International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

DESIGN OF FLEXIBLE PAVEMENT BY BLACK COTTON SOIL AND 15% KOTA STONE SLURRY WITH WOODEN SAW DUST

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ABSTRACT

California bearing ratio (CBR) value of subgrade is used for designing of flexible pavements. The design of pavement may affect by the construction material. Most of the times, expansive soils is used for pavement and it needs stabilization because expansive soils swell when it comes in contact with water and this is the major reason of failure of expansive soil strata. In this research, the black cotton soil is used with 15% Kota stone slurry and wooden saw dust is mixed at varied percentage. The engineering properties of black cotton soil may be used by fibre, ash, lime and sludge etc. CBR value depends on the liquid limit, Plastic limit, plasticity index, maximum dry density, optimum moisture content and California bearing ratio of soil or mix specimen. These tests are performed in laboratory of University Teaching Department, Rajasthan Technical University, Kota. This research paper deals with design of flexible pavement by using black cotton soil with different percentage of wooden saw dust with 15% Kota stone slurry. In this research, the saw dust is mixed from 2.5% to 12.5% in black cotton soil with 15% Kota stone slurry mix. The engineering parameters are also determined by performed 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), Sieve analysis, standard proctor test, California Bearing Ratio are performed.

Keywords: California Bearing Ratio, 15% Kota Stone Slurry, Wooden Saw Dust, Maximum Dry Density

I. INTRODUCTION

The California bearing ratio is a penetration test for evaluation of the mechanical strength of natural ground, subgrades and base courses beneath new carriageway construction. California bearing ratio is the method of designing the flexible pavement and this is an empirical method of designing the flexible pavement. This method was developed by California Highway Department in 1928. The basic site test is performed by measuring the pressure required to penetrate soil or aggregate with a plunger of standard area. CBR has become so globally popular that it is incorporated in many international standards ASTM 2000. For the pavement design, the Black cotton soil is used as base material and for stabilizing the black cotton soil, the 15% Kota stone slurry is mixed with wooden saw dust. The saw dust is mixed at varied percentage from 2.5% to 12.5% by weight of black cotton soil with 15% Kota stone slurry mix. Due to high swelling and shrinkage characteristics of black cotton soil, the black cotton soil has been a big issue to highway and other civil engineering specializations. The Kota stone slurry is a waste material, which may be used as stabilizing material for black cotton soil to improve engineering properties of soil.

II. LITERATURE REVIEW

For the designing of flexible pavement by black cotton soil and slurry with saw dust, many researchers did work on the black cotton soil with different materials. In the past many researchers have carried out their research work for designing the flexible pavement by 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 design of flexible pavement and material properties and some of the reviewed of the reviewed literatures are presented in proceeding paragraphs.

Hemalatha A et. al. (2017) studied the behaviour of black cotton soil with glass powder and saw dust. They exhibit swelling and shrinkage behaviour when exposed to change in moisture content. The reduction in swelling depends on the size of the sand and the initial moisture content in soil. The quantity of saw dust and glass powder was taken 5% and 12.5% by weight of black cotton soil. They observed strength increases upto 20% with admixtures.

Rakesh Verma et. al. (2017) performed the stabilization of black cotton soil using saw dust and cement. They mixed saw dust and cement at varied percentage. From the results they observed that the property of black cotton soil effectively improved by using of 1% saw dust and 2% cement contents. The CBR value of black cotton soil improves considerably to 4.6 times with 2% of cement and 1 saw dust content and unconfined compressive strength of black cotton soil improves considerably to 2.1 times with 2% of cement and 1% saw dust.

Koteswara Rao D et. al. (2012) conducted laboratory experiments to study the stabilization of marine clay using saw dust and lime. They mix saw dust and lime at variation of 5% and 3% respectively in marine clay. From the results, they obtained that liquid limit decreases when 15% saw dust is added in marine clay and it also decreases when 4% lime is added. From the CBR test results, they observed the value of CBR increases 129.76 on addition of 15% saw dust but when 4% lime is added it increases to 283.12%.

III. EXPERIMENTAL INVESTIGATIONS

Various such as Atterberg's limit (liquid limit and plastic limit), Shrinkage limit, Differential free swelling, Swelling pressure, OMC and MDD, UCS, etc tests have been performed to design the flexible pavement by using black cotton soil with Kota stone slurry. The percentage of wooden saw dust may have varied from 2.5% to 12.5% by 2.5% variation.

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.

- **Wooden Saw Dust –** Wooden industry, Nainwa, Kota

3.2 Engineering Properties of Black Cotton Soil, Kota Stone Slurry, Wooden Saw Dust and Mix Specimen

The following engineering properties are determined by laboratory test for black cotton soil, Kota stone slurry and mix specimen. The properties of wooden saw dust are taken from booklet of the saw dust.

Table 3.1 Engineering properties of BCS, KSS and mix specimen

Properties	Black Cotton Soil	Kota Stone Slurry	Wooden Sawdust	Mix Specimen
Specific Gravity	2.44	2.35	1.00	-
Liquid Limit (%)	41.41	34.28	-	34.56
Plastic Limit (%)	18.46	21.77	-	14.09
Plasticity Index (%)	22.95	12.51	-	20.47
IS Classification	CI	CL	-	CI to CL
Maximum Dry Density (kg/cm^3)	1.725	1.635	417 x 10^{-4}	1.695 – 1.830
Optimum Moisture Content (%)	17.4	17.1	-	10.0 – 18.2
Carbon Content (%)	-	-	56.2	-
Diameter (Microns)	> 75	> 75	-	-
Colour	Red – Brown	Grey Dirty White	Light Red Brown	Light Red – Brown

The Atterberg limits are determined with 15% Kota stone slurry with black cotton soil. The 15% Kota stone slurry in black cotton soil mix specimen having 34.56%, 14.09% and 20.47%, liquid limit, plastic limit and plasticity index respectively. The saw dust is mixed from 2.5% to 12.5% and proctor test is performed for these percentage mix specimens. The variation in maximum dry density is determined from 1.695 kg/cm^3 to 1.835 kg/cm^3. The maximum dry density is increased 1.835 kg/cm3 to MDD of black cotton soil and mix specimen of 15% Kota stone slurry. The variation of tests value is shown in Table 3.1. When 15% Kota stone slurry is mixed in black cotton soil, the liquid limit and plastic limit decreases and plasticity index also decreases. Due to plasticity criteria, the black cotton soil behaviour changes from CI to CL. The results of standard proctor test are shown in fig. 3.1.

International Journal of Advance Research in Science and Engineering
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www.ijarse.com
IJARSE
ISSN: 2319-8354

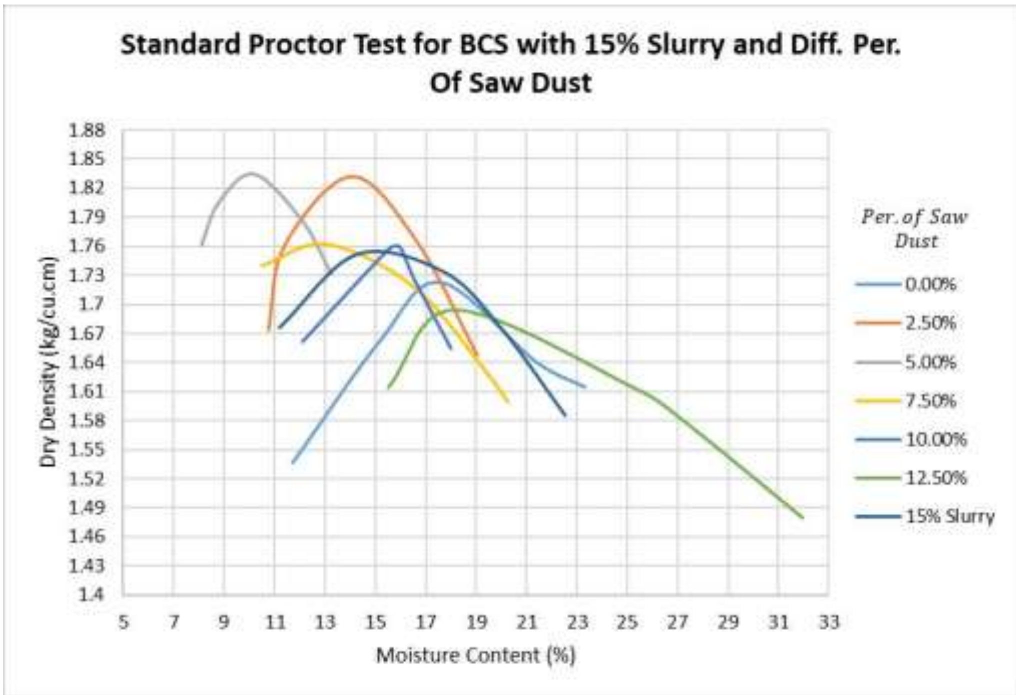

Fig. 3.1 Standard proctor test for BCS with 15% KSS and different percentage of wooden sawdust

3.3 California Bearing Ratio (CBR)

As per IRC recommendation, California bearing ratio value of subgrade is used for design of flexible pavements. California bearing ratio value is an important soil parameter for design of flexible pavements and runway of air fields. The test is performed according to IS 2720 (Part 16) – 1979. The California bearing ratio test is performed in laboratory of University Teaching Department, RTU, Kota for black cotton soil and mix specimen of soil. Table 3.2 is containing CBR value of Black cotton soil with 15% Kota stone slurry and mix specimen of wooden saw dust.

Table 3.2 CBR test load value for black cotton soil, 15% Kota stone slurry and mix specimen of saw dust

Specimen/ Penetration	2.5 mm	5.0 mm	7.5 mm	10.0 mm	12.5 mm
Black Cotton Soil (BCS)	111.28	157.04	177.32	188.76	199.68
BCS + 15% KSS	199.68	292.76	339.56	369.2	376.48
BCS + 15% KSS + 2.5% Dust	292.24	412.88	526.24	610.48	686.92
BCS + 15% KSS + 5.0% Dust	276.12	407.16	499.72	562.12	614.64
BCS + 15% KSS + 7.5% Dust	209.04	318.24	391.56	464.36	536.68
BCS + 15% KSS + 10.0% Dust	178.88	262.08	298.48	306.80	297.44
BCS + 15% KSS + 12.5% Dust	151.84	230.88	277.68	303.68	291.20

Note – All load parameters are in kgf

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www.ijarse.com
IJARSE
ISSN: 2319-8354

According to IS 2720 (Part 16) – 1979, after obtaining the load from CBR machine, the correction in load is applied to determine corrected load. This load is known as test load. The corrected test load is shown in Table 3.3, for black cotton soil and with 15% Kota stone slurry and mix specimen of saw dust.

Table 3.3 CBR corrected load value for black cotton soil, 15% Kota stone slurry and mix specimen of saw dust

Specimen/ Penetration	2.5 mm	5.0 mm	7.5 mm	10.0 mm	12.5 mm
Black Cotton Soil (BCS)	150	172	188	198	210
BCS + 15% KSS	240	318	350	372	378
BCS + 15% KSS + 2.5% Dust	370	480	575	660	730
BCS + 15% KSS + 5.0% Dust	380	478	550	600	663
BCS + 15% KSS + 7.5% Dust	275	358	430	508	580
BCS + 15% KSS + 10.0% Dust	242	290	310	300	280
BCS + 15% KSS + 12.5% Dust	184	252	292	300	282

Note – All load parameters are in kgf

After performing and correcting value of load, it is observed that when 2.5% and 5.0% saw dust is mixed with black cotton soil and 15% Kota stone slurry, the load is obtained 380 and 480 kgf for 2.5 mm and 5.0 mm penetration respectively. Hence, 2.5% saw dust mix specimen gives better results among the all saw dust mix specimen and the determined load is also more than to black cotton soil and 15% Kota stone slurry with black cotton soil mix specimen. In case of 5.0 mm penetration, the 2.5% fibre mix specimen having 480 kgf load value which is more than to CBR value of black cotton soil and it is also more than to 15% Kota stone slurry mix specimen CBR value. By varying the percentage of saw dust, the load value also varied.

As per IRC recommendation, only 2.5 and 5.0 mm penetration value is considered. From the corrected test value, the California bearing ratio is determined and shown in Table 3.4.

Table 3.4 CBR value for Black cotton soil and mix specimen

Specimen/ Penetration	2.5 mm	5.0 mm	7.5 mm	10.0 mm	12.5 mm
Black Cotton Soil (BCS)	10.95%	08.37%	07.15%	06.23%	05.83%
BCS + 15% KSS	17.52%	15.47%	13.31%	11.70%	10.50%
BCS + 15% KSS + 2.5% Dust	27.01%	23.36%	21.86%	20.75%	20.28%
BCS + 15% KSS + 5.0% Dust	27.74%	23.26%	20.91%	18.87%	18.42%
BCS + 15% KSS + 7.5% Dust	20.07%	17.42%	16.35%	15.97%	16.11%

BCS + 15% KSS + 10.0% Dust	17.66%	14.11%	11.79%	09.43%	07.78%
BCS + 15% KSS + 12.5% Dust	13.43%	12.26%	11.10%	09.43%	07.83%

Note – All CBR value is in percentage

The maximum CBR value is taken for the design of flexible pavement. The maximum value of CBR is determined 27.74% for black cotton soil with 15% Kota stone slurry and 5.0% saw dust mix specimen.

3.4 Flexible Pavement Design as per IRC 31 – 2001

For the designing the flexible pavement, the IRC 31 – 2001 is used. This code based on the value of California bearing ratio. Following formula is used for designing the flexible pavement –

$$= 365 \times [(1 + \ ) - 1] \times \qquad \times \qquad \times$$

Where

$$= \qquad \times (1 + \ )$$

n – Design life in year

F – Vehicle damage factor

r – Annual growth rate of commercial vehicles

P – Number of commercial vehicles as per last count

D – Land distribution factor

x – Number of year between the last count and the year of completion of construction

A – Initial traffic in year of completion of terms of the number of commercial vehicle per day

3.5 Design Parameters of Flexible Pavement

For the designing the flexible pavement following design data are taken for 660 traffic volume –

Design life in year (n) – 20

Vehicle damage factor (F) – 3.5

Value of California bearing ratio – 27.74% ≈ 28%

Annual growth rate of commercial vehicles (r) – 7.5%

Number of commercial vehicles as per last count (P) – 660 Nos

Land distribution factor (D) – 0.40 (Four Lane Single Carriageway Road)

Number of year between the last count and the year of completion of construction (x) – 1

Initial traffic in year of completion of terms of the number of commercial vehicle per day (A) – 709.5 ≈ 710

Table 3.5 shows, traffic volume count survey,

Table 3.5 Traffic volume count survey

Time	Bus/Truck (Laden)			Bus/Truck (Unladen)			Bus/Truck (Overloaded)			Agricultural Tractor Trailor (Laden)			Agricultural Tractor Trailor (Unladen)			Agricultural Tractor Trailor (Overloaded)			Cars/ Vans / Jeeps / Three Wheeler			(Laden)			(Unladen)			(Overloaded)		
Days	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3
7 to 8 AM	11	10	10	9	8	7	6	7	5	4	4	5	3	4	4	3	3	2	12	11	11	4	5	4	3	4	3	2	3	2
8 to 9 AM	8	7	9	7	6	8	5	5	6	5	6	5	4	5	4	2	4	3	10	12	10	5	4	3	3	3	2	3	2	2
9 to 10 AM	7	7	8	6	6	7	4	6	6	4	7	4	3	5	3	2	3	2	15	16	14	4	4	4	4	3	4	2	3	3
10 to 11 AM	5	6	7	5	5	6	3	4	5	6	4	4	5	3	3	4	3	4	16	16	15	5	5	3	3	3	2	2	2	3
11 to 12 AM	8	6	7	7	6	6	5	4	6	5	7	7	4	5	5	2	2	3	11	10	9	4	5	4	4	4	3	3	2	2
12 to 1 PM	6	9	6	5	7	6	4	5	5	7	8	5	5	4	4	4	3	4	9	10	11	3	4	4	3	4	3	2	2	2

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

1 to 2 PM	7	6	5	5	6	7	4	5	6	5	6	7	4	4	5	3	2	2	8	7	10	5	3	5	5	3	3	2	3	2
2 to 3 PM	6	8	7	4	6	6	5	6	5	4	7	5	3	5	4	2	3	3	5	6	6	4	5	3	3	2	2	3	3	3
3 to 4 PM	9	10	8	7	7	7	5	6	4	5	4	4	4	3	3	4	2	3	6	8	9	5	4	5	3	2	3	3	2	2
4 to 5 PM	7	6	7	6	5	6	6	5	5	7	3	7	6	2	5	2	3	2	7	7	6	4	5	4	4	3	3	2	3	2
5 to 6 PM	6	5	6	6	4	5	4	4	6	5	7	4	4	5	3	3	2	3	11	10	9	5	4	5	4	4	3	2	2	2
6 to 7 PM	8	7	7	7	6	8	6	4	5	6	5	5	5	3	4	4	4	2	12	11	12	4	4	5	3	2	2	3	2	3
7 to 8 PM	9	7	8	8	6	6	5	4	4	7	7	4	5	4	3	3	3	3	10	10	11	4	5	4	3	4	3	2	3	0
Total	97	94	95	82	78	85	62	65	68	70	75	66	55	52	50	38	37	36	132	134	133	56	57	53	45	41	36	31	32	28
Average	95			82			65			70			52			37			133			55			41			30		
Total Average (P)	660																													

Results for 660 traffic volume survey

The test results are determined for the 28.0% CBR value and 16 msa.

a. Total thickness of pavement – 550 mm
b. Thickness of granular base – 250 mm
c. Thickness of granular sub base – 200 mm
d. Thickness of wearing course (BC) – 40 mm
e. Thickness of binder course (DBM) – 60 mm

For the designing the flexible pavement following design data are taken for 790 traffic volume –

Design life in year (n) – 20

Vehicle damage factor (F) – 3.5

Value of California bearing ratio – 27.74% ≈ 28%

Annual growth rate of commercial vehicles (r) – 7.5%

Number of commercial vehicles as per last count (P) – 790 Nos

Land distribution factor (D) – 0.40 (Four Lane Single Carriageway Road)

Number of year between the last count and the year of completion of construction (x) – 1

Initial traffic in year of completion of terms of the number of commercial vehicle per day (A) – 849.25 ≈ 850 Table 3.6 shows, traffic volume count survey,

Table 3.6 Traffic volume count survey

Time	Bus/Truck (Laden)			Bus/Truck (Unladen)			Bus/Truck (Overloaded)			Agricultural Tractor Trailor (Laden)			Agricultural Tractor Trailor (Unladen)			Agricultural Tractor Trailor (Overloaded)			Cars/ Vans / Jeeps / Three Wheeler			(Laden)			(Unladen)			(Overloaded)		
Days	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3	D-1	D-2	D-3
7 to 8 AM	11	10	10	10	9	9	7	8	6	5	5	6	4	5	4	4	4	3	14	13	14	5	6	5	4	5	4	3	4	3
8 to 9 AM	9	8	9	8	7	8	6	6	7	6	7	6	5	6	5	3	5	4	12	14	13	6	5	6	4	4	5	4	3	3
9 to 10 AM	8	8	7	7	7	8	5	7	7	5	6	5	4	6	4	3	4	3	17	17	16	5	4	4	5	4	5	3	4	4
10 to 11 AM	6	7	8	6	6	7	4	5	6	7	5	7	6	4	4	5	4	5	18	17	16	6	6	5	4	4	3	3	3	4
11 to 12 AM	8	7	7	8	7	7	6	5	7	6	7	7	5	6	6	3	3	4	13	12	14	5	6	5	5	5	4	4	3	3
12 to 1 PM	7	9	8	6	8	8	7	6	6	8	6	6	6	5	5	5	4	5	10	11	12	4	4	4	4	5	5	3	3	3
1 to 2 PM	8	7	6	6	7	7	5	6	7	6	7	7	5	5	6	4	3	4	9	8	10	6	5	5	6	4	6	3	4	3
2 to 3 PM	6	9	7	5	7	5	6	7	6	5	6	6	4	6	5	3	4	4	7	6	7	5	5	4	4	3	4	4	4	4
3 to 4 PM	10	10	9	8	8	7	6	7	5	6	5	5	5	4	4	5	3	5	7	8	8	6	6	5	4	3	3	4	3	3
4 to 5 PM	8	7	8	7	6	7	7	6	6	8	6	6	6	4	5	3	4	3	8	7	8	5	5	4	5	4	5	3	4	3
5 to 6 PM	7	7	7	7	6	6	5	5	7	6	7	5	5	5	4	4	3	4	12	11	11	6	5	6	5	5	4	3	3	3
6 to 7 PM	8	8	8	8	7	8	7	6	6	7	6	6	6	4	4	5	4	5	13	11	12	5	6	5	4	3	4	4	3	4

IJARSE
ISSN: 2319-8354

7 to 8 PM	9	9	9	9	8	6	6	5	5	8	7	7	6	5	5	4	4	4	14	12	11	4	5	4	4	5	5	2	3	2
Total	105	106	103	95	93	93	77	79	81	83	80	79	67	65	61	51	49	53	154	147	152	68	68	62	58	54	57	43	44	42
Average	105			94			79			81			64			51			151			66			56			43		
Total Average (P)	**790**																													

Results for 790 traffic volume survey

The test results are determined for the 28.0% CBR value and 21 msa (19 + 2).

a. Total thickness of pavement – 575 mm
b. Thickness of granular base – 250 mm
c. Thickness of granular sub base – 200 mm
d. Thickness of wearing course (BC) – 40 mm
e. Thickness of binder course (DBM) – 85 mm

IV. DISCUSSIONS ON TEST RESULTS

After the obtaining results, it is clearly defined that black cotton soil changes engineering properties due to Kota stone slurry from CI to CL. The maximum dry density is also increased 1.835 kg/cm3 from MDD of black cotton soil and 15% Kota stone slurry mix specimen. The maximum CBR value also is obtained for 5.0% saw dust mix specimen with 15% Kota stone slurry in black cotton soil, which is 27.74%. The two-traffic volume count sample is taken for design of flexible pavement. First traffic volume count is 660 and second is 790. The msa values 16 and 21 are determined for 660 and 790 traffic volume respectively. The total thickness of pavement is 550 mm and 575 mm determined for 16 msa and 21 msa respectively.

V. CONCLUSIONS

- The Kota stone slurry changes behaviour of black cotton soil CI to CL.
- From the proctor test, the maximum dry density increases to 1.835 kg/cm^3.
- When quantity of traffic increases the total thickness of flexible pavement increases.
- It is also defined, the million standard axles (msa) value is directly proportional to the thickness of pavement and number of traffic.
- When traffic volume increases the total thickness of pavement increases due to granular sub base and wearing course.

VI. ACKNOWLEDGEMENTS

I would like to express my profound gratitude and indebtedness to my guide Dr. K. S. Grover and my best friend Er. Amit Jangid who have always been a constant motivation and guiding factor throughout the research time in and out as well. Dr. K. S. Grover is professor of civil engineering department in University teaching department, RTU, Kota and Er. Amit Jangid is MTech scholar. It has been a great pressure for me to get an opportunity to work under them and complete the research work successfully.

REFERENCES

[1] Hemalatha A, Arun V. Parwate, A study on behaviour of black cotton soil with glass powder and saw dust, IJRESTs, Vol. 3, No. 03, ISSN(O) – 2395 – 6453, Issue 05, 2017.

[2] Rakesh Verma, Shwetank R. Saagar, Chinmayee Ray, Lokendra Panwar and Mayur Rathore, Stabilization of black cotton soil using saw dust and cement, IJSRD, Vol. 5, Issue 09, 2017, ISSN(O) – 2131 – 0613.

[3] Koteswara Rao D., M. Anusha, P. R. T. Pranav, G. Venkatesh, A laboratory study on the stabilization of marine clay using saw dust and lime, IJESAT, Vol. 2, Issue 04, pp. 851 – 862, ISSN(O) – 2250 – 3676.

[4] C.E.G. Justo and A. Veeraragavan S. K. Khanna, Highway Engineering, Khanna Publication, Delhi.

[5] Dr. B. C. Punamia, Ashok Jain, Arun Jain, Soil Mechanics and Foundations, Laxmi Publications, New Delhi.

[6] Dr. K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publications, New Delhi.

[7] Indian Standard Code : IS 1498 – 1970, Classification and identification of soils for general engineering purposes (first revision).

[8] Indian Standard Code : IS 2720 (Part 5) – 1985, Determination of liquid limit and plastic limit (second revision).

[9] Indian Standard Code : IS 2720 (Part 7) – 1980, Determination of water content, dry density relation using light compaction (second revision).

[10] Indian Standard Code : IS 2720 (Part 16) – 1979, Laboratory determination of CBR.