on CBR value of sand when mixed randomly with such fiber of all length of different aspect ratios.

In the present investigation, efficacy of using natural Jute and Coir fiber in locally available sand and moorum have been made. Results of the experimental study made with various length and proportion of natural fiber mixed with different types of sand and moorum are reported in this paper.

II. OBJECTIVES AND SCOPE OF WORK

In the present investigation, 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 construction of road where conventional constructional materials like brick bats are being discourage for use due to dearness of fuel and scarcity of good clay for making bricks.

To determine the engineering properties of fiber-sand-moorum composites, types of fiber (Jute and Coir fiber), types of sand (fine brown sand, medium sand, and silver sand), length of fibers, percentage of fiber used in soil by weight will be varied and compaction effects on the OMC, MDD, CBR at OMC for unsoaked and soaked condition will be experimentally determined.

III. MATERIALS AND TEST PROGRAMME

Sand: Locally available fine brown sand, medium sand and silver sand were used in this experimental study. The reason for choice of these type 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. 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 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	2.632	2.65	2.542
Coefficient of uniformity, C_u	2.09	3.58	2.47
Maximum dry density (gm/cc)	1.623	1.625	1.588
Optimum moisture content (%)	15.3	14.5	15.5
California bearing ratio (%)	8.4	9.1	7

Table 2: Physical Properties of Moorum

Properties	Moorum
Coefficient of uniformity, C_u	27.78
Gravel Content	47.5%
Sand Content	57.4%
Fine Content (Less than 75μ)	0.1%

Table 3: Physical Properties of Fibers

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

IV. METHODOLOGY

In a previous study[3] 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[1.2]. 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 (Maity et al., 2010 and 2011).

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.

V. RESULTS AND DISCUSSIONS

Unsoaked and Soaked CBR tests have been conducted in the Laboratory 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	8.2		7.7	
Fine sand + 1.5% Fiber	12.6	12.2	11.4	11.1
Fine sand + 5% Moorum + 1.5% Fiber	13.1	12.8	11.8	11.6
Fine sand + 10% Moorum + 1.5% Fiber	14.2	13.4	12.6	12.1
Fine sand + 15% Moorum + 1.5% Fiber	17.5	16.1	16.2	15.3
cFine sand + 20% Moorum + 1.5% Fiber	20.1	18.9	19.4	18.6
Fine sand + 25% Moorum + 1.5% Fiber	23.4	22.3	22.1	20.5
Medium sand	9.1		8.7	
Medium sand + 1% Fiber	10.6	10.5	9.8	9.6
Medium sand + 5% Moorum + 1% Fiber	11.9	11.1	10.6	10.3
Medium sand + 10% Moorum + 1% Fiber	14.4	13.2	12.8	12.9
Medium sand + 15% Moorum + 1% Fiber	17.7	16.0	15.6	15.1
Medium sand + 20% Moorum + 1% Fiber	20.7	18.8	19.1	18.1
Medium sand + 25% Moorum + 1% Fiber	23.8	21.7	22.2	20.6
Silver sand	7.0		6.6	
Silver sand + 1.5% Fiber	12.5	12.8	10.3	10.2
Silver sand + 5% Moorum + 1.5% Fiber	12.9	13.0	11.1	10.9
Silver sand + 10% Moorum + 1.5% Fiber	13.9	13.5	12.3	11.1
Silver sand + 15% Moorum + 1.5% Fiber	16.8	15.6	15.2	14.7
Silver sand + 20% Moorum + 1.5% Fiber	19.4	18.8	17.6	17.2
Silver sand + 25% Moorum + 1.5% Fiber	22.9	21.3	21.8	20.3

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 22.1%. But for fine sand–jute–moorum composite, gives maximum soaked CBR value of 20.5%. On the other hand, for medium sand, the highest soaked CBR value of the composite for coir and jute fiber are 22.2% and 20.6% respectively. However, for silver sand, the soaked CBR value of the composite for coir and jute fiber are 21.8% and 20.3% 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.

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.

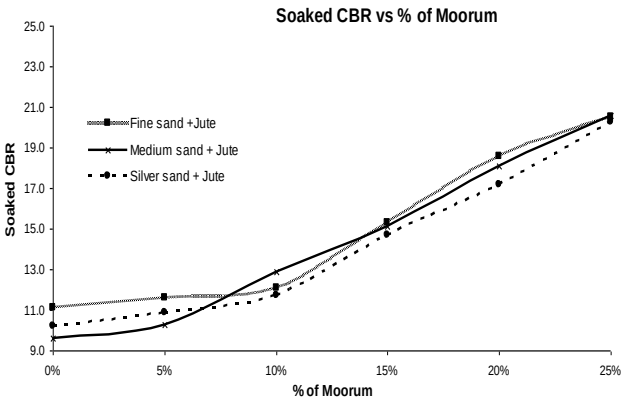

Fig. 4: Variation of soaked CBR for Jute fiber mixed with different % of sand -moorum.

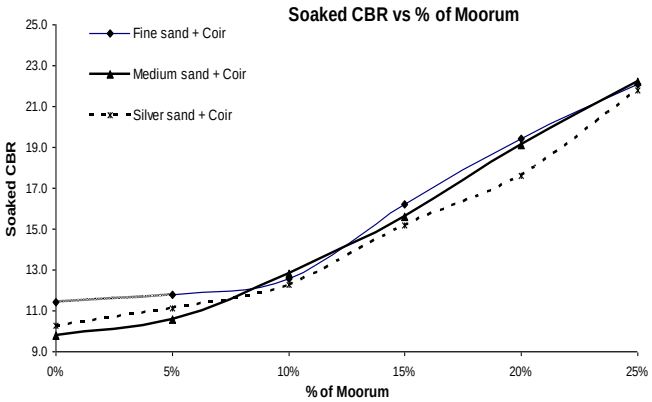

Fig. 5: Variation of soaked CBR for Coir fiber mixed with different % of sand -moorum.

VI. Conclusion

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

1. CBR value is maximum for fiber length of 5mm for Coir fibers used. And optimum percentage of fiber inclusion is 1.5% of the dry weight of sand for coir fiber.
2. 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 subbase material for Highway having CBR greater than 20%.

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