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Application of Hemp Fibre for Subgrade Improvement

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***Abstract*— For transportation development in India huge amount construction of roads are being made through different schemes. For such constructions, requirement of fill material for subgrade is enormous. But in many cases available soils near construction sites are found to be weak in strength and of high compressibility, after routine compaction. Reinforced soil structure is an effective technique for increasing the strength of soil. Reinforced soil is widely used as the construction material in formation of subgrade for roads, railway tracks, airfields and in retaining walls or abutments. Fibre-reinforced soil is becoming a viable soil improvement method for geotechnical engineering problems including stabilization of shallow slopes, construction of new embankments with marginal soils, reduction of shrinkage cracking in compacted clay liners and reinforcement of roadway subgrades. However, extensive research is needed to study the behaviour of randomly mixed Hemp as a natural fibre with soil before their application in practice. This paper presents the stabilization of soil using randomly distributed Hemp fibre at varying lengths and percentages by weight of soil. Compaction tests and California Bearing Ratio (CBR) tests were conducted to investigate the behaviour of soil mixed with Hemp fibre. From the test results, it was observed that with the increase in percentage of Hemp fibre in soil, maximum dry density decreases whereas optimum moisture content increases. Further, the CBR value of the composite at OMC, increased with increase in percentage of Hemp fibre.**

***Index Terms*— Hemp fibre, Health hazards, Deformability, California Bearing ratio (CBR) test.**

I. INTRODUCTION

The main advantages of randomly distributed discrete fibres are the simplicity in mixing, maintenance of strength isotropy and absence of potential planes of weakness which may develop parallel to the oriented reinforcement. The fibres added in constructions are expected to provide better compact interlocking system between the fibre and the soil system. Different materials for fibre being used for study are glass fibre (Pazare et.al 2002), Nylon fibre (Jain et al, 2003), synthetic fibre like polypropylene fibres (Consoli et.al), Polyester fibre (Kaniraj et.al), fragmented rubber shredded tyre (Lindh & Mattsson 2004) etc.

But the cost of synthetic fibres is high in India, which affects cost effectiveness. This problem can be solved by using locally available natural fibres as reinforcing material at least for low traffic unpaved roads. Natural fibres like jute, coir, sisal, palm fibre, sabai grass, etc. are mostly available in third world countries at a low cost and their supply is ensured from agriculture products. Shetty and Rao (1987) reported positive influence of natural coir fibres on the CBR value of soils on mixing such fibre with them. Rickson (2003) reported that jute fabrics performed the best among other natural and synthetic erosion control products under numerous experimental conditions, with different rainfall intensities and soil types.

Hemp is traditionally known as a fibre plant and most historical cultivation of the plant in the United States from the 17th to mid-20th centuries was with use of fibre in mind. Hemp fibre has many qualities including strength, durability and absorbency that make it very desirable to use in a wide range of products. Not all fibres are created equal, given their differing physical properties, best and core fibres have different ideal end uses.

In the present study use of **hemp fibre** with locallected soil has been investigated. Results of the experimental study made with various length and proportion of this natural fibre mixed with clay indicate improvement of its strength property. Different percentages and varying lengths of Hemp fibre have been used to identify the cost effective mixing proportion and size for possible use in highway construction.

II. PROPOSED INVESTIGATION

A. Materials Used:

Soil: Soil has been collected from Kalyani P.S., Nadia, West Bengal at a depth of 1.0 m below the ground surface. It is a partially sandy soil which has 81.5 % of silt and clay. The physical properties of collected soil used are given in Table 1.

Fig. 1 Hemp fibre cut into small pieces.

Fig. 2 Hemp fibre randomly mixed with soil.

Hemp fibre: Hemp fibre which is scientifically named 'HIVISCUS CANABINUS' were collected from local market and processed in the laboratory by cutting into small pieces of various sizes of 1cm, 2cm, and 3cm as shown in fig.1. Hemp fibre were mixed randomly with soil as shown in fig.1 and fig.2, at different percentages of 0.5%, 1%, 1.5% and 2%.Fibre strength 17 – 20.9gm/tex.

Table 1: Physical Properties of Soil

Properties	Clayey Silt
Classification (IS)	CL
Specific gravity	2.57
Liquid Limit (%)	30.5
Plastic Limit (%)	19.0
Plasticity Index	11.50
Gravel (%)	0.06
Clay (%)	15%
Silt (%)	66.5%
Sand (%)	18.50
Maximum dry density (gm/cc)	1.743
Optimum moisture content (%)	15
Unsoaked California bearing ratio (%)	3.9
Soaked California bearing ratio (%)	2.49

B. Test Programme:

In this study to investigate the effect of inclusion of Hemp fibre on compaction and strength characteristics of collected soil, standard Proctor test and unsoaked CBR tests at OMC were conducted for soil mixed with randomly distributed varying percentages and lengths of Hemp fibre. All the tests were conducted as per relevant I.S. codal provision [1, 2].

III. RESULTS AND DISCUSSIONS

For different series of Soil- Hemp composite. The result of the test are given in the table 2.

Table 2: Summary of Results of compaction and CBR tests

Description of Mix	Length (mm)	MDD	OMC	Unsoaked CBR
Soil		1.743	15.00	3.9
Soil + 0.5% NHF		1.723	15.30	5.43
Soil + 1% NHF		1.7	15.90	5.99
Soil + 1.5% NHF		1.691	16.80	6.62
Soil + 2% NHF	10	1.686	18.62	5.16
Soil + 0.5% NHF		1.708	15.50	5.64
Soil + 1% NHF		1.698	16.10	6.56
Soil + 1.5% NHF		1.689	17.20	7.18
Soil + 2% NHF	20	1.67	18.60	6.43
Soil + 0.5% NHF		1.702	15.80	5.76
Soil + 1% NHF		1.69	16.30	6.87
Soil + 1.5% NHF		1.685	17.50	7.24
Soil + 2% NHF	30	1.6675	19.00	6.76

3.1 Compaction characteristics:

The Standard Proctor tests were conducted as per IS 2720 (Part-VII) on soil- Hemp fibre mix composites to determine the optimum moisture content (OMC) and maximum dry density (MDD). The soil wes mixed with randomly distributed Hemp fibre of varying percentages (0.5%, 1%, 1.5% and 2%) and sizes (1cm, 2cm, and 3cm) and standard proctor test were conducted on these mixtures. The OMC and MDD values obtained from the standard Proctor test are given in table 2 and variations of MDD and OMC with percentage of Hemp fibre are shown in fig. 3 and 4 respectively.

From these figures, it can be observed that with the increase in percentage of Hemp fibre, the MDD value of soil- Hemp fibre mix composites decreases whereas OMC value increases significantly. The decrease in MDD is due to the light weight nature of Hemp in comparison with soil and the increase in OMC is due to the water absorption property of natural fibre.

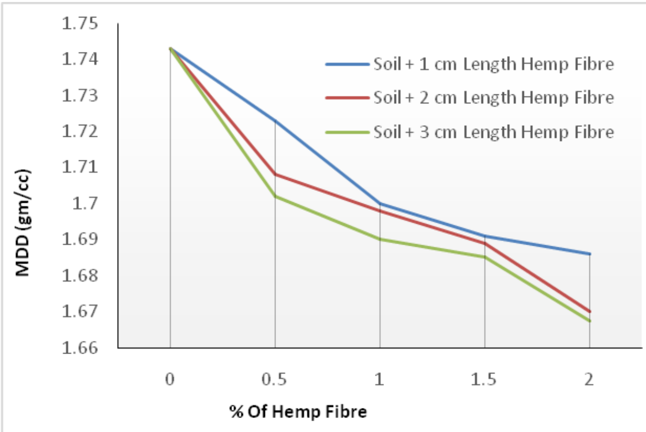

Fig. 3: Variation of MDD with % of Hemp fibre.

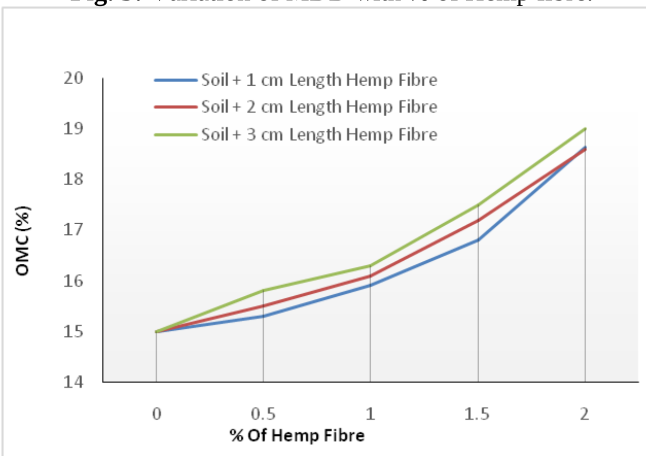

Fig. 4: Variation of OMC with % of Hemp fibre.

3.2 Strength characteristics:

Unsoaked CBR tests at OMC were conducted as per IS: 2720 (Part-X) on soil- Hemp fibre mix composites to evaluate the strength characteristics of soil stabilized with Hemp fibre. Randomly distributed Hemp fibre of varying percentages (0.5%, 1%, 1.5% and 2%) and sizes (1cm, 2cm, and 3cm) were mixed with soil. The unsoaked CBR values obtained from the laboratory CBR test are given in table 2 and the variation of unsoaked CBR with percentage of Hemp fibre is shown in fig.5.

From the figure, it is observed that the CBR values of soil-Hemp mix composite increases with increase of percentage of Hemp fibre and reaches a maximum value and after that it decreases slowly with further inclusion of Hemp fibre within the range of the testing programme. The maximum unsoaked CBR value of soil obtained from the laboratory test is 7.24% for addition of 1.5% Hemp fibre size of 3 cm length.

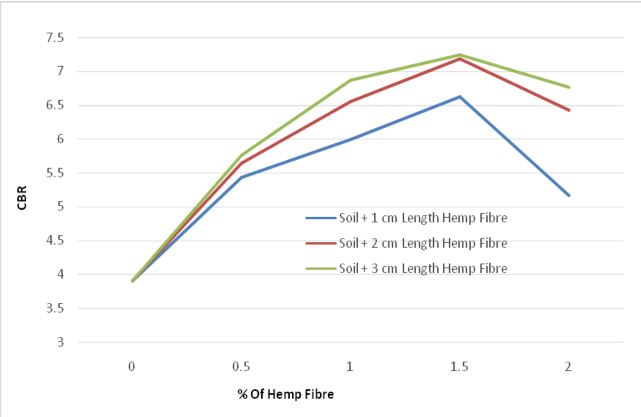

Fig. 5: Variation of unsoaked CBR with % of Hemp fibre.

IV. Conclusion

On the basis of the results of experimental investigation made above, following conclusions may be drawn.

1) Maximum dry density decreases with the increase in percentage of Hemp fibre. This is due to light weight nature of Hemp fibre.
2) On the other hand, the optimum moisture content increases with the increase in percentage of Hemp fibre due to the greater water absorption property of natural fibre.
3) There is a considerable increase in the unsoaked CBR value for soil due to mixing of randomly distributed Hemp fibre. The maximum improvement in unsoaked CBR value is due to addition of Hemp fibre size of 3 cm. And optimum percentage of Hemp fibre is 1.5% of the dry weight of soil for all sizes of Hemp fibre used. Further addition of Hemp fibre to soils lead to a decrease in CBR values.

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