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A STUDY OF ENGINEERING PROPERTIES OF BLACK COTTON SOIL WITH KOTA STONE SLURRY

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ABSTRACT

Black Cotton soil is expansive soil which expands when it contacts with water. This is the major reason of failure of black cotton soil strata. Different areas having different types of black cotton soil and it is engineering properties. These properties may be improved by adding or mixing the different types of admixture or fibre or stabilizing materials. Most of the times, the black cotton soil is stabilized by synthetic fibres and natural fibres. The polypropylene, polyester are synthetic and jute is natural fibre. This research paper deals with behaviour of black cotton soil with different percentage of black cotton soil. In this research, the Kota stone slurry is mixed from 5% to 30% in black cotton soil. The engineering parameters are also determined by conducting tests. For studying the behaviour of black cotton soil with different percentage of Kota stone slurry, the Atterberg's limits (Liquid Limit, Plastic Limit, Plasticity Index), standard proctor test, differential free swelling index, swelling pressure and wet sieve analysis tests are conducted.

Keywords: Kota Stone Slurry, Effect on Plasticity Index, Low Degree of Expansiveness, Maximum Dry Density, Shear Strength, Swelling Pressure

I. INTRODUCTION

Black cotton soil is cohesive soil. The black cotton soil is characterized by high shrinkage and swelling properties. The black cotton soil is mostly found in the central and western parts and cover approximately 20% of total area of India. Due to high swelling and shrinkage characteristics, the black cotton soil has been a big issue to highway and other civil engineering specializations. In dry state, the black cotton soil is very hard but loses it strength parameters. Black cotton soils are highly expansive clay with high potential for shrinkage or swelling as a result of changing moisture content. From the ancient times, the stone is used as construction material. From previous years, the amount of stone slurry waste has been generated in stone production plants with significant environmental impacts. This waste causes serious environmental problems. This disposal of waste in agricultural land causes a reduction of water infiltration, soil fertility, plant growth etc. the main objective of this work is to investigate the possibility of improving engineering properties of black cotton soil by using Kota stone slurry.

II. LITERATURE REVIEW

For the improving the engineering properties of black cotton soil, many researchers did work on the black cotton soil with different stabilizing materials. In the past many researchers have carried out their research work for improving the engineering properties of black cotton soil using different types of admixture, stone dust and fibre.

Some detailed literatures have been reviewed on this topic i.e. related to black cotton soil engineering properties and some of the reviewed of the reviewed literatures are presented in proceeding paragraphs.

Dhananjay Kumar et. al. (2016) conducted laboratory tests to evaluate the stabilization properties of black cotton soil with stone dust and polypropylene fibre. They have conducted standard proctor test, unconfined compressive strength and Atterberg's limit. From the test results, they have concluded that the proposed methodology is very effective for improving engineering properties of black cotton soil.

Dr. P. J. Gundaliya et. al. (2012) studied black cotton soil characteristics with cement waste dust and lime. They did work for the improving the pavement system performance. They have conducted Atterberg's limit test, standard proctor test, unconfined compressive strength. From the test results, they have concluded that the proposed methodology is very effective for improving engineering properties of black cotton soil with cement dust and lime and the results are more effective than cement dust mix specimen and lime mix specimen.

K. Suresh et. al. (2009) did experimental study on stabilization of black cotton soil with stone dust and fibre. They used polypropylene fibre with stone dust as stabilizing material. They found that, the optimum combination of mix at 3% stone dust with black cotton soil and the value of CBR is determined more to CBR value of black cotton soil. From test results, they have concluded that the proposed methodology is very effective for improving engineering properties of black cotton soil for pavement design.

III. EXPERIMENTAL INVESTIGATIONS

Various such as Atterberg's limit (liquid limit and plastic limit), Differential free swelling, Swelling pressure, OMC and MDD, UCS, etc tests have been performed to find out the engineering properties of black cotton soil as well as soil mixed with Kota stone slurry. The percentage of Kota stone slurry may have varied from 5% to 30% at 5% interval.

3.1 Material Used

- **Black Cotton Soil –** About 100 kg of soil sample for the present work was collected from the Borkheda, Kota.
- **Kota Stone Slurry –** Kota stone slurry for the present work was obtained from Kota stone slurry industry, Anantpura, Kota.

3.2 Atterberg's Limits

The for classifying the soil, Kota stone slurry and mix specimen of soil, the wet sieve analysis for black cotton soil and Atterberg's limit test are conducted. For determining the type of soil, the wet sieve analysis of soil particles is done by using 75-micron sieve. It is found that the soil particles are passed more than 50% and the soil is classified as fine grain soil based on these results classification is done as per IS 1498 (1970). In Atterberg's limit test, the soil and Kota stone slurry Atterberg's limits are determined separately and these tests

are also conducted for mix specimen of the black cotton soil with different percentage of Kota stone slurry. The results of Atterberg's limit is shown in Table 3.1.

The liquid limit and plastic limit are 41.41% and 18.46% determined for black cotton soil. Kota stone slurry having 34.28% and 21.77%, liquid limit and plastic limit. Its observed that the plasticity index is more than to Kota stone slurry. That shows, when amount of Kota stone slurry increases, the plasticity index decreases. The plasticity index of black cotton soil was found to be 22.95%.

Table 3.1: Atterberg's limit for different specimen

Test Specimen	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specimen Classification
Black Cotton Soil (BCS)	41.41	18.46	22.95	CI
Kota Stone Slurry (KSS)	34.28	21.77	12.51	CL
BCS + 5.0% KSS	40.38	18.01	22.37	CI
BCS + 10.0% KSS	37.42	17.14	20.28	CI
BCS + 15.0% KSS	34.56	14.09	20.47	CL
BCS + 20.0% KSS	28.09	10.65	17.44	CL
BCS + 25.0% KSS	19.57	09.29	10.28	CL
BCS + 30.0% KSS	13.01	09.16	03.85	CL

From Table 3.1, the value of liquid limit and plastic limit continuously decreases from 40.38% to 13.01% and 18.01% to 9.16% respectively in mix specimen. When 30% Kota stone slurry is mixed in black cotton soil. the plasticity index decreased from 22.95% to 03.85%. The graphical representation of plasticity limit of mix specimen is shown in fig. 3.1.

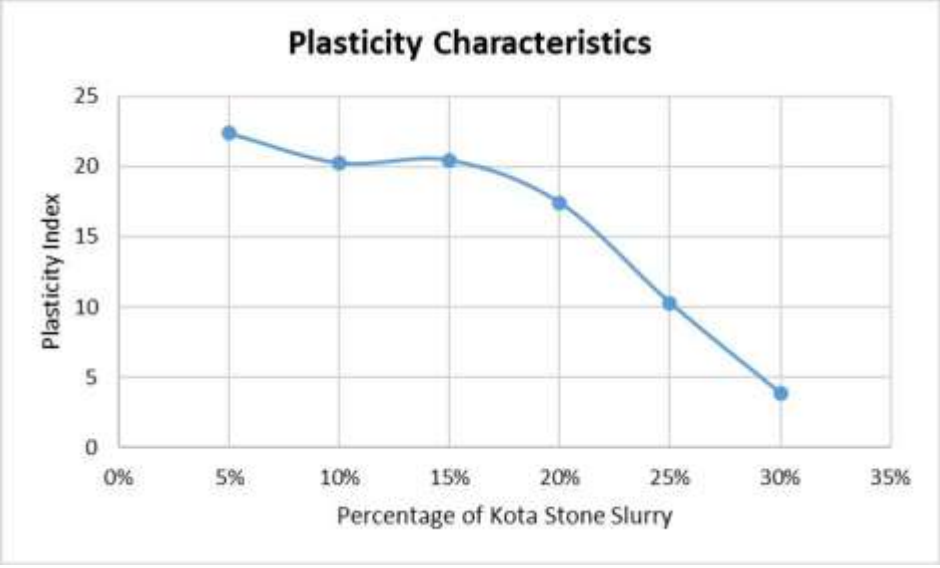

Fig. 3.1 – Plasticity characteristics of mix specimen

From Table 3.1, it is observed that the black cotton soil is inorganic soil of medium plasticity clay and Kota stone slurry is inorganic fine of low plasticity. When the amount of the Kota stone slurry increases, the behaviour of soil comes from medium plasticity to low plasticity clay.

3.3 Standard Proctor Test

The object of test is to find out optimum moisture content and maximum dry density of black cotton soil with varied percentage of Kota stone slurry. The results of standard proctor test are shown in Table 3.2.

From Table 3.2, it is observed that the maximum dry density of soil is 1.725 kg/cm^3 determined. With increasing the percentage of Kota stone slurry in clay, the maximum dry density increases with increasing the percentage of Kota stone slurry till 15% which is 1.755 kg/cm^3. The maximum dry density and optimum moisture content was obtained 1.635 kg/cm3 and 17.1% respectively for Kota stone slurry. The graphical representation of standard proctor test is shown in fig. 3.2.

Table 3.2: Standard Proctor Test for Black Cotton Soil, Kota Stone Slurry and Mix Specimen

Test Specimen	MDD (kg/cm^3)	OMC (%)
Black Cotton Soil (BCS)	1.725	17.4
Kota Stone Slurry (KSS)	1.635	17.1
BCS + 5% KSS	1.740	15.5
BCS + 10% KSS	1.745	14.5
BCS + 15% KSS	1.755	15.2
BCS + 20% KSS	1.705	16.2
BCS + 25% KSS	1.680	15.6
BCS + 30% KSS	1.615	15.0

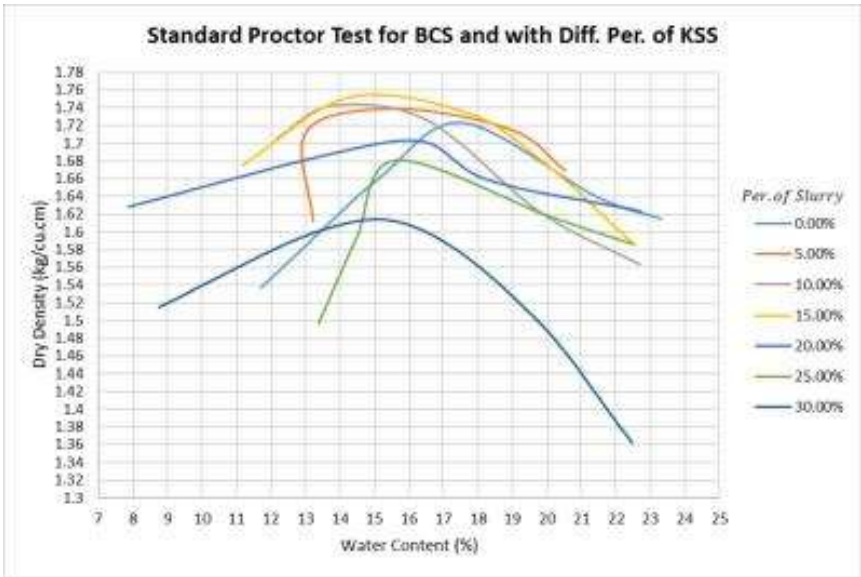

Fig. 3.2 – Standard proctor test for black cotton soil and mix specimen

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3.4 Differential Free Swelling

The object of testing is to find out the free swell index of soil which helps to identify the potential of specimen. The test results were obtained on the basis of IS 2720 (part 40) 1977. The test results are shown in Table 3.3 and graphical representation is also shown in fig. 3.3.

Table 3.3 – DFS results for black cotton soil and mix specimen

Test Specimen (Slurry)	Free Swell Index (%)	Degree of Expansiveness	Percentage Decrease
BCS	53.33	Very High	-
5.0% +BCS	36.84	High	30.9%
10.0% + BCS	31.58	Moderate	40.8%
15.0% + BCS	25.00	Moderate	53.1%
20.0% + BCS	14.29	Low	73.2%
25.0% + BCS	09.52	Low	82.1%
30.0% + BCS	04.55	Low	91.5%

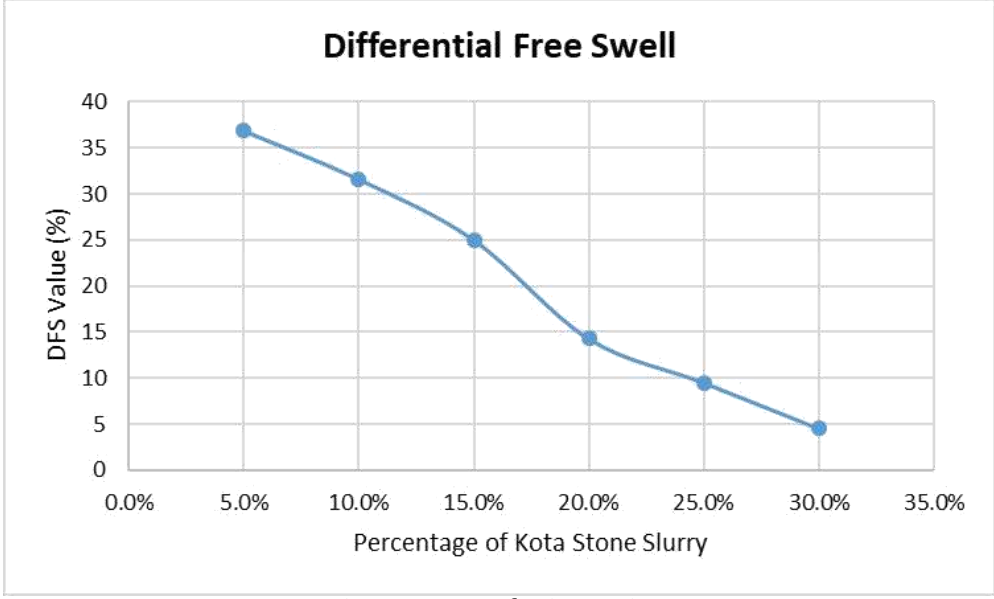

Fig. 3.3 – DFS of Mix Specimen

From fig. 3.3, it has observed that with increasing the percentage of Kota stone slurry in the clay, the degree of expansiveness decreases. The clay is having high degree of expansiveness and the value is 53.33%. This degree of expansiveness, decreases from 55.33% to 4.55%. This is meant, when 30% Kota stone slurry is added in clay, the expansiveness decreases about 91.5%.

3.5 Swelling Pressure

The swelling pressure test is also conducted for determining the pressure for black cotton soil and with different percentage of Kota stone slurry. The results are based on IS 2720 (Part 41) 1977. The obtained results are shown in Table 3.4 and graphical presentation is shown in fig. 3.4.

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Table 3.4 – Swelling Pressure Results for BCS and Mix Specimen

Test Specimen	Pressure (kg/cm^2)	Percentage Decrease
Black Cotton Soil (BCS)	1.10	-
BCS + 5.0% KSS	1.09	0.90%
BCS + 10.0% KSS	0.45	59.1%
BCS + 15.0% KSS	0.25	77.2%
BCS + 20.0% KSS	0.20	81.8%
BCS + 25.0% KSS	0.15	86.4%
BCS + 30.0% KSS	0.09	91.8%

Fig. 3.4 shows, the variation of swelling pressure with dial reading for black cotton soil and with varied percentage of Kota stone slurry. It is also observed that the swelling pressure value for clay is 1.1 kg/cm^2. By varying percentage of Kota stone slurry in black cotton soil, at 5% of Kota stone slurry in black cotton soil, the swelling pressure is 1.09 kg/cm^2 and there is decrement is 0.9%. Further with increasing the amount of Kota stone slurry upto 30% in clay, the swelling pressure decreased from 0.90% to 91.85% decrease from swelling pressure of clay.

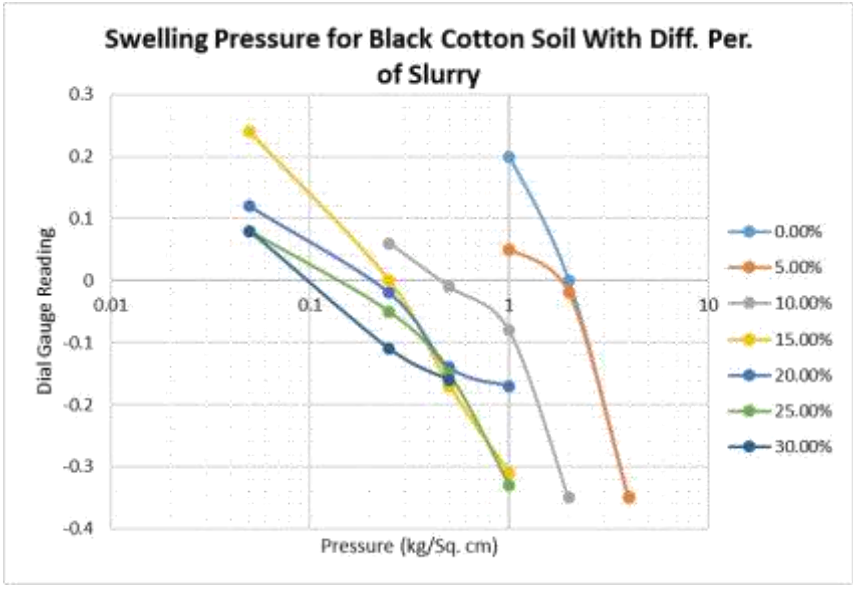

Fig. 3.4 – Swelling pressure for black cotton soil with different percentage of KSS

3.6 Unconfined Compressive Strength

The object of testing is to determine the shear strength parameter of clay and mix specimen by loading axially cylindrical specimen. The test results are obtained according to IS 2720 (part 10) 1973. The observation and calculation of UCS test is shown in Table 3.5.

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Table 3.5 – UCS Test for Black Cotton Soil and Mix Specimen

Test Specimen	UCS, q_u (N/cm^2)	Shear Strength C_u (N/cm^2)	Percentage Variation in C_u
Black Cotton Soil (BCS)	15.967	07.987	-
BCS + 5% KSS	16.874	08.437	05.68
BCS + 10% KSS	19.075	09.537	19.46
BCS + 15% KSS	21.465	10.732	34.43
BCS + 20% KSS	17.573	08.786	10.06
BCS + 25% KSS	16.469	08.234	03.14
BCS + 30% KSS	14.685	07.342	- 08.03

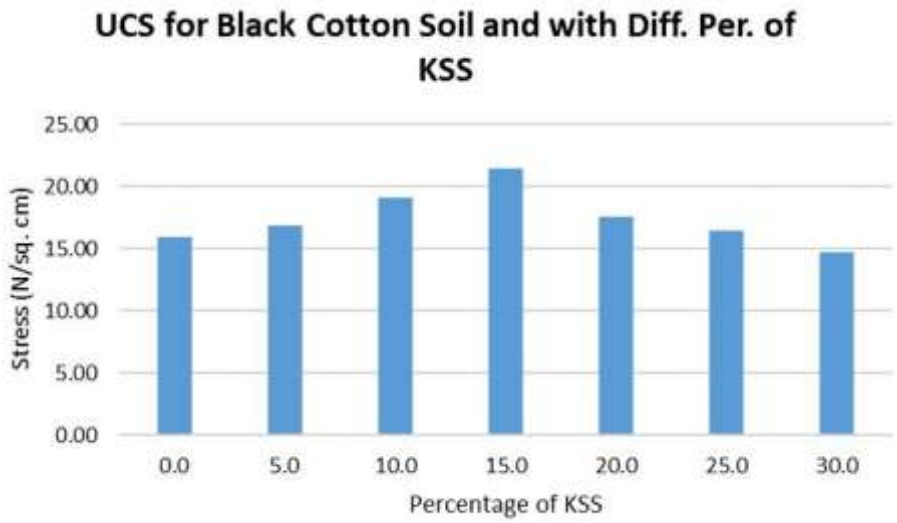

Fig. 3.5 – UCS for black cotton soil and with diff. per. of KSS

From fig. 3.5, it is observed that the unconfined compressive strength of black cotton soil is 15.967 N//cm^2 and shear strength is 7.983 N/cm^3. The maximum value of UCS is 21.465 N/cm^2 determined for 15% Kota stone slurry with black cotton soil. the UCS value 14.685 N/cm^2 is determined for 30% mix specimen, which is decreased 8.09% from UCS value of black cotton soil.

IV. DISCUSSIONS ON TEST RESULTS

The black cotton soil changes it is behaviour due to Kota stone slurry. The Kota stone slurry is low plasticity material and black cotton soil is inorganic clay of medium plasticity but when amount of Kota stone slurry increases, the black cotton soil changes behaviour from CI to CL. When plasticity of the mix specimen decreases, it means the differential free swell and swelling pressure also decreases. The maximum dry density and optimum moisture content is determined at 15% Kota stone slurry. It is also observed that 5% to 15% Kota

stone slurry, the dry density increases but after 15% Kota stone slurry it decreases 1.755 kg/cm^3 to 1.615 kg/cm^3. The shear strength is also increasing from 5% to 15% Kota stone slurry mix specimen but after 15% Kota stone slurry it decreased and it is decreased 8.03% from the UCS value of black cotton soil.

V. CONCLUSIONS

With increasing the quantity of Kota stone slurry in black cotton soil, the resulting mixture turned gradually medium plasticity clay (CI) to low plasticity clay (CL). The Optimum moisture content and maximum dry density is found on 15% Kota stone slurry. The differential free swell index decreases with increasing the percentage of Kota stone slurry. When 30% Kota stone slurry is added in black cotton soil, the differential free swell index decreases about 91.5%. The UCS value increase with increasing the percentage of Kota stone slurry till 15%. The UCS value is maximum determined on 15% mix specimen but after 15% Kota stone slurry mix, the value of UCS decreases.

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