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EXPERIMENTAL EVALUATION OF COIR GEOTEXTILE FIBER ALONG WITH CEMENT TO REINFORCE THE WEAK SUBGRADE SOIL FOR LOW VOLUME ROADS

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Abstract- The construction of any types of roads paved/unpaved roads over the weak subgrade soil is challenging task to civil engineering within the economic cost. The weak subgrade soil associated with poor properties such as high swelling, shrinkage, compressibility, and settlement. The properties of this soil are encounter as a Black cotton soil (BC). Due to the lower shear strength of the BC soil, the failures are the caused in the low-volume roads such as rutting, fatigue and reflecting and the high settlement. To arrest this problem in the pavement many of the conventional Stabilization techniques were adopted in the pavement engineering. In the present study, an attempt is made in the laboratory to evaluate the performance of the coir geotextile fiber to enhance the weak subgrade soil by the stabilization method by using the cement. The Stabilization is a process to change the soil properties to enhance strength and bearing capacity of the weak sub-grade soil. From the last three decades, several studies are done on the usage of natural fiber material to improve the characteristics of weak soils. The coir fibers serve as functions like Reinforcement, erosion control etc. In this paper, the present investigation conducted with a sub-grade as black cotton soil with adding of various percentages of coir fiber (0.25, 0.5, 0.75 and 1 %) and percentage of cement (5 %) by weight of the soil. The CBR test is conducted at the soaked and un-soaked condition with adding of cement and curing period of 0, 7, and 28 days. The study was also conducted along with cement and adding of coir fiber in both the test. The study results are concluded that the coir percent (1 %) in both un-soaked and soaked conditions. Similarly, the CBR test found that maximum compressive strength also obtained at coir (1 %), the inclusion of coir improved the compressive strength and bearing capacity and also the increase in CBR values with increasing the percent of coir fiber and found that (1%) of coir is optimum in un-soaked and soaked condition. The use of coir fiber along with the cement gives additional reinforcement to the Low-volume roads and improved the service life of the pavement.

Key Words: Stabilization, Reinforcement, Coir fiber, CBR.

1. INTRODUCTION

The connectivity of rural roads (or) low-volume roads to the nearest products center plays a key role in economic development of the rural area as well as the development of the country. In the world 80 percent of the roads are low-volume roads (LVRs), these roads are constructed with the lack of technical standard, poor quality of the material and maintenance. Among them, few of the roads are constructed over the weak subgrade soil, such as black cotton soil and expansive soil. The construction of the roads over weak subgrade soil results in failure of pavement. To arrest this many of the stabilization techniques were adopted in the pavement and geotechnical aspects. These techniques are cement; lime, fly ash, and bitumen are commonly application form the last few decades. In the present study, the coir fiber stabilization is taking place with cement to reinforce the weak subgrade soil for LVRs. The Coir geotextile is most abundantly available; it is available in most parts of the Asian countries like Indonesia, Sri-lanka and south part of India. It's widely applicable material in transportation and geotechnical fields. From the 1990's several investigations have been done with application of coir fiber material by conducting the laboratory tests such as California bearing ratio test (CBR), to know the strength and performance behavior of the weak soil subgrade with coir fiber. The Cement Stabilization is used for improving strength and stiffness of the clayey soils. The primary hydration reaction of the cement and water and the secondary pozzolanic reactions between the limes released by the cement and the clay minerals. The processes of stabilization involve the two type of reaction while adding of cement to the clay soil. The primary reaction is hydration and the secondary reaction is the pozzolanic reaction in between the cement and the clay soil. Due to these reactions, forming calcium silicate hydrate (CSH) and calcium aluminate hydrate (CAH). During the treatment period, the curing temperature, stresses, time and humidity affect the strength development of the treated soil. In general, the longer the curing period, the better is the strength development, due to the pozzolanic reaction.

2. LIETARATURE REVIEW

The expansive soil poses the several problems to the pavement in the form of rutting, fatigue and reflection due its high swelling, shrinkage and volume change behaviour upon wetting and drying condition [1, 2, 3] to prevent this 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 the pavement in term of Reinforcement, separation, and drainage, they proved to be cost effective especially for low volume roads [4, 5]. The Geotextiles are one of the largest groups of geosynthetics, Geotextiles can be woven and non-woven type, and there are enormous specific application areas for geotextiles [6]. The geotextiles perform the functions like Separation, Filtration, Drainage, and Reinforcement. The study was conducted an experimental study on Itanagar soil (Doimukh, Itanagar, Arunachal Pradesh) reinforcing with coir fiber (0.25, 0.5, 0.5 and 1 %) by weight of the dry soil. He observed that increase in CBR value with the increase of coir content in un-soaked and soaked conditions [7]. The exhaustive study carried out to explore the behavior of coir geotextile reinforced subgrade soils in terms of California Bearing Ratio [8]. The studies were also conducted that the presence of coir geotextiles influences the strength of subgrade due to the interaction between soil and coir geotextile in soaked and un-soaked condition. The maximum tension effect is available to decrease the bearing capacity of the pavement when the uses of woven and non-woven coir mats are placed over the interface [9,10]. Investigated the behavior of geogrid between the subgrade and Baselayer in unpaved roads, concluded that the geosynthetics are reducing the degradation of base layer and deformation [11]. To study the performance of the geogrid reinforcement indicates that the use of Geosynthetics in pavement over the poor subgrade soil tends to reduce the Sub Base thickness with increasing traffic volume [12].

3. MATERILAS USED FOR THE STUDY

3.1 Black Cotton Soil (Subgrade)

To conduct the study in the laboratory black cotton soil is collected from the lake which is near to the NIT Warangal and used as a subgrade soil. The basic properties of BC soils are determine in the laboratory and presented in table 1.

Table-3.1 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

The coir geotextile is naturally available material extracted from the husk of coconuts. It is strong in nature and high durability as compared with other natural material. the components of the fibers are cellulose, hemicellulose, lignin, pectin, waxes, and water-soluble substances. Lignin is the compound that gives rigidity to the fiber. The basic properties of coir geotextile are presented in Table 3.2

Table- 3.2 Properties of Coir Fibre

Properties of the Coir	Values
Length (mm)	15-280
Density (g/cc)	1.15-1.4
Breaking elongation (%)	30
Diameter (mm)	0.1-1.5
Specific Gravity	1.15
Rigidity modulus (dynes/cm)	1.8924
Swelling in water (%)	5
Young's modulus (GN/m²)	4.5
Specific heat	0.27

4. RESULTS AND DISCUSSION

4.1 CBR Test Results Without Coir and Cement Stabilization

The CBR test is performed in soaked and unsoaked condition as per the standard. The CBR test was conducted with the addition of water at OMC to the soil and it is compacted to MDD. The load versus penetration curve for BC soil without any coir reinforcement is shown in Fig. 4.1 the unsoaked CBR value of the soil is 5.51 %, soaked CBR value is 0.5 %. The soaked CBR value is very less because of the black cotton soil behaves swelling property in the presence of water due to the presence of montmorillonite clay.

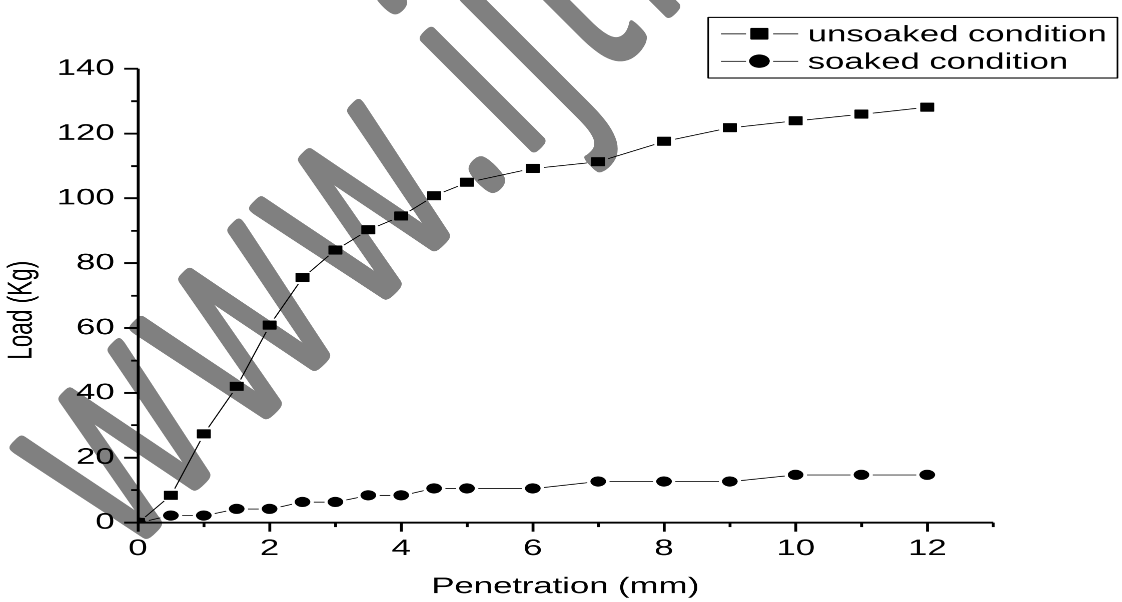

Fig. 4.1 CBR Values of the Soil in Soaked, Unsoaked Conditions for BC Soil

4.2 CBR Results after Cement Stabilization

Now a day's cement stabilization has been widely used to improve the engineering properties of the soil like silty, sandy-clayey and other types of soils. It is a commonly used technique in pavement engineering. The cement stabilization takes place two type of reaction to harden the clay soil. In addition to that, the coir fibres are added to the clay soil to enhance the strength in varying percentages. The hydration reaction leads to the initial gain in strength because of the formation of primary cementitious products and drying up of the soil-cement mix.

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Table-4.1 CBR Values with 5 % Cement + Various Percentages of Coir

Percentage of Materials to be added	Type of Condition	Curing Period (Days)		
		0 days	**7 days**	**28 days**
5 percent cement + 0 percent coir	Unsoaked CBR (%)	22.0	37.0	41.0
	Soaked CBR (%)	24.0	39.0	42.0
5 percent cement + 0.25 % coir	Unsoaked CBR (%)	24.0	37.0	43.0
	Soaked CBR (%)	26.0	41.0	44.0
5 percent cement + 0.5 % coir	Unsoaked CBR (%)	27.0	40.0	46.0
	Soaked CBR (%)	29.0	43.0	48.0
5 percent cement + 0.75 % coir	Unsoaked CBR (%)	31.0	45.0	51.0
	Soaked CBR (%)	34.0	47.0	52.0
5 percent cement + 1 % coir	Unsoaked CBR (%)	35.0	48.0	55.0
	Soaked CBR (%)	37.0	51.0	57.0

In the laboratory, the CBR test is performed in soaked and un-soaked condition by adding of cement and coir fiber the BC soil subgrade. The soaked condition CBR values are noticed after 7 and 28 days of curing. The adding of the cement to the BC soil changes the properties and improved the strength of the BC subgrade. With the addition of the cement to the BC soil, the CBR value of the BC soil is increased from 5.5% to 22%. As the curing period progresses' the CBR value is also increased. The un-soaked CBR value of the BC soil with the addition of the cement is observed in fig. 4.2.

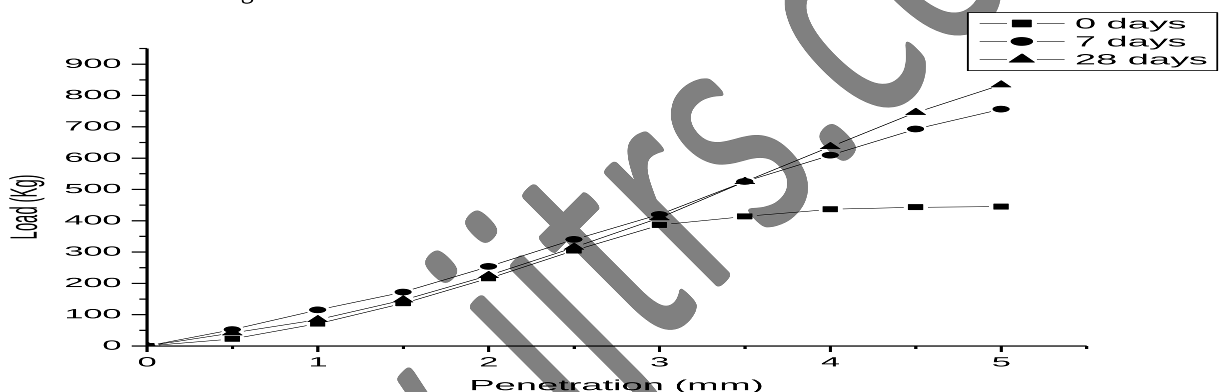

Fig. 4.2 Unsoaked CBR Value With Addition of Cement (5%)

The experimental study has shown the CBR value of BC soil increases with the mixing of cement to BC soil. The adding of 5 percent cement to clay soil improves the CBR value up to 24 percent. The soaked CBR value is more compared with un-soaked CBR value because in the soaking condition the soil sample is kept in water for 4 days. During the four days, the curing will take place between the BC soil and cement. The soil sample in soaked condition, the soil having cementitious compounds due to the presence of cement in it reacts with water forms (CSH, CAH) due to the pozzolanic reaction, due to this reaction the BC soil subgrade became the harder.

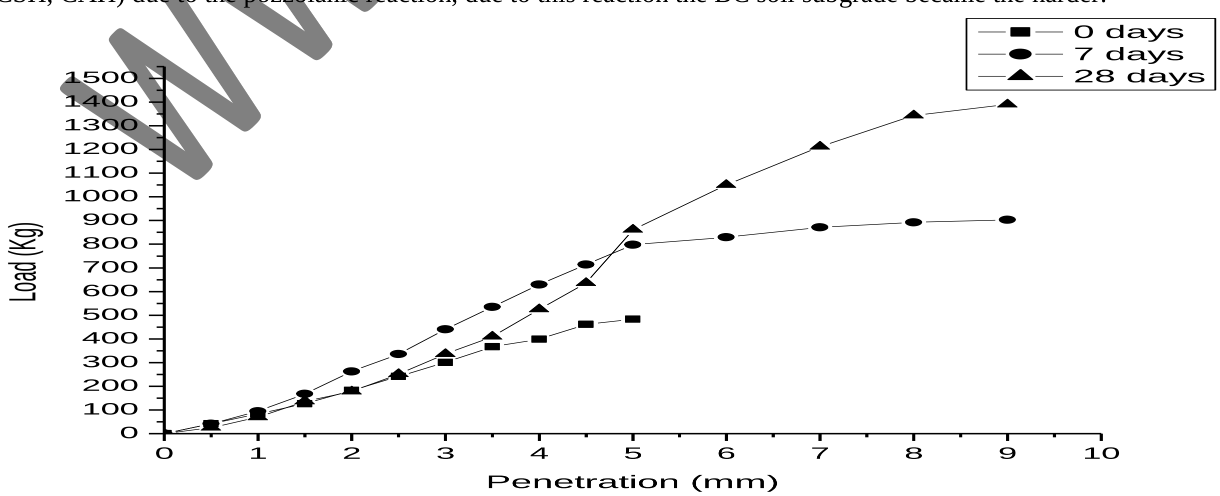

Fig. 4.3 Soaked CBR Value With Addition of Cement (5%)

In the other case, the soaked condition CBR values increase with increasing the curing period. The pozzolanic reaction will notice when the cement is added to the BC soil. The soaked CBR values increase with the increase in curing periods. The soaked CBR values correspondingly 7, 28 days curing periods are 39%, 42%. The soaked CBR values with the addition of the cement to the BC soil with various curing periods see fig. 4.3.

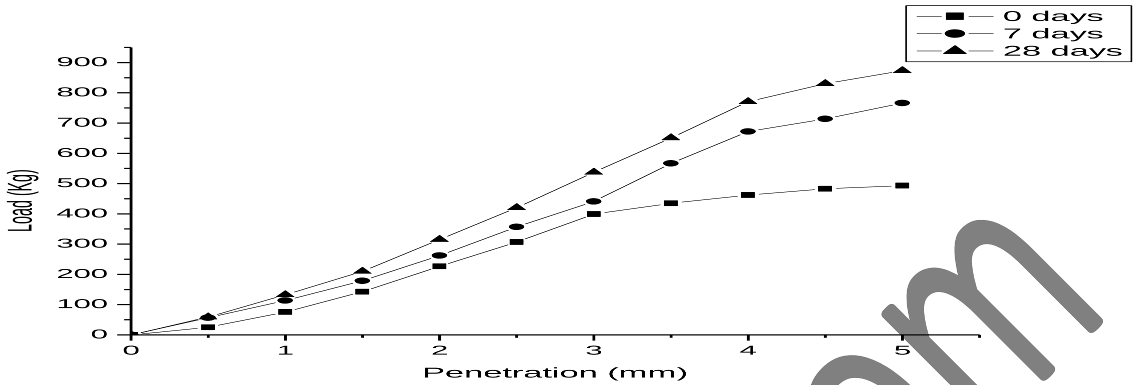

Fig. 4.4 Unsoaked CBR Value With Addition of Cement (5%) and 0.25% Coir

The adding of coir fiber (0.25) along with the 5% of the cement had shown the clear differences in CBR values at 0, 7 and 28 days. The coir is added to the stabilized BC soil is to improve the ductile behavior of the soil. The cement is mixed with the soil, the strength of the soil is improved but the failure occurs brittle failure. To avoid the sudden failures as well as improve the strength of the soil, coir is added to BC soil. The un-soaked CBR values of the soil are mixed with 0.25 % of coir and 5 % cement see fig. 4.4.

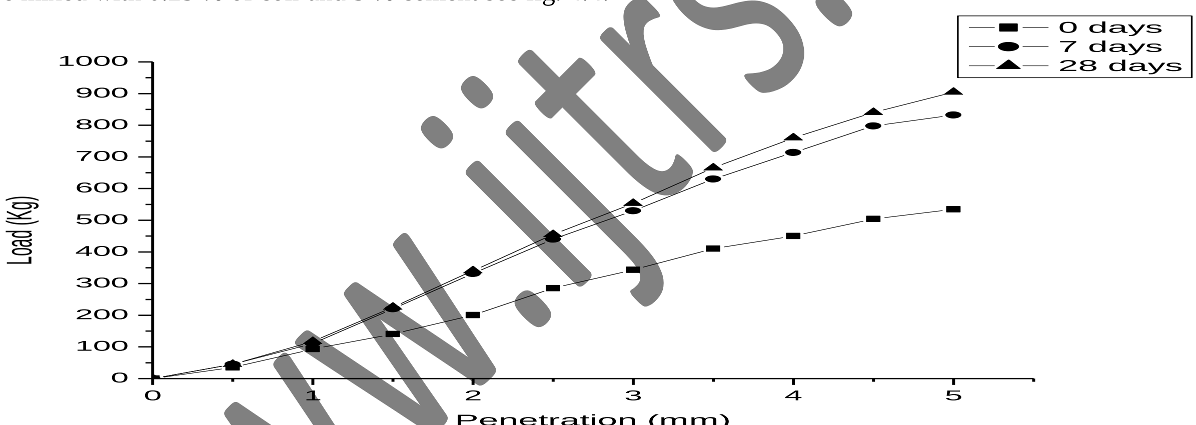

Fig. 4.5 Soaked CBR Value With Addition of Cement (5%) and 0.25% Coir

The soaked CBR values of the soil are mixed with 0.25 % of coir and 5 % cement see figure 4.8. The soaked CBR values at 0.25% coir and 5 % of cement to various corresponding curing periods are 26%, 41 %, and 44 %. The soaked CBR values are more compared to unsoaked values due to the pozzolanic reaction in soaked condition. In addition to that, the increasing percentage of the coir fiber increase the confinement pressure and strength of the subgrade soil. Fig. 4.5 showed the soaked CBR value with 0.25 percent of coir fiber along with 5 percent of the cement stabilization.

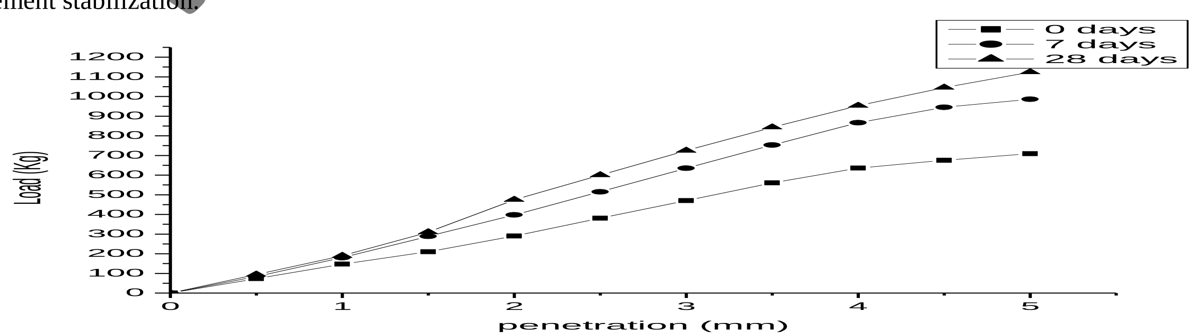

Fig. 4.6 Unsoaked CBR Value With Addition of Cement (5%) and 1% Coir

The incorporation of coir fiber to the BC soil along with the cement, improved the CBR values to increase the confinement to the BC soil subgrade. The CBR values are increased with the addition of the cement to various curing periods in both soaked and unsoaked conditions. The CBR values are increases with the increase of coir fiber content in the cement stabilized BC soil. The unsoaked CBR value with 1 percent of the coir fiber and 5 percent of the cement are shown in fig. 4.6.

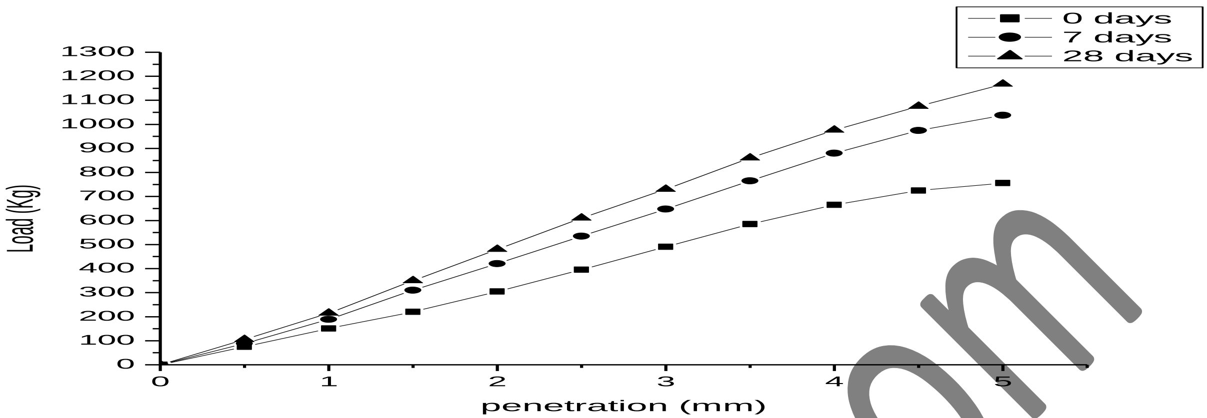

Fig. 4.7 Soaked CBR Value With Addition of Cement (5%) and 1% Coir

The unsoaked CBR values at 1% coir and 5 % are corresponding to various curing periods (0, 7, 28 days) are 35%, 48% and 55 % respectively. The unsoaked CBR values at 1percent coir and 5 percent cement to various curing periods see figure 4.9. The soaked CBR values at 1% coir and 5 % are corresponding to various curing periods (0, 7, 28 days) are 37%, 51% and 57 % respectively. The soaked CBR values at 1 percent coir and 5 percent cement to various curing periods see fig. 4.7.

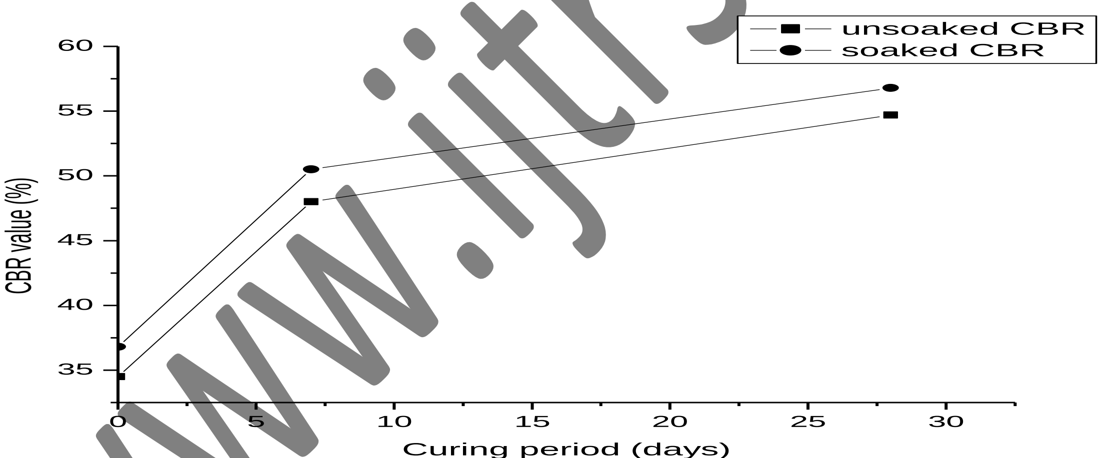

Fig. 4.8 CBR Values With Addition of Cement (5%) and 1% Coir to Soil Various Curing Periods

The CBR values in both the soaked and unsoaked conditions are improved with the addition of the coir in various percentages (0.25, 0.5, 0.75 and 1 %) and cement (5 %). The cement stabilization is very effective in modifying the subgrade properties of the BC soil. The coir is used to reinforcing the cement stabilized soil to improve the ductile behavior by tensile strength of the coir as well as strength of the BC soil. The CBR values of 7 and 28 days of curing period with 1 percent of the coir fiber and 5 percent of the cement are shown in fig. 4.8.

CONCLUSION

- The adding of cement to the clay mineral is more significant in improving the CBR strength and it is determined the 5 percent is optimum when is stabilized with coir fiber.
- The provision of the coir geotextile fiber improves the confinement of the BC soil and also enhances the weak subgrade soil. The confinement of the coir fiber and the reaction between the cement and clay become the stiffer subgrade.
- The 1 percent of the coir fiber is determined as optimum coir fiber to stabilize the weak subgrade along with the cement to reinforce the weak subgrade soil to improve the performance of the roads.

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