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The Effect of Coir Fibre and Polypropylene Fibre Inclusion on Engineering Properties of Kota Stone Slurry Stabilized Expansive Soil

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Abstract: :- Expansive soil which have a tendency to expands and contract in presence and absence of moisture respectively. This is one of the major reason of failure of engineering structures. These property of expansive soil may be improved by adding or mixing the different types of admixture or fibre or stabilizing agents. In this Study, the engineering properties of expansive soil is tried to improve by using Kota stone slurry with coir fibre and polypropylene fibre. In this experimental work, the 15% Kota stone slurry is mixed with different percentage of coir fibre and polypropylene fibre in expansive soil. The following tests were conducted to know the behaviour of expansive soil with stabilizing agents atterberg limit Standard Proctor Test, Unconfined Compression Test, California Bearing Ratio(3days soaked).

Keywords - MDD, OMC, UCS, CBR, Coir Fibre, PPF.

I. INTRODUCTION

Expansive soil is one among the problematic soils that has a high tendency of shrinkage or swelling due to change of moisture content. This expansive soil occurs mostly in the central and western parts and covers approximately 20% of the total area of India. Because of its high swelling and shrinkage characteristics, the expansive soils (E.S) has been a challenge to the highway engineers. The expansive soil is very hard when dry, but loses its strength completely when in wet condition. The racks disappear during wet season but an uneven soil surface stays as a result of irregular swelling and heaving. The black cotton soils have low strength and are susceptible to excessive volume changes, making their use for construction purposes very difficult. In this research paper, for the improvement of expansive soil the following tests were performed:- Standard proctor, UCS(3days soaked), CBR test(3days Soaked) on 15% of Kota Stone Slurry used with different percentage of Coir fibre and polypropylene fibre . The main objective of this work was to investigate the potential of improving engineering properties of expansive soil by using Kota stone slurry, natural and synthetic fibre.

II. MATERIAL USED

Kota stone slurry with coir fibre and PPF were mixed with different percentage in Expansive soil to examine the behaviour of Expansive soil. Before mixing of KSS with CF and PPF, the physical and chemical parameters were studied to understand the behaviour of material.

2.1 Expansive Soil

Soil was taken from depth of 2m-3m from ground level and soil was grey-black in colour. Expansive soil used for experimental investigation was collected from the place Dantli Area, which is situated in Jaipur city of Rajasthan state (India).

2.2 Kota stone slurry

KSS used in the present study was collected from the industrial area of kota district of Rajasthan state of India. The main engineering parameters of Kota stone slurry are enlisted in Table I.

Table I. Parameters of Kota Stone Slurry

Parameters	Values (Percent)
Specific gravity	2.64
Calcium Oxide	66.32
Ferrous Oxide	2.72
Titanium Dioxide	2.09
Silica	22.69

2.3 Coir Fibre

Coir fibre used in the present study was collected from nearby temples. The mature brown coir fibre contain more lignin and less cellulose, this give the strength but less flexibility, fine but the strength is very low as compare to the other one. Generally the length of fibre is 10 – 20 centimeters and diameter is 10 to 20 µm, in this study the aspect ratio was 100.

2.4 polypropylene fibre

Polypropylene fibers are composed of crystalline and non-crystalline regions. It is a by-product of petroleum. Some properties of polypropylene fibre include: lightweight (floats on water), extremely low moisture regain, quick drying, highly resistant to mechanical abuse, mildew and insect resistant, better durability, sunlight resistant, chemical resistant, abrasion resistant etc.

III. Results:-

3.1 Atterbergs limits:- Particle sieve analysis, liquid limit and plastic limit tests were performed on soil, Kota Stone slurry and mix specimens. From Table 1, it has obtained that expansive soil is inorganic clay having medium plasticity. When Kota Stone slurry is mixed with expansive soil on varied percentage of Kota Stone slurry, the expansive soil behavior changes CI to CL on 15% of Kota Stone slurry (inorganic clay having low plasticity).

Table II. Atterbergs limits Test Results for different mixes of Expansive soil with Kota stone slurry.

Percentage of KSS With Expansive Soil	Liquid Limit WL (%)	Plastic Limit WP (%)	Plasticity Index P.I. (%)	Specimen Classification As Per IS 1498(1970)
Expansive Soil	48.13	20.58	27.55	CI
E.S. + 5% KSS	40.74	17.42	23.32	CI
E.S.+ 10% KSS	33.38	13.19	20.19	CI
E.S. + 15% KSS	25.62	11.31	14.31	CL
E.S. + 20% KSS	20.11	9.22	10.89	CL

3.2 Standard Proctor Test:-

Standard proctor test was performed to obtain the optimum moisture content and maximum dry density of the soil and mix specimens. The test was performed as per Indian standard. The values of OMC and MDD for different proportions of coir fibre and PPF with 15%KSS are enlisted in the table III and table IV respectively. Initially the OMC and MDD of the expansive soil was 17.27 % and 1.68 Kg/cm^3 respectively. After adding the 15% KSS and varying percentage of Coir Fibre in the expansive soil, MDD of the mix started increasing and OMC started decreasing. The maximum value of MDD was recorded at 15% KSS with 1.5% for coir fibre and 15% KSS with 1% of PPF. Further increment of Coir Fibre and PPF results in decrease in the MDD of mix. Hence optimum dose of Kota stone slurry was recorded at 15% KSS with 1.5% for coir fibre and 15% KSS with 1% of PPF.

Table III. Standard Proctor Test Results for Mix Specimens of 15% KSS and varying percentage of Coir Fibre.

Test specimen	MDD(Kg/cm^3)	OMC(%)
Expansive soil	1.68	17.27
E.S+15%KSS	1.74	15.98
E.S+15%KSS+0.5%CF	1.76	15.33
E.S+15%KSS+1%CF	1.78	14.82
E.S+15%KSS+1.5%CF	1.81	13.88
E.S+15%KSS+2%CF	1.8	14.14

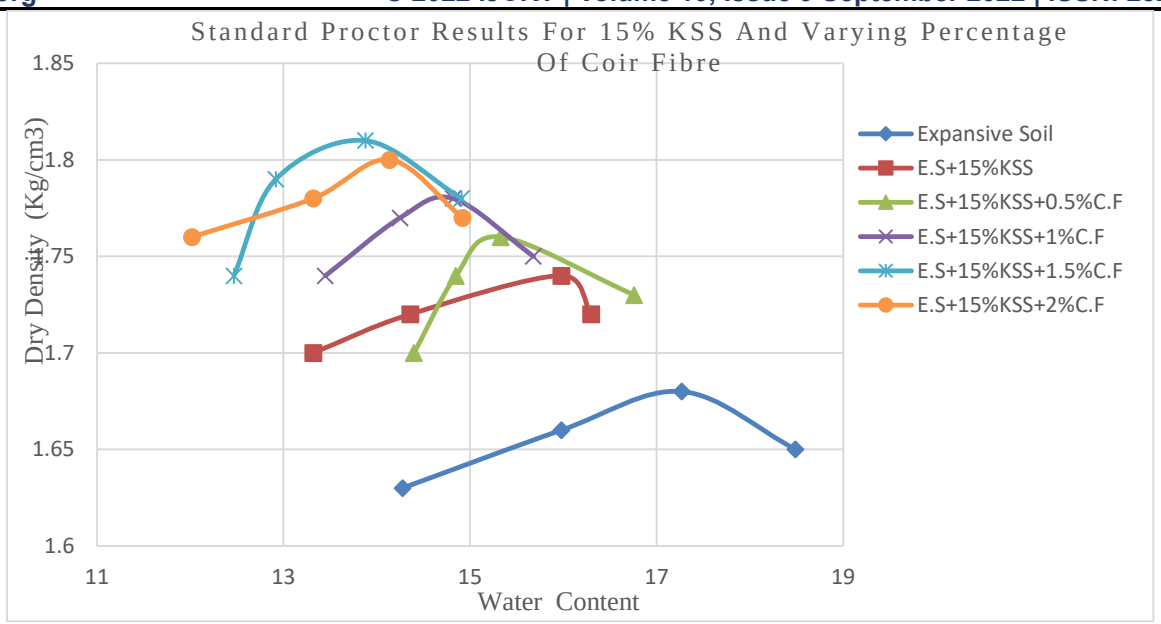

Figure1. Standard Proctor Results For 15% KSS and Varying Percentage of Coir Fibre

TABLE IV Standard Proctor Test Results for Mix Specimens of 15% KSS and varying percentage of Polypropylene Fibre.

Test Specimen	MDD(kg/cm3)	OMC(%)
Expansive Soil	1.68	17.27
E.S+15%KSS	1.74	15.98
E.S+15%KSS+0.5%PPF	1.75	16.37
E.S+15%KSS+1%PPF	1.77	16.08
E.S+15%KSS+1.5%PPF	1.75	16.19
E.S+15%KSS+2%PPF	1.73	16.61

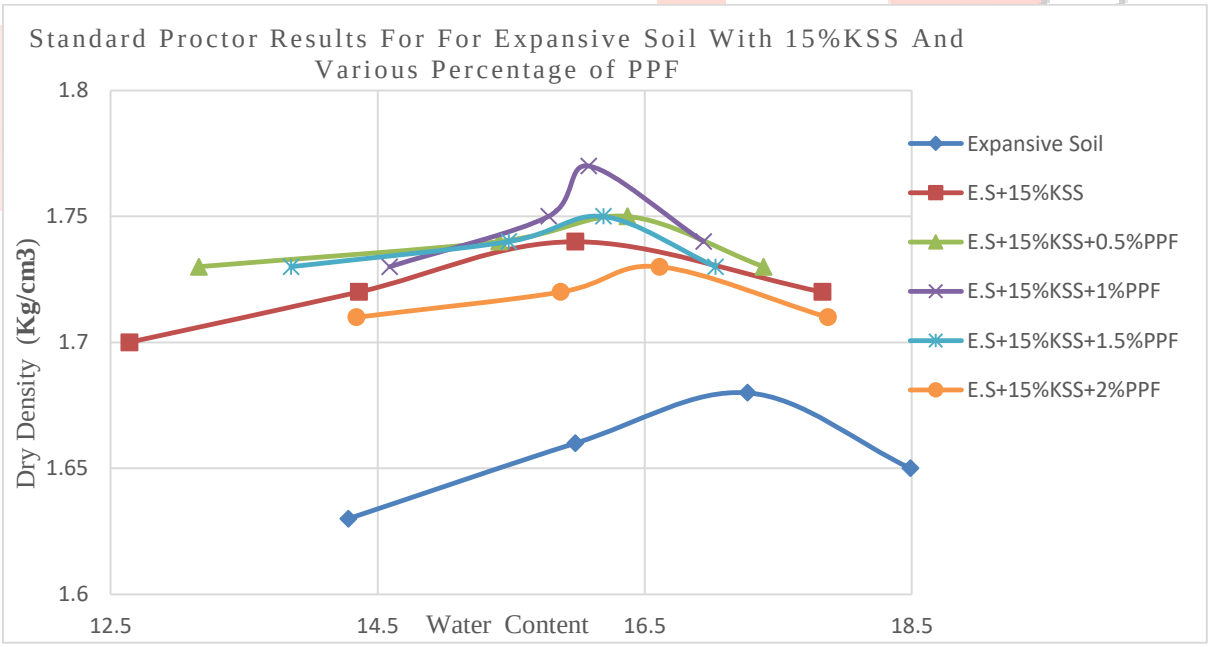

Figure2. Standard Proctor Results For 15% KSS and Varying Percentage of PPF

3.3 Unconfined Compressive Strength Test

In order to determine the shear strength and UCS value of soil and mix specimen of soil and Kota stone Slurry, the laboratory test of UCS was performed as per Indian standards. The results of UCS test and the variation of compressive strength and shear strength is enlisted in the Table V and VI for Coir fibre and Polypropylene fibre respectively. The graphical representation is shown in Figure 3, 4. It can be seen that by adding of 15% KSS with 1.5% Coir Fibre in the soil, The value of UCS increases and the max value of UCS was 4.60 Kg/cm2 at15% KSS with 1.5% Coir Fibre. Hence the optimum dosage of Coir fibre is found to 1.5% for the UCS test.

Table V: Results of UCS test for15% KSS with Varying Percentage of Coir Fibre

Test specimen	UCS, (q_u)Kg/cm2	Variation of q_u (%)	Shear Strength(Cu) Kg/cm2	Variation of C_u (%)
Expansive soil	2.01	-	1.00	-
E.S+15%KSS	3.54	76.05	1.77	76.05
E.S+15%KSS+0.5%CF	3.99	98.50	1.99	98.50
E.S+15%KSS+1%CF	4.39	118.67	2.20	118.67
E.S+15%KSS+1.5%CF	4.60	129.19	2.30	129.19
E.S+15%KSS+2%CF	4.31	114.87	2.16	114.87

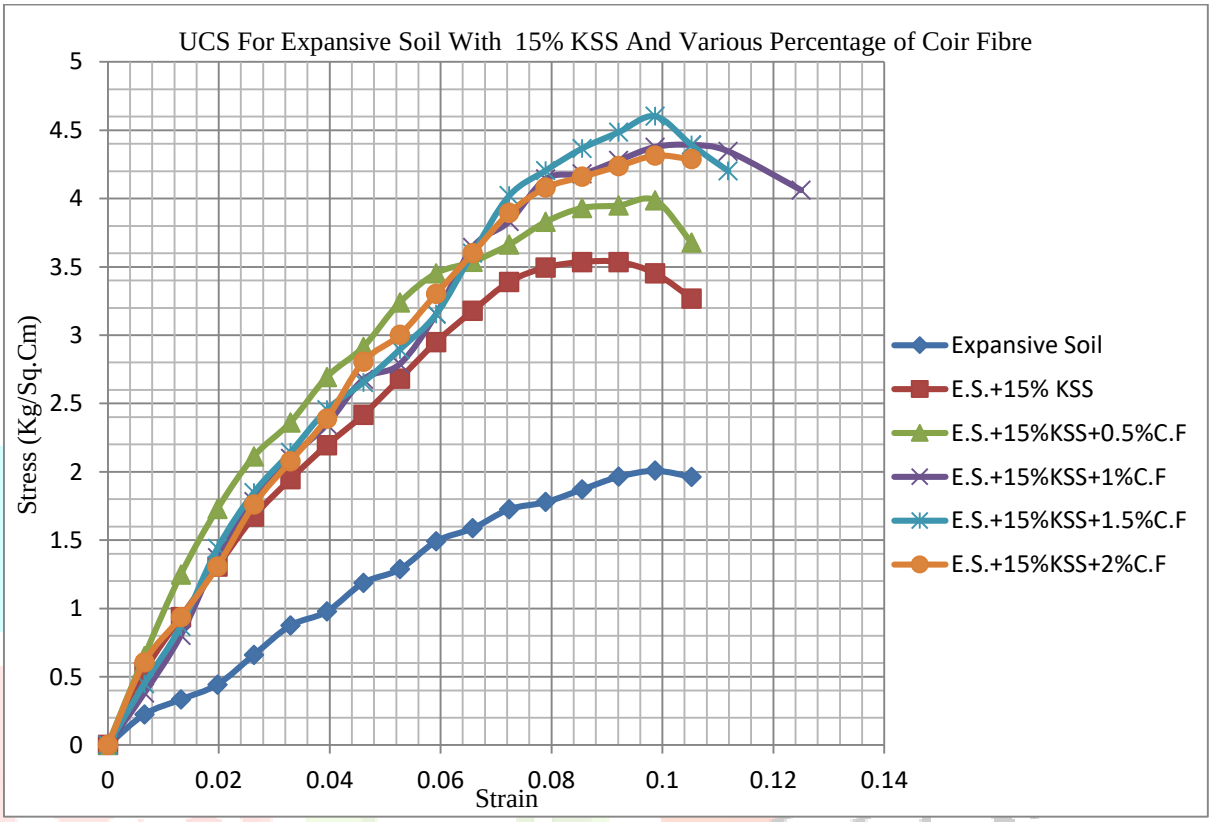

Figure3. UCS Results For 15% KSS and Varying Percentage of Coir fibre

It can be seen that by adding of 15% KSS with 1% PPF in the soil, The value of UCS increases and the max value of UCS was 4.34 Kg/cm^2 at15% KSS with 1% PPF. Hence the optimum dosage of PPF is found to 1% for the UCS test.

Table VI: Results of UCS test for15% KSS with Varying Percentage polypropylene fibre

Test specimen	UCS, (q_u)Kg/cm^2	Variation of q_u (%)	Shear Strength(Cu) Kg/cm^2	Variation of C_u (%)
Expansive soil	2.01	-	1.00	-
E.S+15%KSS	3.54	76.05	1.77	76.05
E.S+15%KSS+0.5%PPF	3.85	91.73	1.93	91.73
E.S+15%KSS+1%PPF	4.34	116.14	2.17	116.14
E.S+15%KSS+1.5%PPF	4.24	111.16	2.12	111.16
E.S+15%KSS+2%PPF	4.08	103.19	2.04	103.19

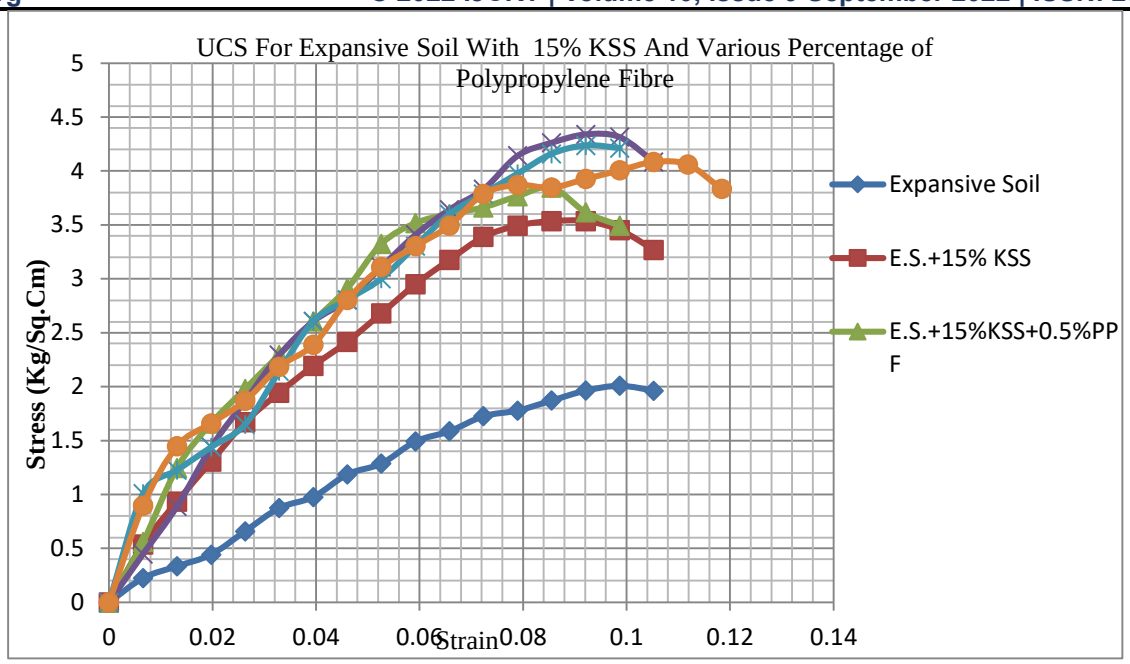

Figure4. UCS Results For 15% KSS and Varying Percentage of Polypropylene fibre

3.4 California Bearing Ratio Test

The California Bearing Ratio test was performed in the laboratory as per Indian standards to analyze the effect of coir fibre and polypropylene fibre on expansive soil with 15%KSS. The Coir fibre and Polypropylene fibre provide reinforcement to the material hence it increases the shear strength of the specimen and ultimately it provides more resistance to the penetration. The results of the CBR test are shown in the Table VII and the graphical results are depicted in the Figure 5.

Table VII: Results Of UCS Test For15% KSS With Varying Percentage Of Coir Fibre

Test Specimen	CBR Value	% Increment
Expansive soil	2.03	-
E.S+15%KSS	4.69	131.0344828
E.S+15%KSS+0.5%CF	5.55	173.3990148
E.S+15%KSS+1%CF	5.62	176.8472906
E.S+15%KSS+1.5%CF	5.94	192.6108374
E.S+15%KSS+2%CF	5.78	184.729064

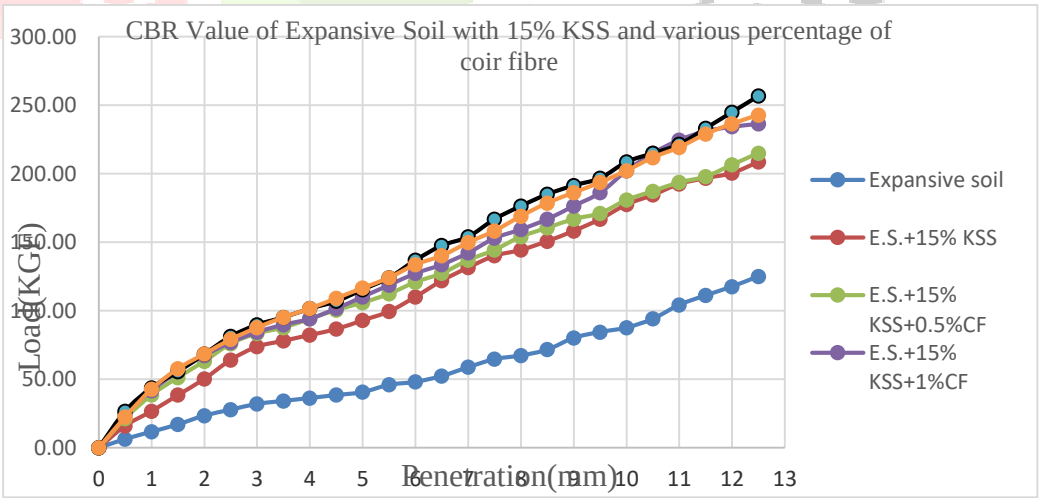

Figure5. UCS Results For 15% KSS and Varying Percentage of Coir fibre

The results of the CBR test on expansive soil with 15%KSS and varying percentage of PPF are shown in the Table VIII. The value of CBR increases and the max value of CBR is 5.78 Kg/cm^2 at15% KSS with 1% PPF. The graphical results are depicted in the Figure 6.

Table VIII: Results Of UCS Test For15% KSS With Varying Percentage Of PPF

Test Specimen	CBR Value	% Increment
Expansive soil	2.03	-
E.S+15%KSS	4.69	131.0345
E.S+15%KSS+0.5%PPF	5.39	165.5172
E.S+15%KSS+1%PPF	5.78	184.7291
E.S+15%KSS+1.5%PPF	5.62	176.8473
E.S+15%KSS+2%PPF	5.23	157.6355

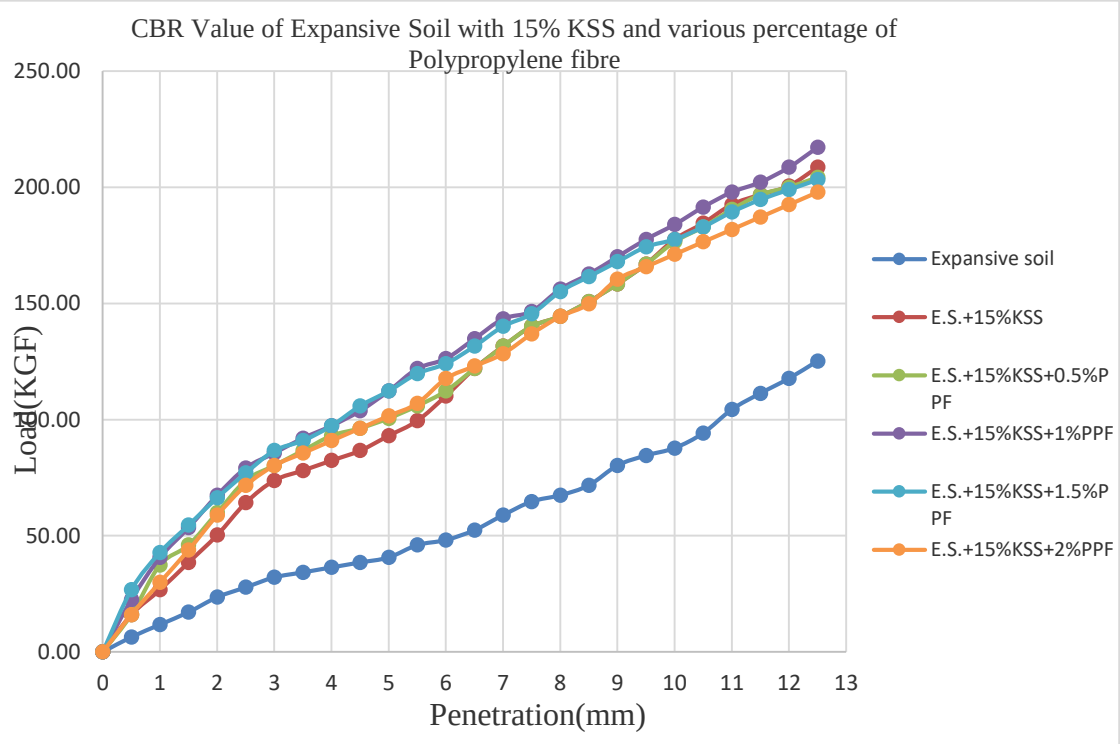

Figure6. UCS Results For 15% KSS and Varying Percentage of Coir fibre

IV. CONCLUSION

1. Study reveals that with increasing the quantity of Kota stone slurry in expansive soil, the resulting mixture turned gradually from medium plasticity clay (CI) to low plasticity clay (CL).
2. The optimum moisture content is decreased and maximum dry density is increased with increment of percentage of Kota stone slurry in expansive soil. Further on adding Coir fibre and Polypropylene fibre, the optimum moisture content decreases and maximum dry density increases.
3. The UCS value increases by increasing the percentage of Kota stone slurry with coir fibre till 1.5% by the further increment of coir fibre, the value of UCS is decreased. The UCS value was found to increase for 15% KSS with 1.5% coir fibre in expansive soil, it has been increased by 129.19% of expansive soil.
4. For PPF, UCS value increases by increasing the percentage of Kota stone slurry with PPF till 1% by the further increment of PPF, the value of UCS is decreased. The UCS value was found to increase for 15% KSS with 1% PPF in expansive soil, it has been increased by 116.14% of expansive soil.
5. From the study it is revealed that the combination of 15% KSS with 1.5% coir fibre and combination of 15% KSS with 1% PPF is gives best results for compaction, shear strength and CBR. Hence the KSS and coir fibre prove to be good stabilizing material for expansive soil and it can be used for various civil engineering constructions.

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