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RESEARCH ARTICLE

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A COMPARATIVE STUDY ON MODULUS OF SUBGRADE REACTION USING DIFFERENT MATERIALS

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ABSTRACT
Any man made structure should be rested on the ground surface i.e. on the soil. So ultimately soil becomes a base for any Civil Engineering structure which actually supports the structure from beneath and distributes the load effectively over the surroundings. The stability and durability of a pavement depends upon the subgrade soil on which it is resting and the failure of the pavement takes place if the subgrade is not enough stable to resist the loads transmitting from the pavement surface. These kind of problems can be mostly seen in the expansive soil well known as black cotton soil due to presence of montmorillonite mineral in it, which has ability to undergo changes like large swelling and shrinkage with seasonal fluctuations in natural moisture content. To overcome this, engineering properties of soil must be improved by artificial means known as 'Soil Stabilization'. In the present paper a comparative study was done on modulus of subgrade reaction (K_s- values) of black cotton soil stabilized with different materials. K_s-values is the basic fundamental parameter of the subgrade which defines the degree to which a subgrade tends to deform. In this study the soil is improved with different percentages of waste materials like coconut coir, crumb rubber and RHA and tested in the laboratory to evaluate the K_s values. The K_s .values are devised from the results of CBR test by using the correlations between CBR, E (modulus of elasticity) and υ (Poisson ratio) values.

Keywords: - Black cotton soil, coconut coir, crumb rubber, Rice husk ash, K_S-value, CBR, UCS.

1. INTRODUCTION

Black cotton soils or tropical black earth soils occurs in black or greyish in colour which are known to be potentially expansive soils.Black cotton soils are clayey soils which having high compressibility nature. These are the soils which exhibit high swelling and shrinking nature when exposed to fluctuations in moisture content and hence have been found to be most problematic soils for any Geotechnical Engineer. They are characterized by extreme hardness and cracks when they are in dry condition. The stability and performance of the pavements are greatly influenced by the sub grade as it serves as foundations for pavements but when these are to be laid on black cotton soils they leads to failure of the pavements due to wetting and drying process causes vertical movement in the soil mass. The failure in such pavements takes place in the form of settlement, heavy depression, cracking and unevenness. Thus there is need to improve the soils that are selected for the construction of pavements. The selection of stabilizers always

throws backs a significant affect over the degree of improving and economical aspects of the soil stabilization. In India, the rate of solid waste generation from industries and agricultural fields is found to be increasing at a very rapid rate in past few years. Mainly the rubber waste from rebutted tires (crumb rubber) is being produced and accumulated in large volumes causing an increasing threat to the environment. In order to eliminate the negative effect of these depositions and in terms of sustainable development there is great interest in the recycling of these solid wastes. Use of waste material and natural fiber for improving soil is very advantageous because they available locally at very cheap cost which makes the stabilization economical.

2. Overview of Literature Review

[1] The correlation between E and CBR gives several advantages that can be used to obtain the Modulus of subgrade reaction, (Ks) which is used for designing the road pavement thickness. This correlation will help one for improving the design of highway formations using the empirical relations such as CBR value and analysis based methods which adopt values of E or, threshold stress, liquefaction etc., [2] When soil mixed with crumb rubber content, it is observed that MDD and OMC decreases with increase in percentage of crumb rubber content on soil. [3] The UCS value increased with increase in % of crumb rubber content and the optimum percentage of crumb rubber was observed at 10% and 15%. [4] The results obtained from various tests indicate a general decrease in the MDD and increase in OMC with increase in RHA content to soil. There was a slight improvement in the CBR and UCS with increase in the RHA content to the soil. [5] The water content percentage and density (g/cc) curves indicates that addition of RHA results in an increase in OMC and decrease in MDD, while these values decrease with addition of FA powder. [6] Coir fiber is a useful and also a biodegradable waste that improves strength and stiffness of all types of soil. Coconut coir used in different proportion percentages and different lengths affect the soil properties drastically. Further work can be done on reducing it by degradation of coir waste to sustainable environment. [7] Admixtures like coconut coir waste and Bagasse ash added with soil have to be effective in stabilizing the expansive clayey soil because of their better adjustment with soil and its basic behaviour. 6% coconut coir in a soil is taken as optimum percentage of admixtures having maximum Unsoaked CBR value. Hence this proportion may be economically used in the pavements, embankments and earth retaining walls. [8] The optimum percentage of coconut coir fibre waste content was found to be 1%. The MDD of the expansive clayey soil increases while OMC decreases with the addition of fibre content.

3. EXPERIMENTAL INVESTIGATIONS

3.1 MATERIALS USED

3.1.1 ***Black cotton soil*****:** The soil used in this investigation was collected from surrounding area of Ainavilli temple which is located near to Amalapuram, East Godavari district.

Fig 1 : Black cotton soil in the field

3.1.2 STABILIZERS: Crumb rubber, Rice husk ash, Coconut coir. The materials which are used as stabilizers in this study are collected locally from the Kakinada

Fig 2 : crumb rubber

Fig 3 : Rice husk ask

Fig 4 : coconut coir pulp

TABLE 1: PROPERTIES OF BLACK COTTON SOIL

SOIL PROPERTIES	RESULTS
Grain size analysis	gravel -1.3%
	sand - 20.7%
	fines - 78 %
Plastic limit (%)	36
Plasticity Index	26
Shrinkage limit (%)	19
Compaction test (OMC) (%)	16
Compaction test (dry density) (g/cc)	1.532
Unconfined compressive test (UCS) (KN/m2)	128
(CBR) California bearing ratio test	**UNSOAKED:** 3.1%
	SOAKED: 1.95%

TABLE 2: PROPERTIES OF CRUMB RUBBER

TYPE OF RUBBER	CRUMB TYPE
Size	600µ to 300µ
Colour	Black
Specific gravity	1.15
Density	352 kg/m^3

TABLE 3: PROPERTIES OF RICE HUSK ASH

S.NO	PROPERTIES	VALUE
1	specific gravity	2.3
2	Colour	grey
3	Density	86 -114 kg/ cm3
4	silicon dioxide	86.94%
5	Aluminium oxide	0.20%
6	Iron oxide	0.10%
7	Calcium oxide	0.3-2.2%
8	Magnesium oxide	0.2-0.6%
9	Sodium oxide	0.1-0.8%
10	potassium oxide	2.15-2.3%

TABLE 4: PROPERTIES OF COCONUT COIR

PROPERTIES	VALUES
Specific gravity	0.87
Colour	Dark brown
Diameter	0.1 to 0.8mm
Length	5 to 12 cm
Lignin	20-48 %
Density	1.40 g/cc
Hemi cellulose	15-28%
Cellulose	35-60%

3.1.3 CORRELATION BETWEEN CBR AND MODULUS OF SUBGRADE REACTION (K_S):

The CBR test results can also be used to get the curve of load settlement of the soil in the field somewhat similar to that of Plate Bearing Test.

Usually from Plate Bearing Test, we can determine the following

1. Bearing capacity of the soil
2. Settlement of soil
3. K_s value (Modulus of subgrade reaction)

The base correlation to evaluate the Ks value from the CBR test is given below.

$$K_s = 1.13\frac{E}{(1-\nu^2)} \cdot \frac{1}{\sqrt{A}}$$

Where E = Modulus of elasticity

ν = Poisson ratio

A = Area of the CBR plunger (0.2026 m^2)

3.1.4 MODULUS OF ELASTICITY (E) FROM EMPIRICAL RELATIONS:

The value of E for the above relation of Ks can be computed from the correlations between E and CBR values for different values of Poisson ratio (ν).

For ν = 0, E = 863.82 X CBR value (kPa)

For ν = 0.3, E = 840.53 X CBR value (kPa)

For ν = 0.4, E = 751.00 X CBR value (kPa) (for clayey soils)

In the absence of Poisson's ratio, the average value of E from CBR values can be taken as

E = 810 X CBR (kPa)

4. RESULTS AND DISCUSSIONS

From the laboratory tests conducted on the soil added with different percentages of stabilizers the following results were obtained which are tabulated and compared. Tabulated results from the CBR test were used to evaluate the K_S _ values from the correlations mentioned in the above for E and CBR values. The K_S _ values thus calculated are tabulated in table no:6 which gives a comparative study of the soil tested.

TABLE 5: COMPARISON TABLE OF SOIL PROPERTIES FROM THE RESULTS

Soil with different percentages of stabilizers	Modified Soil properties				
	OMC %	MDD g/cc	UCS KN/m^2	CBR UNSOAKED %	CBR SOAKED %
Natural soil	16	1.532	128	3.1	1.95
Soil+2% crumb rubber	15	1.520	153	3.8	2.08
Soil+5% crumb rubber	14	1.491	171	5.6	2.2
Soil+8% crumb rubber	13.5	1.472	201	7.5	2.7
Soil+11% crumb rubber	13	1.443	182	9	3.4
Soil+14% crumb rubber	12	1.418	139	10.3	4.1
Soil+2% RHA	18	1.523	195	6.2	2.72
Soil+5% RHA	20	1.516	218	7.8	4.24
Soil+8% RHA	21	1.498	227	9.9	4.67
Soil+11% RHA	22	1.472	188	9.5	3.32
Soil+14% RHA	24	1.448	132	7.2	2.01
Soil+0.3% COIR	16.8	1.515	255	6.43	3.45
Soil+0.6% COIR	19	1.502	322	7.2	4.18
Soil+0.9% COIR	20.4	1.476	264	7.89	4.45
Soil+1.2% COIR	21.6	1.457	221	8.5	4.70
Soil+1.5% COIR	23.2	1.433	148	9.1	4.88

TABLE 6: COMPARISON TABLE OF K_S – VALUES

Soil with different percentages of stabilizers	K_S – values for soil with different percentages of stabilizers	
	K_S Value from Unsoaked CBR values (KN/m^3)	K_S Value from soaked CBR values (KN/m^3)
Natural soil	69563.63	43757.77
Soil+2% crumb rubber	85271.54	46674.95
Soil+5% crumb rubber	125663.3	49367.74
Soil+8% crumb rubber	168299.1	60587.68
Soil+11% crumb rubber	201958.9	76295.59
Soil+14% crumb rubber	231130.8	92003.51
Soil+2% RHA	139127.3	61036.47
Soil+5% RHA	175031.1	95145.09
Soil+8% RHA	222154.8	104794.2
Soil+11% RHA	213178.9	74500.4
Soil+14% RHA	161567.1	45104.16
Soil+0.3% COIR	144288.4	77417.59
Soil+0.6% COIR	161567.1	93798.7
Soil+0.9% COIR	177050.7	99857.47
Soil+1.2% COIR	190739	105467.4
Soil+1.5% COIR	204202.9	109506.6

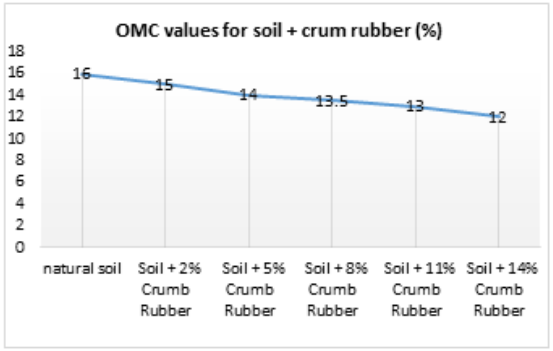

Fig 5: Comparison of OMC with soil+ crumb rubber

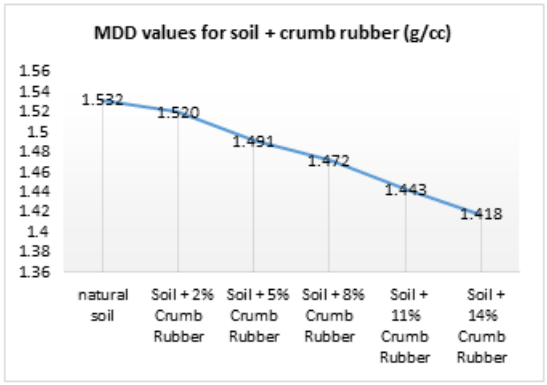

Fig 6: Comparison of MDD with soil+ crumb rubber

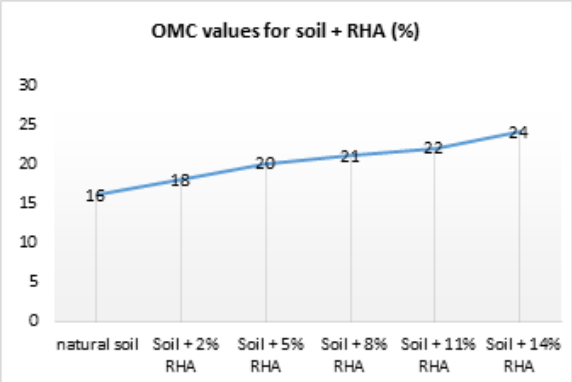

Fig 7: Comparison of OMC with soil+ RHA

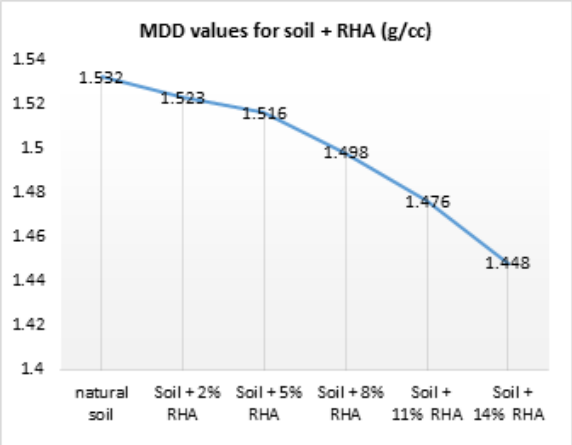

Fig 8: Comparison of MDD with soil+ RHA

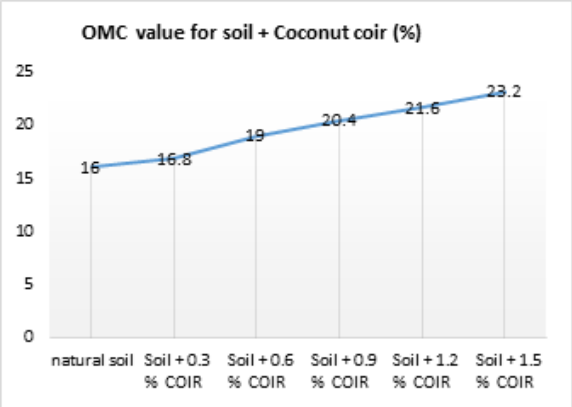

Fig 9: Comparison of OMC with soil+ coconut coir

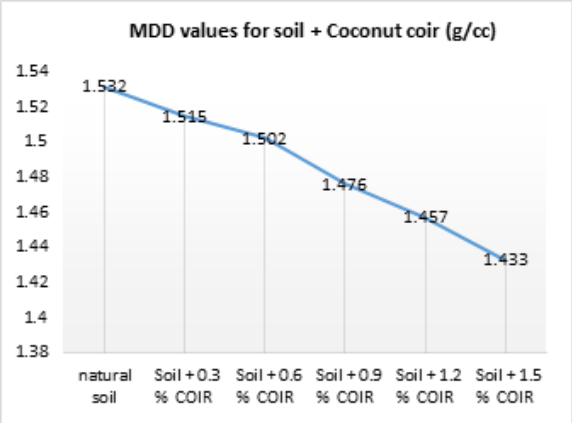

Fig 10: Comparison of MDD with soil+ coconut coir

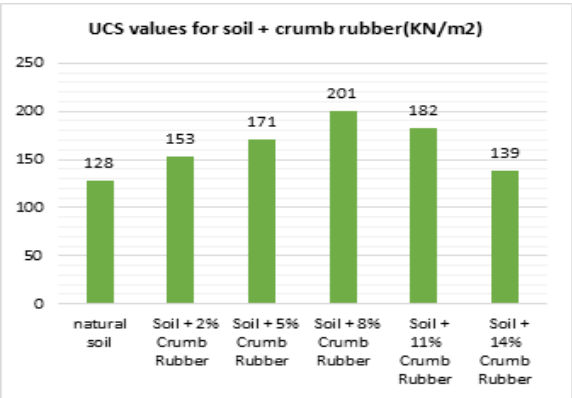

Fig 11: Comparison of UCS with soil+ crumb rubber

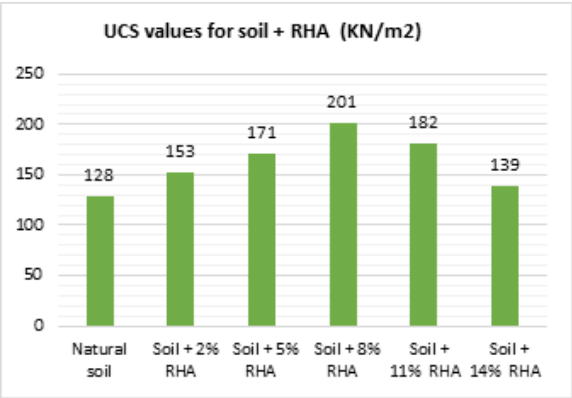

Fig 12: Comparison of UCS with soil+ RHA

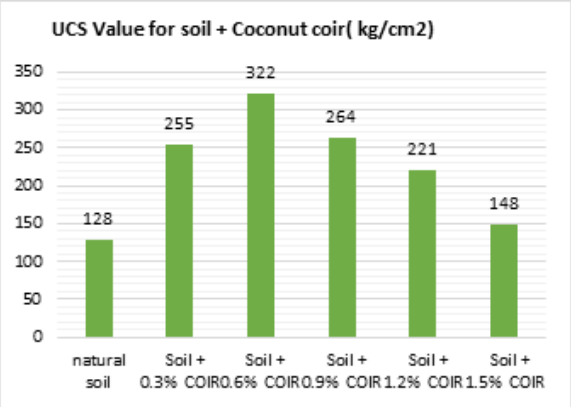

Fig 13: Comparison of UCS with soil+ coconut coir

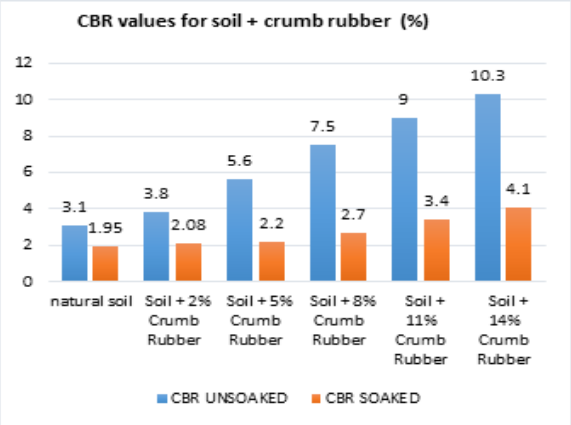

Fig 14: Comparison of CBR with soil+ crumb rubber

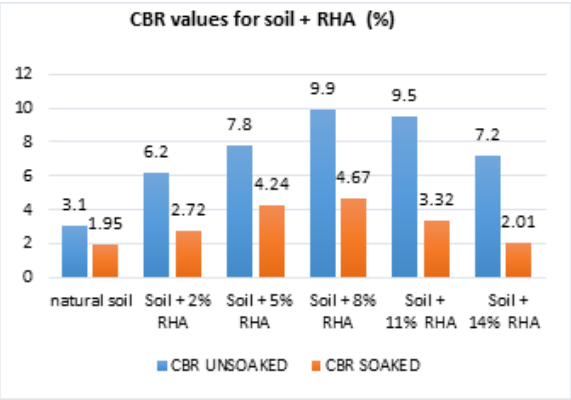

Fig 15: Comparison of CBR with soil+ RHA

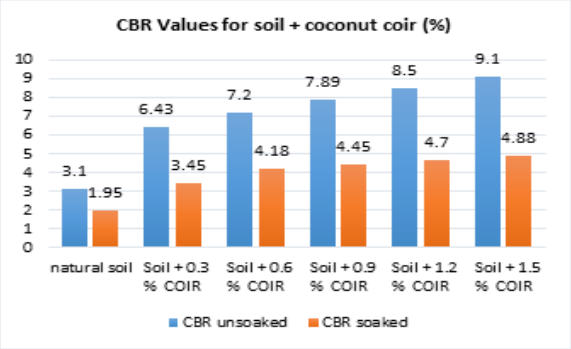

Fig 16: Comparison of CBR with soil+ coconut coir

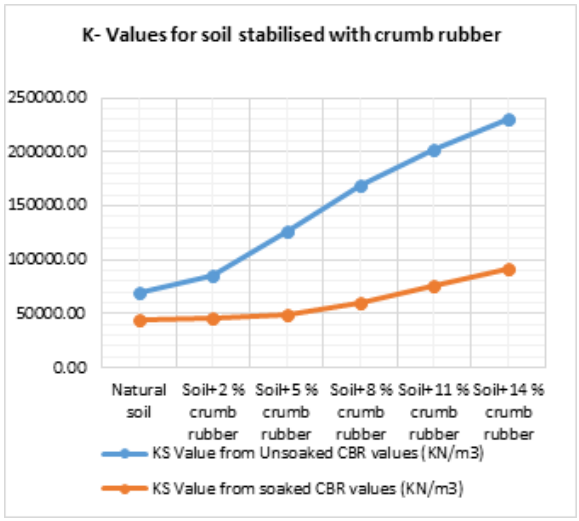

Fig 17: Comparison of Ks with soil+ coconut coir

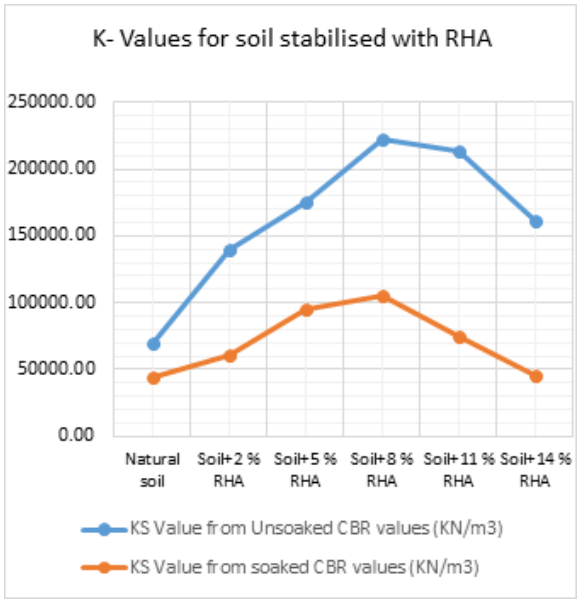

Fig 18: Comparison of Ks with soil+ RHA

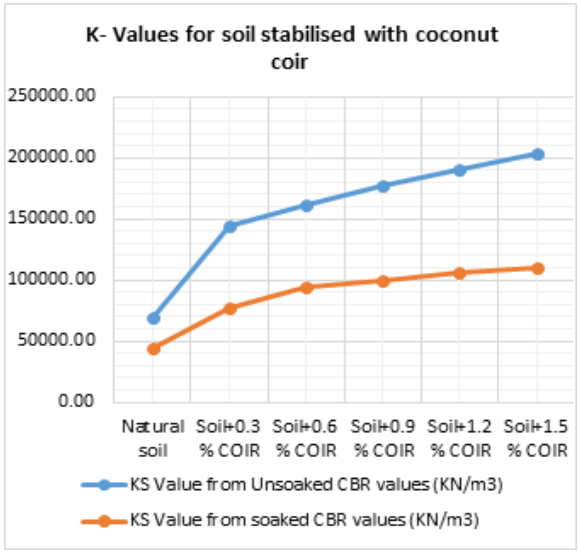

Fig 19: Comparison of Ks with soil+ coconut coir

5. CONCLUSIONS

The present study gives an overview on the potential of utilizing the waste materials like crumb rubber, Rice husk ash and Coconut coir as stabilizers in improving the properties of the problematic soils for evaluating the modulus of subgrade reaction (K_S-Values). From the marked results the following conclusions can be done.

1. The OMC values got increased gradually with increase in the percentages of RHA and coconut coir while the OMC values gradually reduced for the soil modified with crumb rubber.
2. The MDD values are decreased to 1.448 gm/cc & 1.418 gm/cc from 1.532gm/cc with increase in addition of RHA and crumb rubber. The MDD value also decreased from 1.532gm/cc to 1.433 gm/cc with increase in percentages of Coconut coir.
3. The UCS values for soils increased from 128 KN/m^2 to 227 KN/m^2 at 8% of RHA and increased to 201KN/m^2at 8 % addition of crumb rubber to soil. The maximum UCS value was marked 322 KN/m^2 at 0.6 % addition of Coconut coir.
4. There is an appreciable increase in the CBR values at 9% of RHA and the CBR values for Unsoaked and soaked condition are noted as 9.9% and 4.67%. The CBR values for soil with crumb rubber are found to be increased with increase in addition of crumb rubber which are marked as 10.3% in Unsoaked condition and 4.1% in soaked condition. The CBR values for soil with coconut coir are increased to 9.1% and 4.8% in Unsoaked and soaked condition at 1.5% of coconut coir addition.
5. Finally, there is a significant increase in the value of K_S for the black cotton soil treated with different percentages of stabilizers compared to that of natural soil. The K_S-value increased from 69563.63 to 231130.76 KN/m^3 at 14% addition of crumb rubber while the value increased to 222154.81 KN/m^3 at 8% of RHA and increased to 204202.91 KN/m^3 at 1.2% of coconut coir. After all the comparisons we can conclude that the K_S-value is achieved maximum at 14% addition of crumb rubber to the Black cotton soil.

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