# Experimental Study of Subgrade Properties Reinforced with Natural Fibres

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**Abstract—***The stability of any pavement depends upon the stability of its subgrade soil. Subgrade governs the performance, life span and effectiveness of the pavement. The entire load coming over the pavement is ultimately borne by the subgrade. Thus, the subgrade plays a very important role in the pavement design. Now-a-days, many techniques are used to stabilize the subgrade soil, use of natural fibres being one of them . Natural fibres are cheap, easily available and eco friendly. In order to stabilize the subgrade soil, jute fibres in different lengths (30mm, 60mm and 90mm) and proportions of 0.25%, 0.5%, 0.75% and 1% were used as the reinforcing agents in the present study. The California Bearing Ratio test was conducted on all the samples and the results have been presented in the paper.*

**Keywords***: California Bearing Ratio, Subgrade, Jute fibre.*

## 1. INTRODUCTION

Subgrade is the lowest layer of the pavement. It takes all the loads of the pavement as well as the loads coming on the pavement. So, it should possess sufficient stability under adverse climatic and loading conditions. The defects in black top pavement surface like rutting, corrugation, etc. are generally attributed to poor subgrade. Thus the stability of the pavement depends upon the stability of the subgrade.

In order to enhance the engineering properties, soil can be reinforced using jute fibre. Jute fibre is preferable because of its better durability, high tensile strength and capacity to withstand rotting and heat, porous texture which gives it good drainage and filtration properties. Moreover, jute is locally available, cheap, eco-friendly and biodegradable. Reinforcing in soil masses increases its strength, bearing capacity and ductility; reduces settlement and inhibits lateral deformation. [1] Fibre reinforced soils show greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness.

## 2. LITERATURE REVIEW

Many studies have been carried out in regard to reinforcing the soil, so as to enhance its properties. Some of the notable works are mentioned here. The effect of jute fibre on the soil was studied and later jute textiles were used in rural roads.[2] The effect of jute fibre in subgrade characteristics

improvement was also studied. It was concluded that jute fibre reinforced soil has reduced maximum dry density and increased optimum moisture content. The CBR value of the soil was also increased by upto 250% with the inclusion of bitumen coated jute fibre.[3] Savastano et al. (2000) used waste jute fibers as reinforcement for cement-based composites in construction work instead of concrete. Singh and Bangra conducted the experimental study for the application of jute fibre in subgrade soil. They reported the increase in the CBR value of subgrade soil with the increase in jute content as well as the increase in length and diameter of jute threads. [4] Chandra et al. studied CBR and shear values of Jute fibre for preparation of fibre reinforced flexible pavements.[5] Islam and Iwashita used jute reinforced material to construct earthquake resistance building for low income stake holders. They showed that jute fibers are effective for improving the mortar strength as well as coherence between block and mortar.[6]

Singh made the comparative study between the improvement in CBR value of soil using jute and coir fibre as reinforcing materials separately, and suggested the dominance of jute fibre. Based on his study, he concluded that the load carrying capacity of soil increases and amount of immediate settlement decreases when soil is reinforced with Jute geotextile sheets. [7 ] Karthika et.al stabilized the soil with coir geotextile. They concluded that reinforcing the soil with geotextile can improve the strength characteristics of the soil. It can increase the CBR by 140 per cent and decrease the rut depth by 17 per cent. [8] Talukdar et al. (1994) studied performance of jute fibre after treating with antimicrobial solution in the form of non-woven fabrics [9]. Ghavami et al. (1999) studied behaviour of composite soil reinforced with natural fibers jute and coir.

## 3. RESEARCH METHODOLOGY

### 3.1 Materials used

Soil

Jute fibres

**Soil**

The soil used in the investigation was the natural soil collected from **Awantipora** area of Kashmir. The soil sample was collected from a depth of 60 cm after removing the top surface soil from natural ground surface.

**Jute Fibres**

The jute fibre used was procured from the local market. The diameter of the jute fibre used was 2mm. These fibres were cut in the lengths of 30mm, 60mm and 90mm for conducting our research. Jute fibres are generally available in the threaded form. These are mechanically woven fibres with very fine threads.

Following are the advantages of jute geotextile

1. Abundant availability
2. Superior drapability, jute geotextile can perfectly shape itself to ground contours.

3. High moisture/water absorbing capacity. Jute Geotextile can absorb moisture/water up to about 5 times its dry weight.
4. High initial strength.

**Fig. 1: View of Jute Fiber (D = 2mm, L = 30 mm)**

## 4. METHODOLOGY

1. Identification of suitable site.
2. Collection of soil samples.
3. Determination of CBR value of soil.
4. Reinforcement of other soil samples using different percentages of jute fibre of lengths 30mm, 60mm and 90mm.
5. Determination of CBR value of jute reinforced soil.
6. Comparison of the CBR values of the reinforced and unreinforced soils.
7. Conclusion.

**Test conducted**

California Bearing Ratio test was conducted on the soil reinforced with different percentages of jute fibre of different lengths. It is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm /min.

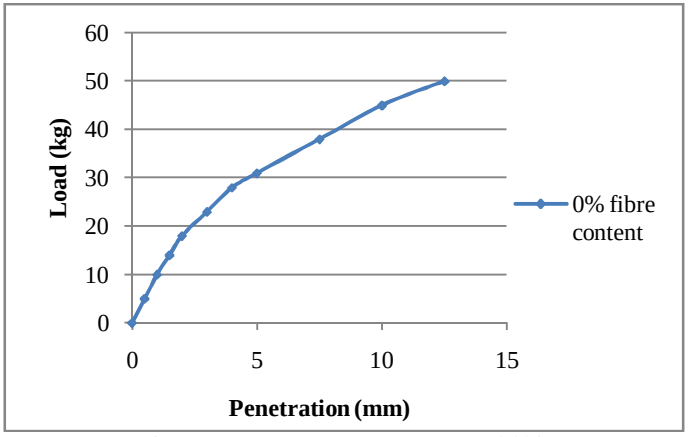
**Fig. 2: CBR test being conducted in the laboratory**

## 5. EXPERIMENTAL RESULTS

### CBR of unreinforced soil

**Table 1: CBR Test Data Of Unreinforced Soil Sample**

| Penetration (mm) | Load dial readings (divisions) | Load (kg) |
|---|---|---|
| 0.0 | 0 | 0 |
| 0.5 | 0.7620 | 5 |
| 1.0 | 1.5004 | 10 |
| 1.5 | 2.1007 | 14 |
| 2.0 | 2.6999 | 18 |
| 3.0 | 3.4498 | 23 |
| 4.0 | 4.1997 | 28 |
| 5.0 | 4.6579 | 31 |
| 7.5 | 5.6997 | 38 |
| 10.0 | 6.7508 | 45 |
| 12.5 | 7.4996 | 50 |




CBR at 2.5mm penetration = 1.496%
CBR at 5mm penetration = 1.508%

**Fig. 3: CBR Curve of Unreinforced Soil**

**CBR of soil reinforced with jute fibre of length 30mm.**

CBR test was conducted on the soil reinforced with jute fibres of length 30 mm with different percentages of 0.25%, 0.55, 0.75% and 1%. The results are tabulated below.

**Table 2: CBR Test Data Of Reinforced Soil Sample (fibre length=30mm)**

| Penetration (mm) | Load (kg) | | | | |
|---|---|---|---|---|---|
| | Fibre content =0% | Fibre content=0 .25% | Fibre content= 0.5% | Fibre content=0 .75% | Fibre content= 1% |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 5 | 8 | 12 | 14 | 15 |
| 1 | 10 | 15 | 22 | 22 | 24 |
| 1.5 | 14 | 24 | 29 | 32 | 33 |
| 2 | 18 | 30 | 36 | 38 | 38 |
| 3 | 23 | 42 | 50 | 54 | 54 |
| 4 | 28 | 51 | 58 | 65 | 60 |
| 5 | 31 | 58 | 65 | 70 | 69 |
| 7.5 | 38 | 75 | 74 | 80 | 79 |
| 10 | 45 | 89 | 84 | 91 | 84 |
| 12.5 | 50 | 97 | 92 | 102 | 88 |

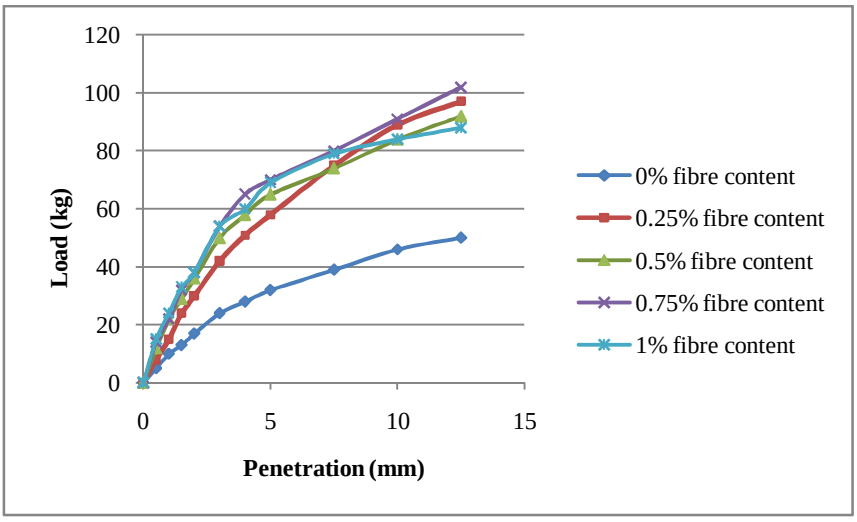



**Fig. 4. CBR curve for soil sample with different fiber content and fiber length=30mm**

**The CBR values as calculated from the above data at different fibre contents are tabulated below.**

**Table 3: CBR values at different fibre contents and fibre length of 30 mm**

| Fibre Content | CBR at 2.5 mm penetration | CBR at 5 mm penetration |
|---|---|---|
| 0% | 1.496% | 1.508% |
| 0.25% | 2.627% | 2.822% |
| 0.5% | 3.138% | 3.163% |
| 0.75% | 3.357% | 3.406% |
| 1% | 3.357% | 3.357% |

### CBR of soil reinforced with jute fibre of length 60mm.

CBR test was conducted on the soil reinforced with jute fibres of length 60 mm with different percentages of 0.25%, 0.55, 0.75% and 1%. The results are tabulated below.

**Table 4: CBR Test Data Of Reinforced Soil Sample (fibre length=60mm)**

| Penetration (mm) | Load (kg) | | | | |
|---|---|---|---|---|---|
| | Fibre content=0% | Fibre content=0.25% | Fibre content=0.5% | Fibre content=0.75% | Fibre content=1% |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 5 | 13 | 16 | 15 | 15 |
| 1 | 10 | 21 | 24 | 25 | 25 |
| 1.5 | 14 | 28 | 30 | 33 | 33 |
| 2 | 18 | 35 | 38 | 42 | 42 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 23 | 43 | 50 | 56 | 54 |
| 4 | 28 | 53 | 59 | 65 | 62 |
| 5 | 31 | 60 | 63 | 72 | 70 |
| 7.5 | 38 | 71 | 76 | 86 | 85 |
| 10 | 45 | 84 | 82 | 99 | 97 |
| 12.5 | 50 | 92 | 90 | 106 | 104 |

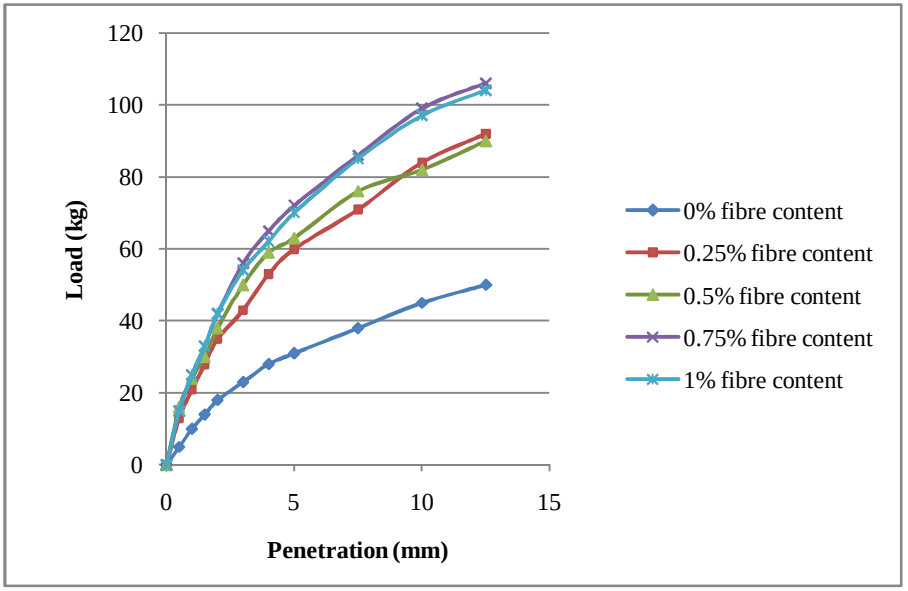



**Fig. 5: CBR curve for soil sample with different fiber content and fiber length=60mm**

**The CBR values as calculated from the above data at different fibre contents are tabulated below.**

**Table 5: CBR values at different fibre contents and fibre length of 60 mm**

| Fibre Content | CBR at 2.5 mm penetration | CBR at 5 mm penetration |
|---|---|---|
| 0% | 1.496% | 1.508% |
| 0.25% | 2.846% | 2.919% |
| 0.5% | 3.211% | 3.065% |
| 0.75% | 3.576% | 3.503% |
| 1% | 3.503% | 3.406% |

**CBR of soil reinforced with jute fibre of length 90mm.**

CBR test was conducted on the soil reinforced with jute fibres of length 30 mm with different percentages of 0.25%, 0.55, 0.75% and 1%. The results are tabulated below.

**Table 6: CBR Test Data Of Reinforced Soil Sample (fibre length=90mm)**

| Penetration (mm) | Load (kg) | | | | |
|---|---|---|---|---|---|
| | Fibre content=0% | Fibre content=0.25% | Fibre content=0.5% | Fibre content=0.75% | Fibre content=1% |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 5 | 14 | 18 | 19 | 18 |
| 1 | 10 | 23 | 28 | 30 | 28 |
| 1.5 | 14 | 28 | 33 | 39 | 35 |
| 2 | 18 | 36 | 42 | 48 | 45 |
| 3 | 23 | 47 | 55 | 62 | 59 |
| 4 | 28 | 56 | 63 | 72 | 71 |
| 5 | 31 | 64 | 72 | 80 | 78 |
| 7.5 | 38 | 70 | 88 | 95 | 93 |
| 10 | 45 | 77 | 96 | 100 | 99 |
| 12.5 | 50 | 83 | 99 | 106 | 103 |

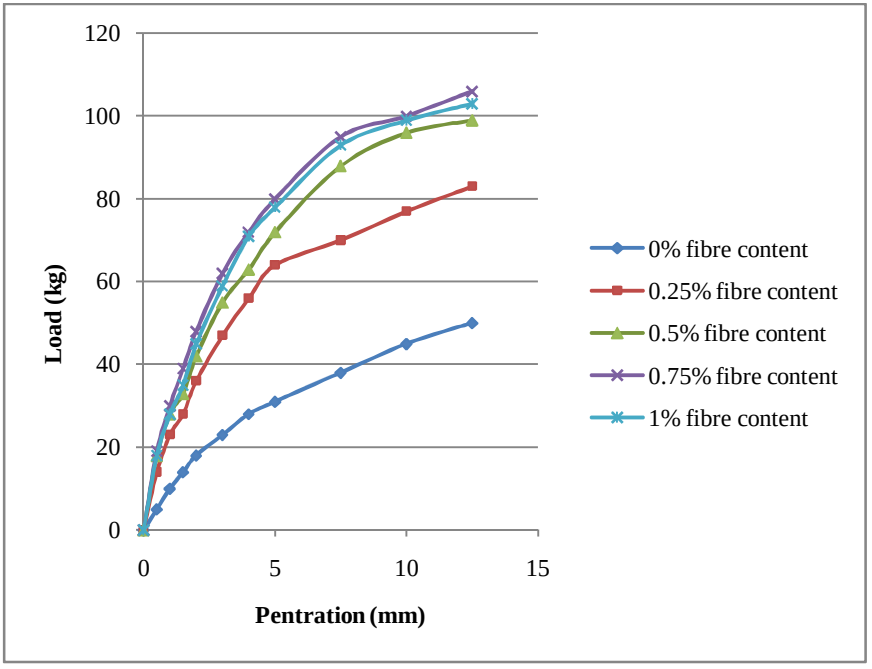



**Fig. 6. CBR Curve For Soil Sample with 0.25% fiber content and fiber length=90mm**

**The CBR values as calculated from the above data at different fibre contents are tabulated below.**

**Table 7: CBR values at different fibre contents and fibre length of 90 mm**

| Fibre Content | CBR at 2.5 mm penetration | CBR at 5 mm penetration |
|---|---|---|
| 0% | 1.496% | 1.508% |
| 0.25% | 3.029% | 3.114% |
| 0.5% | 3.540% | 3.503% |
| 0.75% | 4.014% | 3.892% |
| 1% | 3.795% | 3.795% |

**CBR at different fibre contents**

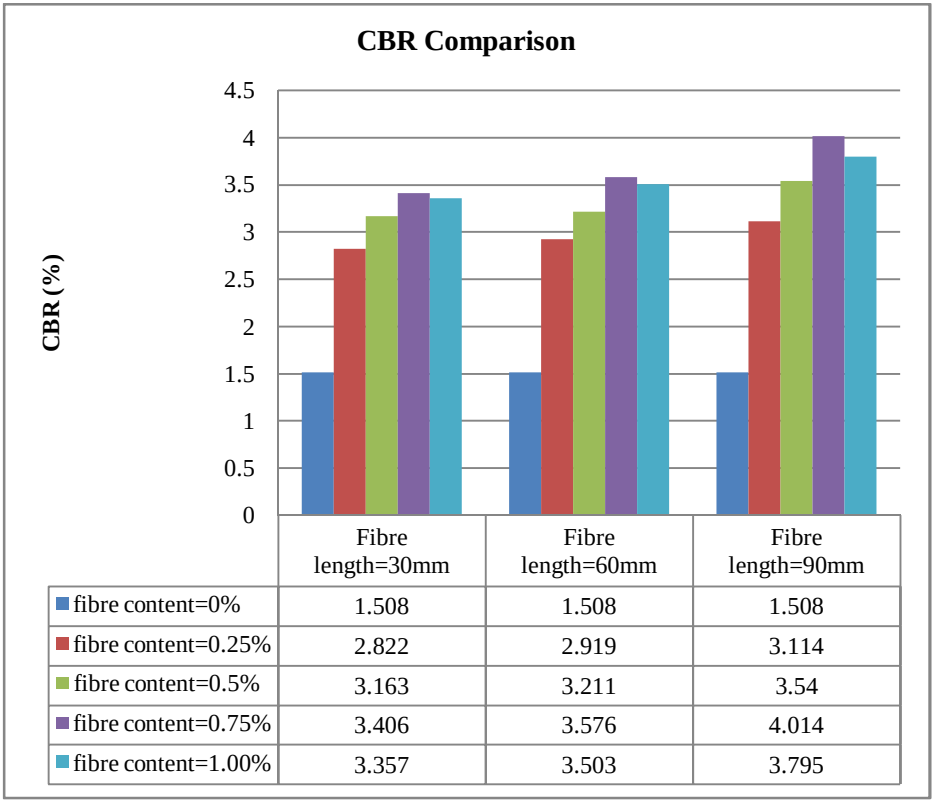



**Fig. 7: CBR at different jute compositions**

## 6. CONCLUSION

The CBR values of plain soil and soil reinforced with different combinations of jute fibre determined in the laboratory are shown in figure 7. Based on the present investigation, it is concluded that CBR value of soil increases with the inclusion of jute fibre. When the jute fibre content is increased, the CBR value of soil further increases and this increase is remarkable at fibre content of 0.75%. It is also concluded that there is significant effects of length of fiber on the CBR value of soil. The CBR value of soil also increases with the increase in length of fibre. The maximum increase in CBR value was found to be more than 200 % over that of plain soil at fiber content of 0.75% for fiber having diameter 2 mm and length 90 mm. It has been concluded that reinforcement of soil using jute-geotextile is economically advantageous as it is cheap and locally available material. Compared to existing methods of soil reinforcement which have practical difficulties in the field, the application of jute-geotextile is easier. The jute-geotextile reinforcement is a superior solution for the construction of low volume roads on weak subgrades.

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