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Performance Evaluation of Waste Kota Stone Slurry Powder Mixed with Black Cotton Soil

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Abstract: ***Kota city is having major problem of disposing of waste Kota stone slurry powder. It is a by–product which is obtained during cutting, grinding and polishing operations of locally available Kota stone in stone industries. One of the innovative ground improvement techniques can be practiced by using Kota stone slurry powder (KSSP) as stabilizing agent or admixture. Advantages such as space saving, environmental sustainability, maintained fertility around the area, material availability etc can be offered by this technique. Studied and found that, Kota stone slurry powder is used as a stabilizing material for black cotton soil. Experimental work done in laboratory on black cotton soil and the black cotton soil mixed with waste Kota stone slurry powder. Different proportions of waste Kota stone slurry powder from 4% to 24% at the interval of 4% were mixed with the black cotton soil to improve the soil characteristics. The liquid limit, plastic limit, shrinkage limit, differential free swell, specific gravity, standard proctor test (SP test), unconfined compression test, swell pressure test and California bearing ratio tests are conducted on soil and mix specimens to predict and ascertain the behaviour of the soil and the stabilized BC soil was assessed by evaluating the changes in the physical and strength parameters. Increasing in Kota stone slurry powder upto a certain percent improved the natural soil properties. 20% mix of waste Kota stone slurry powder by dry weight of the soil in the black cotton soil mix is the optimum amount.***

Keywords: Black Cotton Soil (BC soil), Kota Stone Slurry Powder (KSSP), Unconfined Compressive Strength (UCS), Differential Free Swell (DFS), California Bearing Ratio (CBR).

I. INTRODUCTION

Cladding of the walls, decorating the floors and in many other ways Kota stone is generally used. KSSP have oil resistant, non-water absorbent, non–slippery and excellent stone resolvability properties. Kota stone deposits spread in some areas of Ramganj mandi in district Kota and some part of Jhalawar district in Rajasthant state. Kota stone fine slurry is a semi liquid substance consisting of particles originating during cutting, grinding and polishing of the Kota stones in stone industries and water is used to cool and lubricate the sawing and polishing parts of machine. Approximately 3 to 3.25lakh metric ton of stone slurry is produced and disposed of into local convenient places in every year. This waste influences about 5 to 10 hectares useful and fertile land every year and also causes general environmental and economical drawback and health problems. The loss in soil fertility due to increasing of alkalinity in soil, contamination of underground water, health problem due to slurry dust suspended particles in air, stone slurry clusters or heaps etc. The waste KSSP can be used as a filler, stabilizing material and as a pozzolanic material also. In this research work through various laboratory experiments, results are presented for a possible use of KSSP as stabilizing or filler material. Kota stone slurry powder is obtained by drying of waste Kota stone slurry. Kota stone is basically a flaggy lime stone. This waste slurry powder having the characteristics, which is very useful to improving the properties of the expansive soil and helps to escalating the solid waste dumping problem. Expansive soils covers almost 20% of total land of the country India and it also cover a considerable part of various other countries, it is also called black cotton soil. It is found mostly in part of Andhra Pradesh, Madhya Pradesh, Tamilnadu, Karnataka, some part of Gujarat, southern part of Rajasthan. Black cotton soil is generally highly expansive soil and the variation of seasonal moisture content is responsible for substantial distress to the structures that are built over the soils. In black cotton soil, when water content decreases the soil gets shrink and particles get rearranged and movement takes place with change in moisture content. Characteristics of shrinkage and swelling of these expansive soils threats to the structures like foundations, roadways, railways and some other life line structures. Black cotton soil is black in colour or dark grey due to the presence of high iron, humus and magnesium minerals derived from trap and basalt. Swelling or shrinkage in expansive soil causes differential settlement and alternate swelling & shrinkage in black cotton soil also leads to development of cracks in the structure. Black cotton soils become compressible, when it absorbed water and leads to decrease in the strength of the soils. Swell and shrinkage properties in expansive soils are due to the presence of montmorillonite minerals. Swell and shrinkage in black cotton

soils causes various problems to the civil engineers not only during the time of construction but also throughout the life of the structures, it reduces the serviceability of the structures also. Problematic soils create problems to the structures, it forced to the researchers to search appropriate methods for improvement in the soils. Therefore, the treatment of BC soil is required to avoid such a situation. Stabilization is a technique to improve the properties of natural soil by using chemical or physical means. The aim of this study is to improve the geotechnical properties of BC soil economically. To determine the improvement in geotechnical properties of BC soil, plasticity index, the standard proctor test, shrinkage limit, specific gravity, swell index, swell pressure, CBR value and unconfined compressive strength (UCS) tests are conducted with mixing of different percentage of waste Kota stone slurry powder in the black cotton soil in dry state at required conditions in laboratory.

Construction of roads, houses, railways and other facilities are required suitable soils, if not then engineers are forced to explore an appropriate and efficient methods to improvement in the problematic soil. Composition of expansive problematic soils can be altered by adding some additives to improvement in the performance of the soils. Utilization of marble dust/ash/lime/cement/lime containing material to stabilize expansive soil for enhancing the characteristics of BC soil or expansive soils, the research work have been introduced in worldwide. Erdal Cokca (2001) presented work on the use of fly ash to improve engineering properties of an expansive soil. E.A. Basha et al. (2005) presented paper on stabilization of expansive soil with rice husk and cement. From the test results it is observed that the plasticity of soil reduces but other engineering properties improves at optimum dosage of rice husk and cement. Koonnamas Punthutaecha et al. (2006) performed tests to analyse the effectiveness of volume change of expansive soil with recycled ash, fibre. Palaniappan KA et al. (2009) founded that marble dust powder is effective waste material for stabilization of expansive soil to improve the engineering properties of the soil.

Pankaj R. Modak, Prakash B. et al. (2012) presented work to improvement in BC soil by using admixtures. Vishvakarma Amit et al. (2013) founded the utilization of marble with expansive soil to improve the soil properties. Parte Shyam Singh et al. (2014) studied the effect of marble dust on index properties of BC soil on different of water content and did experiments basis on mixed 0% to 40% marble dust in BC soil and concluded that the differential free swell, plastic limit, liquid limit of BC soil is decreasing by increasing the percentage of marble dust but it is also observed that the shrinkage limit of BC soil increasing. Gupta

Chayan and Sharma Ravi Kumar (2014) determined the influence of marble dust, fly ash and Beas sand on sub grade characteristics of expansive soil.

The series of test conducted in laboratory on fly ash, sand stabilized BC soil which further blended with 0% to 20% marble dust and concluded that the 15% marble dust is sufficient to increase the CBR-soaked value up to 200% approximately. Akshay Kumar Sabat et al. (2014) did experiments to determine the improvement of expansive soil by mixing marble powder with rice husk ash. Vikash Malik et al. (2017) completed the work based on compaction and swelling behaviour of black cotton soil mixed with non – cementitious materials. A series of proctor tests and one dimensional swell test were conducted to study the effect of the compaction and swelling behaviour.

The specimens were prepared by adding 4%, 8%, 12%, 16% and 20% non – cementitious materials in black cotton soil. This percentage was taken by weight of the dried back cotton soil and from the test results, it was observed that swelling pressure, OMC were increasing but MDD remained same.

The main objective of this study is to utilize the waste Kota stone slurry powder to improve the geotechnical properties of BC soil. A laboratory investigation was conducted on BC soil and waste KSSP mixed in varied percentage. The test results showed a significant improvement in consistency, compaction, DFS, UCS, CBR, and swell properties of the BC soil.

II. MATERIALS USED

A. Kota Stone Slurry Powder (KSSP)

Locally available KSSP is used in mix which is produced from cutting, polishing in stone industries. The KSSP is taken to use for research work from Inderprasth nagar industrial area, behind Mittal stone factor, district Kota in Rajasthan state. The KSSP is first air dried and then oven dried as per experimental need.

B. Black Cotton Soil (BC Soil)

The BC was taken from field at a depth about 1.2m to 1.4m from ground surface, where soil is excavated in foundation work for civil structure, Amrit Nagar (Bohrkhera), Ramganj mandi, Modak and Saraswati nagar (Baran road) district Kota in Rajasthan state. Experimental tests were conducted for all four sites black cotton soil, but the weakest black cotton soil was Amrit nagar, Bohrkhera, district Kota as per their test results.

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III. EXPERIMENTAL PROGRAM, RESULTS AND DISCUSSION:

A. *Objective*

To study the behaviour of expansive soil/black cotton soil and BC soil mix by using KSSP using as a stabilizer by stabilization technique, the percentage of mixing Kota stone slurry powder is 0% to 24% at an interval of 4%.

B. *Experimental Details, Result and Discussion*

The following geotechnical properties were studied by using various percentage of Kota Stone Slurry Powder.

1) Atterberg limits [liquid limit (LL), plastic limit (PL)), IS: 2720 (Part V)].
2) Free swell index/Differential Free Swell (DFS), IS: 2720 (Part XL)
3) Shrinkage limit, IS: 2720 (Part VI)
4) Optimum Moisture Content (OMC), Maximum Dry Density (MDD) by standard proctor test, IS: 2720 (Part VII)
5) Specific-gravity, IS: 2720 (Part III).
6) Swell pressure, IS: 2720 (Part XV) – 1965.
7) Unconfined compressive strength (UCS), IS: 2720 (Part X), 1991.
8) California bearing ratio (CBR), IS: 2720 (Part XVI) – 1965.

Table 1 Laboratory test results of BC soils from different sites and from results founded the weakest was soil taken from Amrit nagar, Bohr khera, district Kota in Rajasthan state.

Properties	BC soil Amrit Nagar	BC soil Sarswati Nagar	BC soil Ramganj mandi	BC soil Modak	KSSP
Liquid limit (LL) (%)	55	42	54.83	54	32.8
Plastic limit (PL) (%)	26.62	21.03	24.86	23.20	NP
Plasticity index (PI) (%)	28.38	20.97	29.97	30.8	-
Shrinkage limit (SL) (%)	9.20	10.20	10.76	12.86	22.49
Swell index (%)	50	45	40	40	NS
Sp. gravity	2.57	2.58	2.63	2.61	2.63
OMC (%)	19.4	18.96	20.65	20.26	20.7
MDD (%) g/cm^3	1.67	1.66	1.68	1.68	1.69
Unconfined Compressive Strength (UCS), kg/cm^2	2.81	2.78	2.65	2.60	-
California Bearing Ratio (CBR) Unsoaked (%)	7.51	7.52	9.03	9.18	-
California Bearing Ratio (CBR) Soaked (%)	1.37	1.35	1.36	1.36	-
Swell pressure (kg/cm^2)	1.91	1.86	1.80	1.80	-

1) *Result:* It was founded by the different experiments that the black cotton soil from different sites and choose Amrit nagar soil for their stabilization due to its weakest characteristics among the four sites soil. Experimental test values of the soils of different sites are mentioned in the table No. 1.

C. Liquid Limit Test

Table 2 Variation in liquid limits of different specimens having varying percentage of KSSP in the black cotton soil. Decrease in liquid limit 13.82% in mixes having 24% KSSP.

Descriptions	Liquid limit (%)	Percentage decreasing (%)
Black cotton soil (BC Soil)	55	-
Kota Stone Slurry Powder (KSSP)	32.8	-
BC soil + 04% KSSP	54.10	1.63
BC soil + 08% KSSP	53.66	2.44
BC soil + 12% KSSP	53.11	3.44
BC soil + 16% KSSP	52.04	5.38
BC soil + 20% KSSP	48.86	11.16
BC soil + 24% KSSP	47.40	13.82

1) Result: The liquid limit of black cotton soil, Kota stone slurry powder and mix specimen of Kota stone slurry was determined by cone penetration test. The liquid limit of black cotton soil and Kota stone slurry powder was obtained 55% and 32.80% respectively. The mix percentage of KSSP increases 4% to 24%, the percentage decrease in liquid limit was from 1.63% to 13.82% respectively. The test results of the liquid limit are given in table 2.

D. Plastic Limit

Table 3 Variation in plastic limits of different specimens which having varying percentage of KSSP in the black cotton soil. Decreasing in plastic limit from 1.40% to 23.06% in mixes which having 4% to 24% KSSP.

Descriptions	Plastic limit (%)	Percentage decreasing (%)
Black cotton soil (BC Soil)	26.62	-
Kota stone slurry powder (KSSP	NP	-
BC soil + 04% KSSP	26.25	1.40
BC soil + 08% KSSP	25.89	2.74
BC soil + 12% KSSP	25.50	4.20
BC soil + 16% KSSP	25.02	6.01
BC soil + 20% KSSP	22.51	15.40
BC soil + 24% KSSP	20.48	23.06

1) Result: It is observed from the experiment, that when the mixing percentage of KSSP increases, the plastic limit decreases continuously. Increase of mixes percentage KSSP from 4% to 24%, the plastic limit decreases from 26.25% to 20.48%, Corresponding percentage decrements in plastic limit was 1.40% to 23.06% respectively compare to black cotton soil. The test results are given in Table 4.

E. Plasticity Index

Table 4 Variation in plasticity index of different specimens which having varying percentage of KSSP in the black cotton soil. Decreasing in plasticity index from 1.87% to 7.15% in mixes which having 4% to 20% KSSP, but mixed of 24% KSSP plasticity index decreased less as compare to 20% KSSP mixed.

Descriptions	Plasticity index (%)	Percentage decreasing (%)
Black cotton soil (BC Soil)	28.38	-
Kota stone slurry powder (KSSP	-	-
BC soil + 04% KSSP	27.85	1.87
BC soil + 08% KSSP	27.77	2.50
BC soil + 12% KSSP	27.61	2.71
BC soil + 16% KSSP	27.02	4.80
BC soil + 20% KSSP	26.35	7.15
BC soil + 24% KSSP	26.92	5.14

1) *Result:* Plasticity index variations in different mixed specimens and found decreasing in plasticity index of different mix as compare to the black cotton soil. Specimens having different percentage of Kota stone slurry powder (KSSP) in the soil. Proportion of the admixture in the mixed specimens was by weight of the dry soil. Percentage variation of KSSP in the BC soil mix varying from 4% to 24%. Plasticity index of mix was continuously decreasing with increasing proportions of KSSP upto 20%, but at 24% mix less decreasing in PI. Decreasing in PI indicates improvement in strength of the black cotton soil mixed specimens.

F. Differential Free Swell (DFS)

DFS = $(V_k - V)/V$

The DFS test is also performed in laboratory and it is observed that the black cotton soil is highly expansive soil in nature. If KSSP percentage is varied from 4% to 24%, the differential free swell is continuously decreasing. The test results are presented in Table – 5.

Table 5: Variation in swell index of different specimens which having varying percentage of KSSP in the black cotton soil. Decreasing in swell index from 10% to 40% in mixes which having 4% to 24% KSSP:

Descriptions	Swell index (%)	Percentage decreasing (%)
Black cotton soil (BC Soil)	50	-
Kota stone slurry powder (KSSP)	NS	-
BC soil + 04% KSSP	45	10
BC soil + 08% KSSP	45	10
BC soil + 12% KSSP	40	20
BC soil + 16% KSSP	40	20
BC soil + 20% KSSP	35	30
BC soil + 24% KSSP	30	40

1) *Result:* The DFS value for black cotton soil was 50%, while KSSP is non-swelling in nature. The DFS value of black cotton soil was continuously decreasing with increasing the percentage of Kota stone slurry powder as shown in the Table-5. The maximum decreased in DFS value is determined for 24% mix specimen, which is decreased by 40% from the DFS value of black cotton soil. Decreasing in swell index indicate improvement in the black cotton soil.

G. Shrinkage Limit

Shrinkage limit is the maximum water content where further loss of moisture will not change in volume.

Table 6: Shrinkage limit and Volumetric Shrinkage of Specimens

Descriptions	Shrinkage limit (%)	Percentage increasing (%)	Volumetric shrinkage
Black cotton soil (BC Soil)	9.20	-	86.70
Kota stone slurry powder (KSSP)	22.49	-	16.88
BC soil + 04% KSSP	9.80	6.52	97.80
BC soil + 08% KSSP	10.25	11.41	92.21
BC soil + 12% KSSP	10.80	17.39	88.83
BC soil + 16% KSSP	11.35	23.37	84.91
BC soil + 20% KSSP	11.95	29.89	74.20
BC soil + 24% KSSP	12.40	34.78	72.94

1) *Result:* The shrinkage limit of the black cotton soil and Kota stone slurry was determined 9.20% and 22.49% respectively. By adding and increasing proportion of the Kota stone slurry powder in soil by the interval of 4%, from 4% to 24%, a continuous increment in shrinkage limit from 6.52% at 4% KSSP to 34.78% at 24% KSSP. The test results of shrinkage limit shown in Table 6.

H. Specific Gravity

The specific gravity is determined by density bottle (50 ml) in laboratory. The specific gravity of black cotton soil and mix specimen is calculated and results of mix specimens are given in Table 7.

Table7. Specific Gravity of BCS mix of KSSP Specimens

Descriptions	Specific gravity	Percentage increasing (%)
Black cotton soil (BC Soil)	2.57	-
Kota stone slurry powder (KSSP)	2.63	-
BC soil + 04% KSSP	2.580	0.4
BC soil + 08% KSSP	2.595	0.97
BC soil + 12% KSSP	2.602	1.25
BC soil + 16% KSSP	2.61	1.56
BC soil + 20% KSSP	2.612	1.63
BC soil + 24% KSSP	2.618	1.87

1) *Result:* Fig. 6 representing relationship between black cotton soil mixes of varying percentage of KSSP and specific gravity of the specimens. There were no much variations in the specimens of varying percentage of KSSP as compare to the black cotton soil, because both BC soil (2.57) and mix specimen with 24% KSSP (2.618) has almost equal sp. gravity.

I. Proctor Test

Table 8 Proctor test result of Specimens

Descriptions	Optimum moisture content OMC (%)	Maximum Dry Density MDD (gm/cm^3)
Black cotton soil (BC Soil)	19.4	1.67
Kota stone slurry powder (KSSP)	18.3	1.69
BC soil + 04% KSSP	19.28	1.676
BC soil + 08% KSSP	19.10	1.681
BC soil + 12% KSSP	18.86	1.685
BC soil + 16% KSSP	18.25	1.702
BC soil + 20% KSSP	18.2	1.707
BC soil + 24% KSSP	18.04	1.716

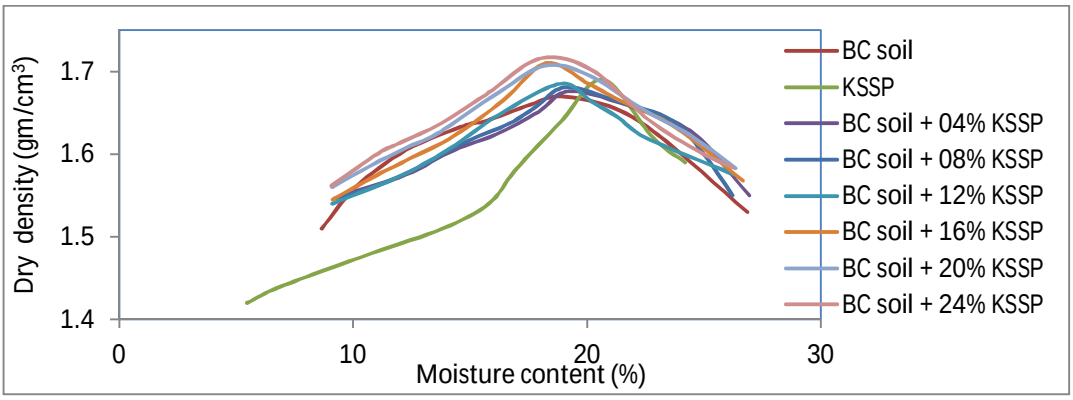

Fig. 1 Variations in Dry Density with Moisture Content of mixed specimens of black cotton soil with varying percentage of KSSP from 4% to 24%.

1) *Result:* The standard proctor test is performed to determine the optimum moisture content (OMC) and Maximum Dry Density (MDD) of black cotton soil, Kota stone slurry and mix specimens. The MDD of black cotton soil and Kota stone slurry powder was determined 1.67gm/cm^3 and 1.69gm/cm^3 respectively and there corresponding OMC was 19.4% and 18.3%. It is observed from the mix specimens that the maximum dry density continuously increases with increasing the percentage of Kota stone slurry powder in black cotton soil. The test results of proctor test are given in Table 8. The MDD increases and it indicates improvement in the BC soil.

J. UCS (Unconfined Compressive Strength)

$$q_u = P / A$$

Table 9 Unconfined compressive strength (UCS) test result of Specimens

Descriptions	UCS, (Sample (I) Kg/cm^2	UCS, Sample (II) Kg/cm^2	UCS, Sample (III) Kg/cm^2	UCS, Sample (IV) Kg/cm^2	Average UCS (Kg/cm^2)	Per. Incr (%)
BCS	2.79	2.81	2.80	2.83	2.81	-
BCS + 04% KSSP	2.90	2.87	2.88	2.87	2.88	2.49
BCS + 08% KSSP	3.01	3.02	2.996	2.995	3.0	6.76
BCS + 12% KSSP	3.40	3.43	3.41	3.43	3.42	21.71
BCS + 16% KSSP	3.58	3.60	3.61	3.61	3.60	28.11
BCS + 20% KSSP	3.995	4.05	4.07	4.06	4.05	44.13
BCS + 24% KSSP	3.15	3.19	3.18	3.17	3.17	12.81

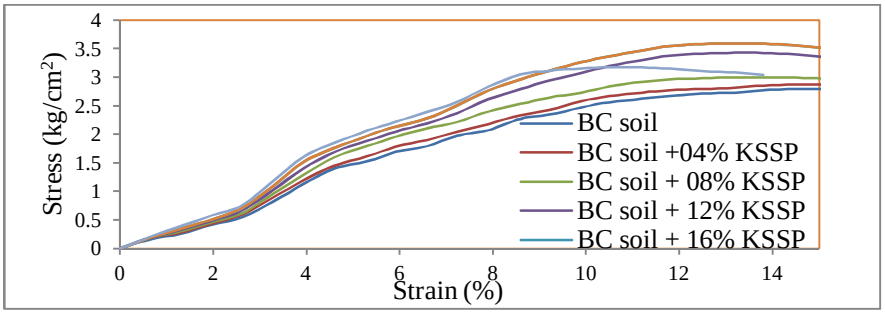

Fig. 2 Stress – Strain curve for UCS.

1) *Result:* Unconfined Compressive Strength of the BC soil soil determined was 2.81 kg/cm^2, it is continuously increasing upto 20% mix of the soil with KSSP (4.05 kg/cm^2) and beyond 20% mix the UCS value was decreasing, at 24% mix it was 3.17 kg/cm^2.

K. California Bearing Ratio (CBR) Test

Table 10 California Bearing Ratio (CBR) test result of Specimens (Unsoaked)

Descriptions	CBR Value (%) Unsoaked	Percentage increasing (%)
BC Soil + 0.0% KSSP	7.51	-
BC Soil + 04% KSSP	7.59	1.0
BC Soil + 08% KSSP	7.67	2.06
BC Soil + 12% KSSP	9.26	23.22
BC Soil + 16% KSSP	11.08	47.44
BC Soil + 20% KSSP	12.37	64.66
BC Soil + 24% KSSP	10.17	35.33

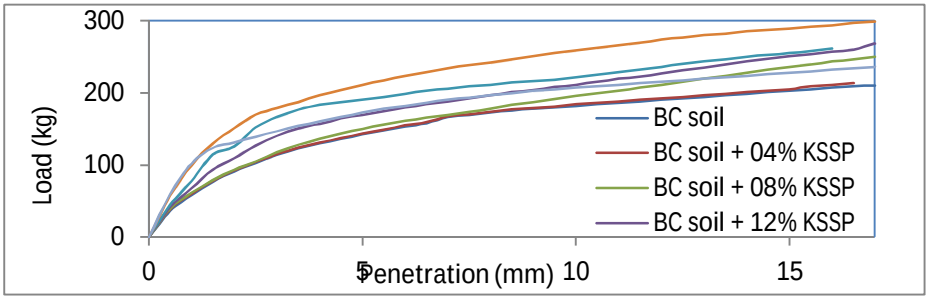

Fig. 3 Load v/s Penetration curve for CBR (Unsoaked)

Table 11 California Bearing Ratio (CBR) test result of Specimens (Soaked)

Descriptions	CBR Value (%) **(Soaked)**	Percentage incr. In CBR
BCS + 0.0% KSSP	1.37	-
BCS + 04% KSSP	1.44	5.11
BCS + 08% KSSP	1.52	10.95
BCS + 12% KSSP	1.60	16.80
BCS + 16% KSSP	1.75	27.73
BCS + 20% KSSP	1.75	27.73
BCS + 24% KSSP	1.52	10.95

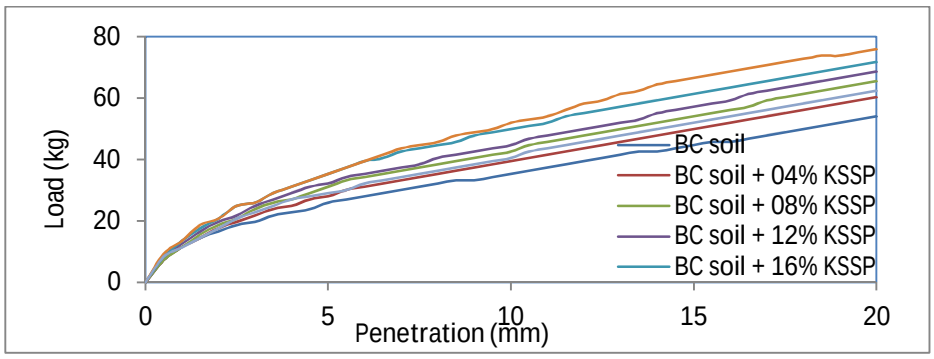

Fig. 4 Load v/s Penetration curve for CBR (Soaked)

1) *Result:* Fig. shows relation between load and penetration, from which determined CBR value by the standard formula. The CBR value of the BC soil found 7.51% in unsoaked state and 1.37% in soaked state. The CBR value increases with increasing percentage of KSSP in the BC soil mix upto 20% and beyond it, the CBR value of mix decreases. The CBR value of 20% KSSP mix found 12.37% in unsoaked state and 1.75% in soaked state. Percentage increases in 20% KSSP mix is 64.66% in unsoaked state and 27.73% in soaked state.

L. Swell Pressure Test

Volume of the soil mass decreasing when a compressive load is applied, the decreasing in the volume of soil mass under compressive stress is known as compressibility.

Table12 Swell pressure of BCS and BCS mixes of Varying Percentage of KSSP

Descriptions	Swell pressure (kg/cm^2)	Percentage decreasing in Swell pressure (%)
BC Soil + 0.0% KSSP	1.91	-
BC Soil + 04% KSSP	1.79	6.28
BC Soil + 08% KSSP	1.625	14.92
BC Soil + 12% KSSP	1.46	23.56
BC Soil + 16% KSSP	1.25	34.55
BC Soil + 20% KSSP	1.125	41.1
BC Soil + 24% KSSP	0.80	58.12

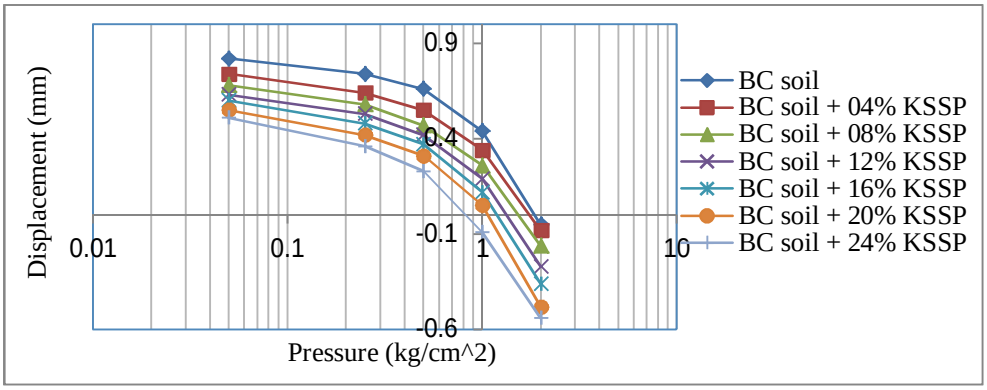

Fig. 5 Pressure v/s vertical displacement relationship in swell potential.

IV. CONCLUSION

Different study reveals that expansive soil stabilized with the materials which having bonding properties like cement, lime, bitumen, etc. Kota stone slurry powder also contains free lime and from experiments result reveals, improvement in properties of the expansive soil. Liquid limit of the expansive soil and the soil mixed with 20% KSSP decreased by 13.82% from 55% to 47.40%. Plastic limit decreased by 23.06% from 26.62% to 20.48% of the expansive soil and the soil mixed with 24% KSSP. Plasticity index is continuously decreasing to 7.15% of the soil having 20% mix of KSSP, beyond 20% KSSP mix of 24% KSSP the decreasing rate is reducing from 7.15% to 5.14%. Decreased in Plasticity index indicate improvement in strength of the black cotton/expansive soil. Differential free swell index (DFS) of the black cotton soil was 50% and was continuously decreasing of mix of 24% KSSP upto 40% indicate improvement in the characteristics of the black cotton soil. Shrinkage limit of the BC soil was 9.20% increased upto 12.40% mix of the BC soil with 24% of KSSP. Slightly variation in specific gravity of the BC soil was founded 2.57 and 2.62 of 24% mix of KSSP. Optimum moisture content (OMC) from standard proctor test of the BC soil was determined 19.4% and continuously decreased to 18.04% of mix of 24% KSSP. The maximum dry density (MDD) determined was 1.67 gm/cm^3 of the BC soil and increased upto 1.716 gm/cm^3 of the BC soil mix with 24% KSSP, increased in MDD indicate improvement in the soil. Unconfined compressive strength (UCS) of the BC soil was determined 2.81 kg/cm^2 and increased to 4.1 kg/cm^2 mix contains 20% KSSP and percentage increase by 44.13% indicate much improvement in the BC soil, beyond 20% KSSP mix UCS decreased. California bearing ratio (CBR) of the untreated BC soil determined was 1.37% (soaked), 7.51% (unsoaked) and it is increased by 27.73% (soaked), 64.66% (unsoaked) and CBR value was 1.75% (soaked), 12.37% (unsoaked), beyond 20% mix of KSSP the CBR value was decreased in both soaked and unsoaked state. Improvement in CBR also indicates improvement in mechanical strength of the mix soil. CBR value is the average of three samples, because variation in CBR value of each sample is not beyond the standard limit, if not then average of six samples. Swell pressure of untreated BC soil founded was 1.91 kg/cm^2 and it is continuously decreasing to 0.80 kg/cm^2 of mix of 24% KSSP with the BC soil, decreasing in swell pressure also indication of improvement of the BC soil.

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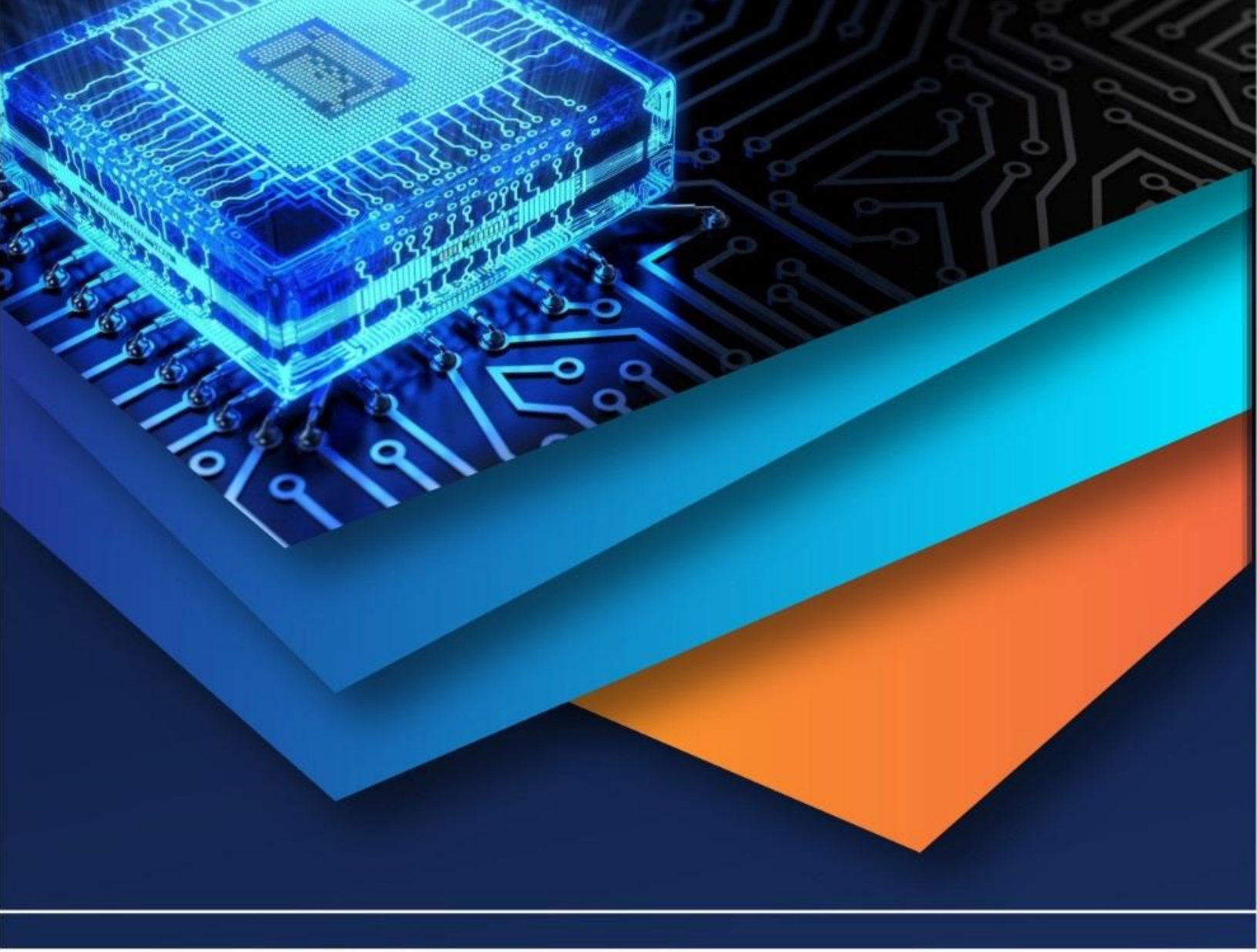

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