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STABILIZATION OF BLACK COTTON SOIL USING KOTA STONE SLURRY DUST FOR SUSTAINABLE PAVEMENT SUBGRADE APPLICATIONS

Shyam Sunder Saini

M.Tech Student, Department of Civil Engineering, Arya College of Engineering, Jaipur

sainishyam769@gmail.com

Anil Kumar Sharma

Assistant Professor, Department of Civil Engineering, Arya College of Engineering, Jaipur

anilsharma2701@gmail.com

Abstract: Expansive soils are a worldwide problem that poses several challenges for civil engineers. Such soils swell when given an access to water and shrink when they dry out. Among the construction activities, a well-connected road network is one of the basic infrastructure requirements, which play a vital role for the fast and comfortable movement of inter-regional traffic in the country like India. The most common and economical method for stabilizing these soils is using admixtures that prevent volume changes. In this study the effect of using Kota Stone Slurry Dust, an industrial waste in reducing the swelling potential is examined. The performance of Black Cotton Soil with Kota stone slurry dust in varied proportion was studied by conducting Grain size distribution, Atterberg's limits, swell percent, California Bearing Ratio and Unconfined Compressive Strength test of the soil alone and of the mixtures. Experiments were done using Kota Stone Slurry Dust in different proportion (3%, 6%, 9%, 12%, 15%, 18%, 21% and 24 %).The result have shown that the Kota Stone Slurry Dust enhances the overall engineering properties of soil i.e. CBR,UCS etc. with the varying proportions of Kota Stone Slurry Dust content a considerable variation had been noted in all the above defined parameters. This method of treatment caused a reduction in the swelling potential and the reduction was increased with increasing percent stabilizers. Also it had been noticed that the considerable improvement in the soil properties was an optimum percentage of Kota Stone Slurry Dust i.e. at 18% of Kota Stone Slurry Dust content. In this work it

has been observed that the engineering properties of the soil like Optimum Moisture Content and Dry Density Relationship (OMC and MDD), California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) is increased with the use of Kota Stone Slurry Dust in varied proportions. The optimum results are found at 18% of Kota Stone Slurry Dust; therefore this proportion has been recommended for making improvement in the engineering properties of Black Cotton Soil which is locally available in Jhalawar (Rajasthan).

Keywords : Stabilization, Kota Stone Slurry, Soil, Strength, CBR, Kota stones sludge, granite sludge, marble slurry, building stone, replacement material.

I. INTRODUCTION

Soil is the final destination of any structure on which the load of structure rests. Therefore strength of soil is very important and in general, soil strength depends upon density, moisture content, and texture of the soil. Increase in density is usually accompanied by increase in strength, whereas increase in moisture content is usually accompanied by decrease in soil strength.

The purpose of a pavement is to provide a smooth surface over which the vehicle may pass under all climatic conditions. In turn, the performance of pavement is affected by the characteristics of the sub grade. Desirable properties which the sub grade should possess include strength, drainage, ease of compaction, permanency of strength, since sub grade varies considerably. It is necessary to make a thorough study of the soil in place for pavement design purposes. Soil is a highly variable material. The inter relationship of soil texture , density, moisture content, and strength are complex , and in particular, behavior under repeated loads is difficult to evaluate. Because of the complexity, it is not possible to set down rules which will be suitable for all cases.

The problem which we continuously facing is that dealing with procedure and techniques by which otherwise unsuitable soils may be improved by stabilization. Sub grade soils that are unsatisfactory in their natural state can be altered by admixtures, by the addition of aggregate, or by proper compaction and this made suitable for highway sub grade construction. Flexible pavements derive their load supporting capacities not from the bending action of the slab but by distributing the load down through a finite thickness of pavement, so that pressure on the sub grade will not be exceeded.

Stabilization for this type of pavement should logically impart additional strength to the sub grade soil. Kota stone slurry is available in huge amount in areas near by Jhalawar and Kota district in Rajasthan. It create soil pollution, water pollution, and air pollution leading to adverse affect on crop production and human health.

In the present study an attempt has been made to use this locally available Kota stone slurry to stabilize sub grade soil for road construction, after examining the properties of soil, slurry and their mixes at different proportions.

II. PROPOSED METHODOLOGY

The Kota stone waste and slurry creates environmental pollution problem in the surrounding of mining and industrial area. There is no technology for proper disposal of Kota stone waste. There is large number of heaps of Kota stone slurry created by dumping the waste surrounding the entire region. Similarly polished waste material surrounding the grinding and polishing industries has been made. The proper drainage system of area has been damaged. Pollution increases surrounding the area and causing problem for habitation. The waste received from polishing industries is, a very fine material, deposited in the agriculture fields and affect the fertility of soil. Thus it is beneficial to use this waste in considered in use for improvement of properties of sub grade soil for flexible pavements. For the present study soil samples and stone slurry was collected form Jhalawar district.

Kota soil sample and Kota stone slurry dust was collected form Jhalawar region. This was the first stage of the research programme i.e. methodology. Soil sample was to be selected from MILITARY area in Jhalawar. The place was chosen because the soil at that place is clean in respect of sand particles, boulder, organic waste, and any other types of vegetation.

III. LIST OF LABORATORY TEST CONDUCTED

The laboratory work had been carried out in two different parts which are:

- On the collected BC Soil sample without the addition of Kota stone slurry dust.
- On the collected Kota stone slurry dust without the addition of BC Soil.
- On the BC Soil mixed with Kota stone slurry dust with their defined proportion.

Test conducted on the above mentioned soil samples are summarized is below mentioned Table 1 to Table 3.

Table 1: Conducted test on the BC Soil sample

S. No.	Name of the Test	Defined Parameter
1	Determination of the Grain Size Distribution by Sieve Analysis (as per IS 2720 : Part 4 : 1985)	Particle Size Distribution
2	Determination of the Specific Gravity of Soil (as per IS 2720 : Part 3 : 1980)	Specific gravity of Soil
3	Determination of the Consistency of Soil (as per IS 2720 : Part 5 : 1985)	Liquid Limit and Plastic Limit
4	Determination of Maximum Dry Density and Optimum Moisture Content relationship by the use of modified proctor test. (as per IS 2720 : Part 8 : 1983)	Maximum Dry Density and Optimum Moisture Content
5	Determination of Free Swell Index of Soil (as per IS 2720 : Part 40 : 1977)	Free Swell of Soil
6	Determination of the Load –Penetration curve by the use of California Bearing Ratio (CBR) Test. (as per IS 2720 : Part 16 : 1987)	California Bearing Ratio (CBR)
7	Determination of the Stress-Strain behaviour of the soil sample by the use of Unconfined Compression Strength (UCS) test. (as per IS 2720 : Part 10 : 1991)	Unconfined Compressive Strength (UCS)

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Table 2: Conducted test on the Kota stone slurry dust

S. No.	Name of the Test	Defined Parameter
1	Determination of the Grain Size Distribution by Sieve Analysis (as per IS 2720 : Part 4 : 1985)	Particle Size Distribution
2	Determination of the Specific Gravity of Soil (as per IS 2720 : Part 3 : 1980)	Specific gravity of Soil
3	Determination of the Consistency of Soil (as per IS 2720 : Part 5 : 1985)	Liquid Limit and Plastic Limit
4	Determination of Maximum Dry Density and Optimum Moisture Content relationship by the use of modified proctor test. (as per IS 2720 : Part 8 : 1983)	Maximum Dry Density and Optimum Moisture Content
5	Determination of Free Swell Index of Soil (as per IS 2720 : Part 40 : 1977)	Free Swell of Soil
6	Determination of the Load –Penetration curve by the use of California Bearing Ratio (CBR) Test. (as per IS 2720 : Part 16 : 1987)	California Bearing Ratio (CBR)

The test conducted on the BC Soil mixed with Kota stone slurry dust with varies proportions of 3%,6%,9%,12%,18%,21% and 24% are listed below in Table 3.

Table 3: Conducted test on BC Soil mixed with KSSD

S. No.	Name of the Test	Parameter
1	Determination of the Specific Gravity of Soil (as per IS 2720 : Part 3 : 1980)	Specific gravity
2	Determination of the Consistency of Soil (as per IS 2720 : Part 5 : 1985)	Liquid Limit and Plastic Limit
3	Determination of Maximum Dry Density and Optimum Moisture Content relationship by the use of Modified Proctor test. (as per IS 2720 : Part 8 : 1983)	Maximum Dry Density and Optimum Moisture Content
4	Determination of the Stress-Strain behaviour of the soil sample by the use of Unconfined Compression Strength (UCS) test. (as per IS 2720 : Part 10 : 1991)	Unconfined Compressive Strength (UCS)

CBR value is calculated as:

(Test load Corresponding to the required penetration value/Standard Load Corresponding to the Required Penetration Value) x100.

The following table gives the standard loads adopted for different penetration for the standard material with a CBR value of 100 % as per IS standards.

Table 4: Standard Loads Adopted For Different Penetrations

S. No.	Penetration of Plunger(mm)	Standard Load(kg)
1	2.5	1370
2	5.0	2055
3	7.5	2630
4	10	3180
5	12.5	3600

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IV. TEST RESULTS AND DISCUSSIONS

All the data obtained from the experimental investigations were analyzed to study the magnitude of inherent variations in Atterberg's limits, Moisture Content and Dry Density relationship, CBR values and unconfined compressive strength of soil –KSSD mixes. The effect of KSSD content on soil was analyzed to arrive at the optimum values of KSSD content to get maximum benefit.

A. Grain Size Analysis (as per IS 2720: Pt.4-1955)

The Grain Size Analysis Tests were conducted on the BC Soil and on Kota stone slurry dust.

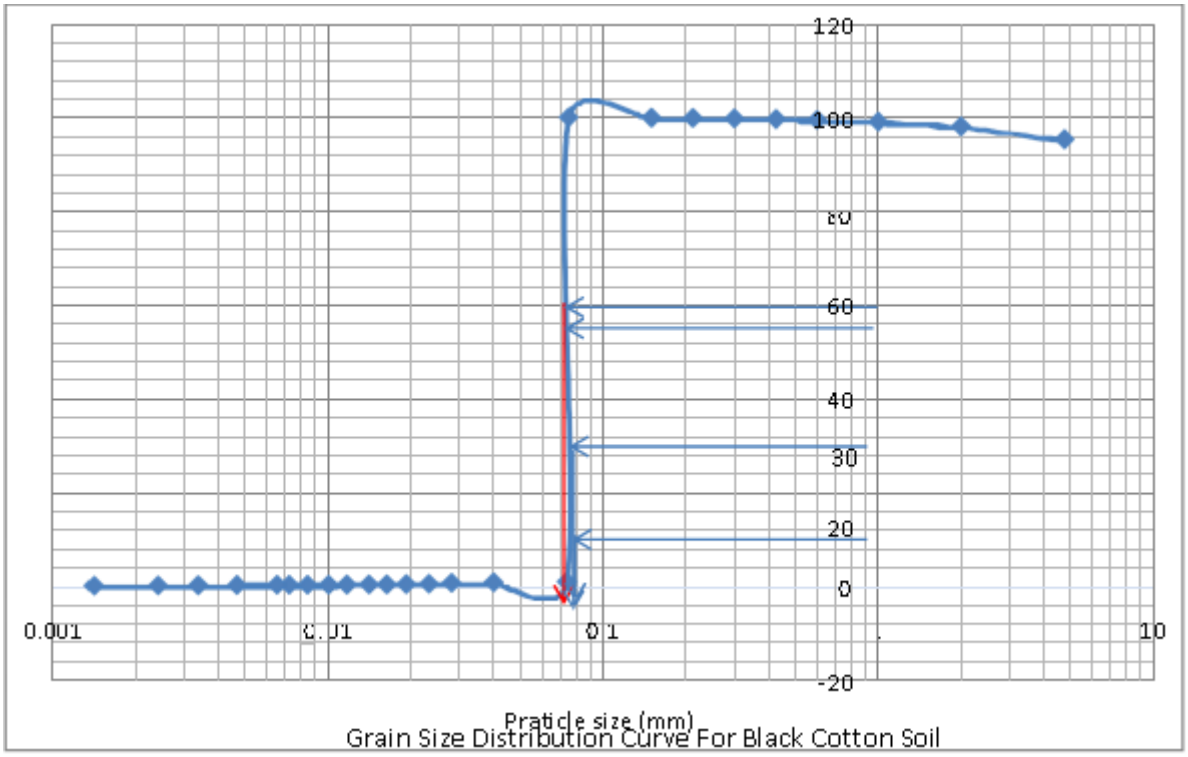

Fig 1: Shows the grains Size distribution of soil and Kota stone slurry dust

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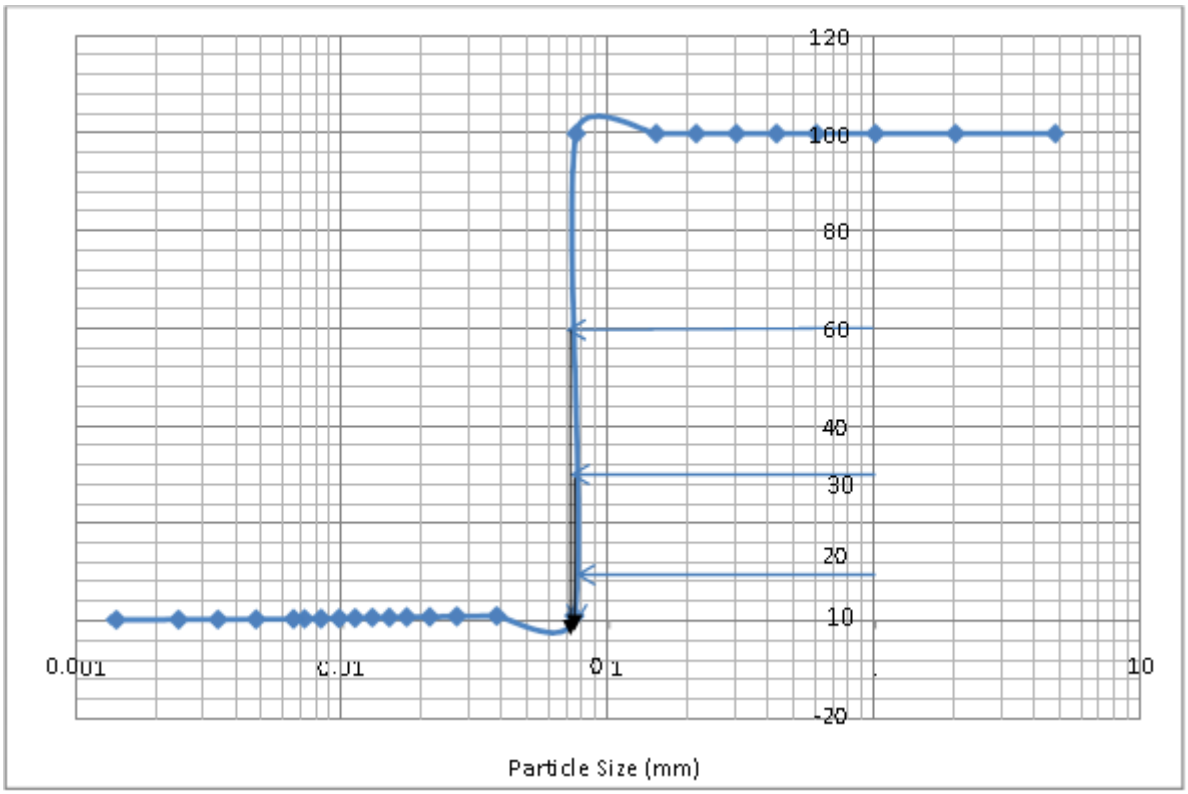

Fig 2: Grain Size Distribution Curve for BC Soil and Kota stone slurry dust

Table 5: Value of Cu and Cc of BC Soil and KSSD

Determination	Coefficient of uniformity (C_u)	Coefficient of curvature (C_c)
Black Cotton Soil	1.006	1.02
Kota Stone Slurry Dust	1.01	1.00

Table 6: Variation in the Liquid Limit value for the BC Soil mixed with Kota stone slurry dust

S. No.	Test Material	Liquid Limit (%)	% Decrease in Liquid Limit
1	BC Soil	42.56	0.00
2	BC Soil + 3% KSSD	42.22	0.81

3	BC Soil + 6% KSSD	41.65	2.18
4	BC Soil + 9% KSSD	40.84	4.21
5	BC Soil + 12% KSSD	39.99	6.43
6	BC Soil + 15% KSSD	39.68	7.26
7	BC Soil + 18% KSSD	39.57	7.56
8	BC Soil + 21% KSSD	38.81	9.66
9	BC Soil + 24% KSSD	38.48	10.60

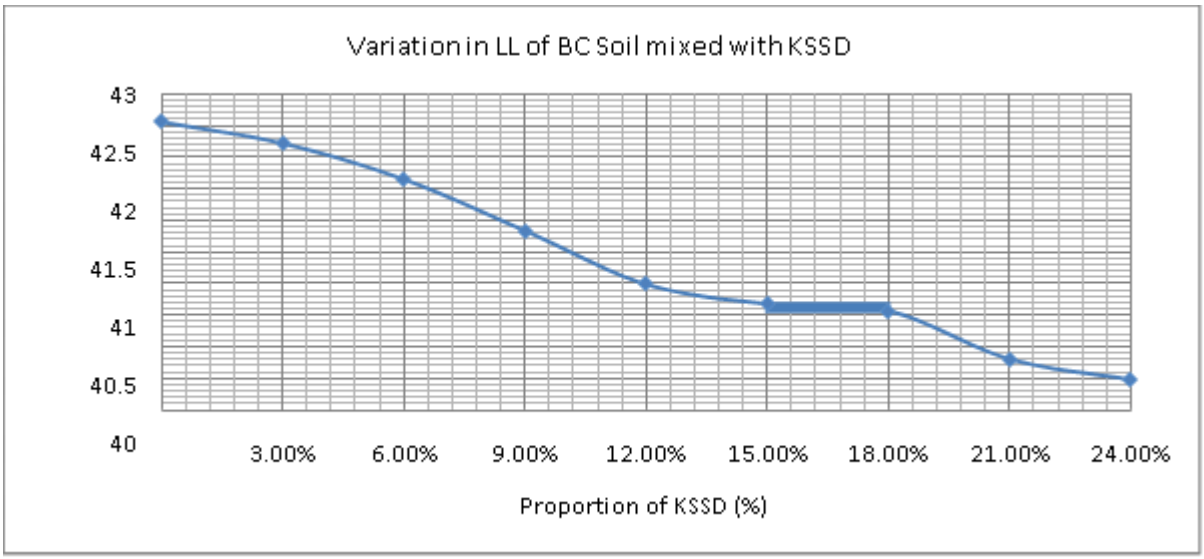

Fig 3: Variation in Liquid Limit value for the BC Soil mixed with Kota stone slurry dust

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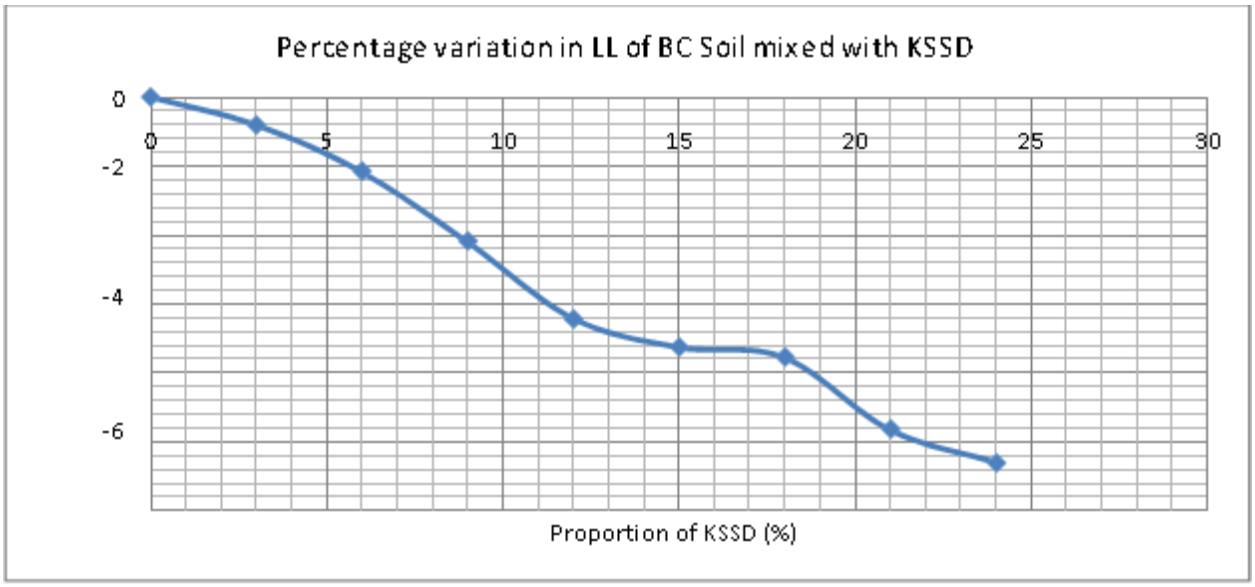

Fig 4: Percentage variation in the Liquid Limit value for the BC Soil mixed with Kota stone slurry dust

From the above shown graph and the recorded data it can be concluded that with the increase in the Kota stone slurry dust content the Liquid Limit decreases .It varies from 42.56 % for Soil to 38.48 % for soil mixed with 24% of Kota stone slurry Dust. The percentage decrease in the Liquid Limit was equal to 10.60 % than compare to BC Soil at 24 % of KSSD.

Table 7: Data collected for Load v/s Penetration curve for the BC Soil

S. No.	Penetration (mm)	Corresponding Load(kg)
1	0	0
2	0.5	6.5
3	1	11.5
4	1.5	19
5	2	25
6	2.5	29
7	3	34
8	4	40
9	5	45
10	7.5	55
11	10	60

12	12.5	65

CBR value at 2.5 mm penetration=2.12 %

CBR value at 5 mm penetration=2.10 %

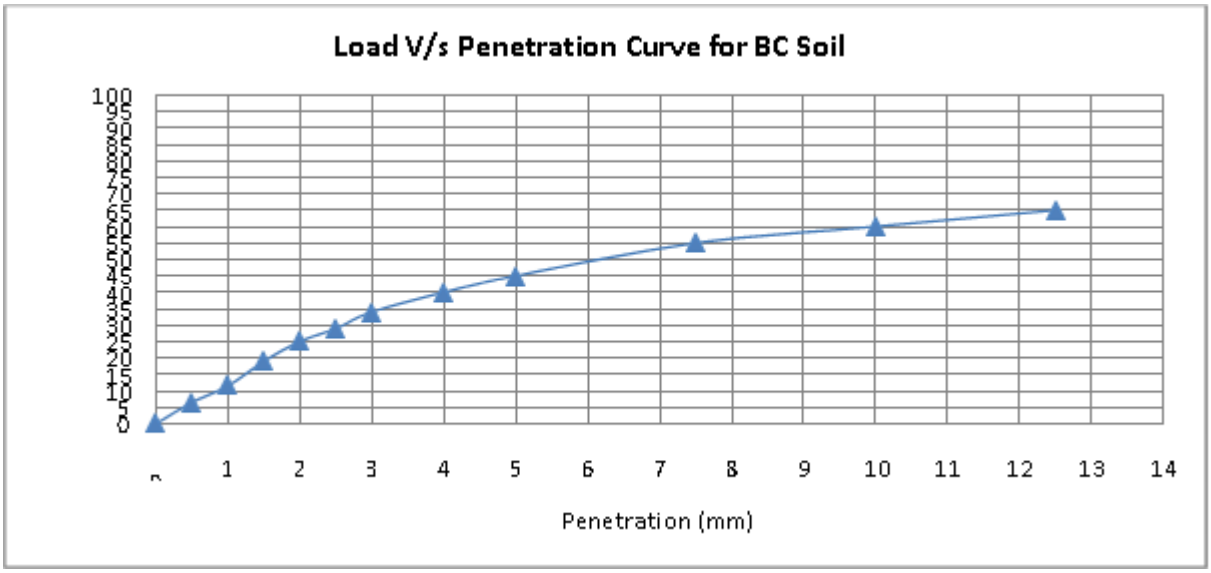

Fig 5 : Load V/s penetration curve for the BC Soil

From the experimental result it was observed that the California Bearing Ratio (CBR) at 2.5 mm penetration was recorded to be equal to 2.118 % and that to 5 mm penetration a value of 2.106 %.

Table 8: Data collected for Load V/s Penetration curve for the Kota stone slurry dust

S. No.	Penetration (mm)	Corresponding Load(kg)
1	0	
2	0.5	12.2
3	1	25
4	1.5	37.2
5	2	55
6	2.5	70.8
7	3	82.4
8	4	90
9	5	100

10	7.5	122
11	10	140
12	12.5	160

CBR value at 2.5 mm penetration=5.18%

CBR value at 5 mm penetration=4.87 %

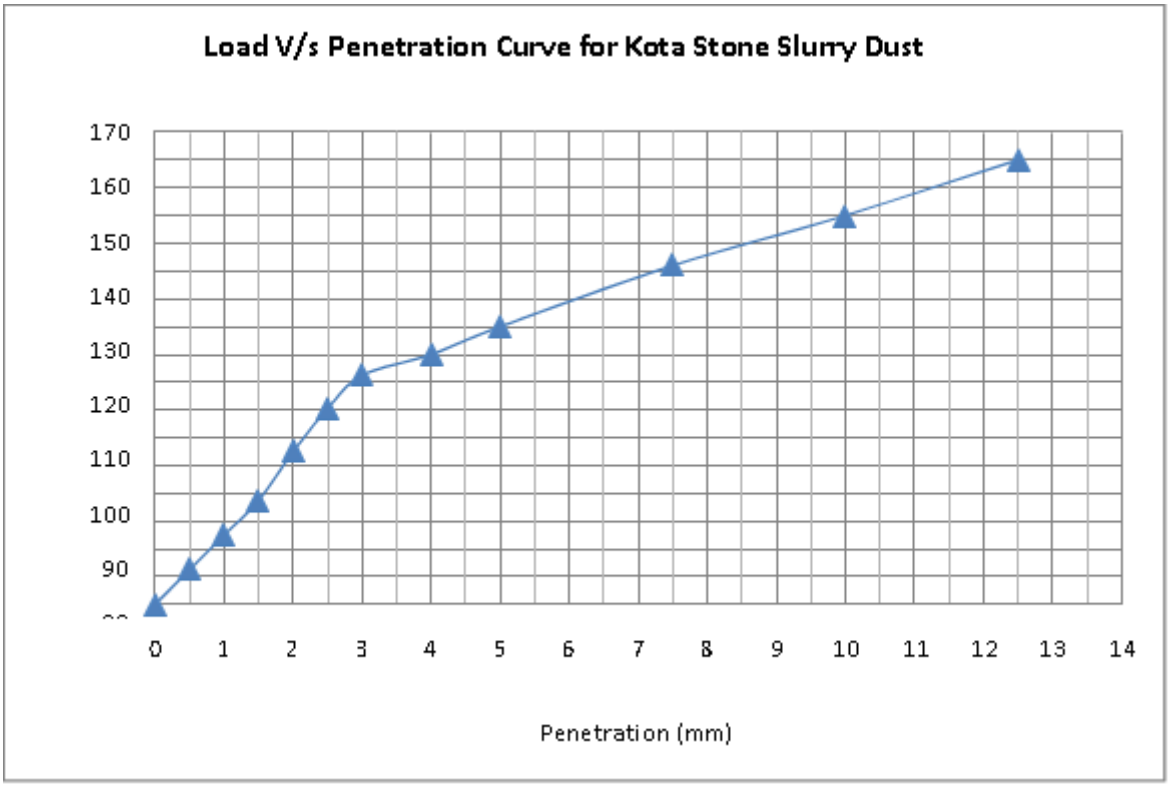

Fig 6: Load V/s penetration curve for the KSSD

From the experimental result it was observed that the California Bearing Ratio (CBR) at 2.5 mm penetration was recorded to be equal to 5.18% and that to 5 mm penetration a value of 4.87 % which is greater than CBR value of BC Soil.

V. CONCLUSION

This thesis is the outcome of the extensive laboratory research work carried out to explore the possibility of utilizing Kota stone slurry Dust, an industrial waste material ,for studying the effect of addition of Kota stone slurry dust for the sub grade soil improvement .Experiments were done to study the functions of Kota stone slurry dust. This was accomplished by

performing elaborate laboratory investigations in different aspects. The main focus in the present investigation was to conduct systematic research work on the use of Kota stone slurry dust, so that new methods of application can be evolved which will pave way for the stabilization of Black Cotton Soil and effective utilization of Slurry waste thus reduces the industrial waste.

The study examined the effect of Kota stone slurry dust on the engineering properties of black cotton soil like, OMC and MDD relationship, CBR values and Stress-Strain behaviour of soils, mixed with the varying KSSD content proportions for use of this soil as sub grade material The Kota stone slurry dust content was introduced as an admixture up to a maximum of 24% by Dry Weight of the soil.

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