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Effect on CBR Value of Soil by Using Steel Slag

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Abstract: **Soil stabilization is nothing but the modification of soils to enhance their physical and mechanical properties to improve the shear strength and load carrying capacity of the subgrade and to reduce the shrinkage property of soil. Black cotton soil is always known for its high fertility rate but when it comes to the construction it becomes the matter of concern. In order to utilize the industrial waste, an attempt is made to stabilize the black cotton soil by adding steel slag. This project work aims to evaluate the effect of addition of steel slag with various percentages to stabilize the black cotton soil and to verify its suitability to be used as a construction material for road, embankment and structural fills. In the first phase, the physical engineering properties of the black cotton soil samples were studied by conducting CBR test on plain black cotton soil whereas in the second phase of the test, black cotton soil was mixed with 5%, 10% and 15% of steel slag as percentage of dry weight of black cotton soil. It is found that the properties of black cotton soil mixed with steel slag are suitably improved.**

Index Terms **- BC soil, soil stabilization, CBR, Steel slag.**

I. INTRODUCTION

Now a day, large acres of land is occupied by industrial waste which not only creates landfilling problem but also leads to adverse impact on the environment. Steel slag is one of the industrial waste which is generates from steel and iron industry as it's by product. As it is a residue material it is being dumped openly on the larger scale which may be one of the reasons for soil pollution. So, in spite of dumping slag into the ground it can be used as a soil stabilizer. Soils vary throughout the globe and engineering property of soils are equally variable. Black cotton (BC) soil is inorganic clays of medium to high compressibility and acquires major soil group in India. They possess high swelling and shrinkage properties and because of these properties of BC soil, it becomes challenge for structural engineers to work in such terrain. So it's become very necessary to find out any suitable ingredient or material which can strengthen all engineering properties of BC soil to make the structure more firm. There are so many stabilizing materials available but steel slag is one of the materials which not only provide better stability to BC soil but also makes the structure more economical. In the present study properties of BC soil are evaluated by replacing soil by various percentage of steel slag. It is found that properties of BC soil shown considerable improvement after the partial replacement by steel slag.

1.1 OBJECTIVE OF STUDY

1. TO ENHANCE THE PROPERTIES OF BLACK COTTON SOIL BY USING STEEL SLAG.
2. TO EVALUATE STABILITY OF BC SOIL BY PARTIAL REPLACEMENT BY STEEL SLAG AT VARIOUS PERCENTAGE.
3. TO DETERMINE OPTIMUM AMOUNT OF STABILIZER REQUIRED TO STABILIZE THE BC SOIL AND MAKE THE STRUCTURE ECONOMICAL WITH THE GREATER STRENGTH AND STABILITY.

1.2 Material to be used

I. Black Cotton Soil

Black cotton soil is one of major soil deposits of India. They exhibit high rate of swelling and shrinkage when exposed to changes in moisture content and hence have been found be most troublesome from engineering consideration. The rate of montmorillonite is more in black cotton soil which causes expansiveness and crack occurs in soil without any warning which is dangerous for construction. Black cotton soils are formed by lava basaltic rocks. Hence they are very dark in color. They develop cracks during dry period and swell if got moisture, hence they are self-tilling in nature, that's why they are fertile and can hold water for long time. Black cotton soils are generally clayey, deep and impermeable. These soils expand and become sticky during rainy season and contract during the dry season causing deep cracks into the soil.

Fig -1: Dry Black Cotton Soil

Black cotton soil is comparatively poor for construction purpose than any other soils. Some of the basic properties of BC soil sample taken for the study are mentioned in Table No. 1

Sr. No.	Properties	Soil
1.	Liquid limit (%)	59.79
2.	Plastic limit (%)	36.8
3.	Plasticity index (%)	22.19

Table -1: Properties of BC Soil

II. STEEL SLAG

Steel slag is produced at steel industry during steel manufacturing. To produce steel, removal of excess silicon and carbon from iron is achieved through oxidation by adding limestone and coke. The steel slag contains higher amount of iron and its physical characteristics are similar to air-cooled iron slag. The fines are utilized in sinter making and lumps are charged in the blast furnace(BF). The iron content is the major basic difference between BF slag and steel slag. In BF slag, FeO is around 0.5%, whereas, in case of steel slag, total iron content varies from 16 to 23%.

Fig -2: Steel slag

III. METHODOLOGY

During the laboratory experiments, The BC soil sample was crumbled, and then it is finely sieved in order to remove other impurities like big stones and vegetation. After getting gentle soil sample it soaked in water for 24 hours. After drying in oven, the various specimen of BC soil was then tested without adding steel slag for the Atterberg's limits, according to as per IS: 2720 (Part 5) 1985. After performing liquid limit, plastic limit and plasticity index tests, California bearing ratio (CBR) test was conducted on plain soil specimens. After conducting test on plain BC soil specimen the soil sample were partially replaced by various percentage of steel slag. Comparison of test results obtained for plain soil sample and sample with the percentage of steel slag is demonstrated in the results and discussion.

3.1 CALIFORNIA BERAING RATIO TEST

The California bearing ratio is a penetration test for evaluation of the mechanical strength of road sub grades and base-courses. The test is performed by measuring the pressure required to penetrate soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

CBR (%)= (Pressure on plunger/Standard Pressure)X100

Fig -3: CBR Test Mould

IV. RESULTS AND DISCUSSION

a) CBR Test on plain BC soil

Table -2: Penetration and Load value for CBR

Penetration (mm)	Dial Gauge Reading	Load Kg
0	0	0
0.5	27	12.03
1	69	19.65
1.5	109	26.47
2	145	31.38
2.5	171	34.80
3	182	41.29
3.5	206	48.87
4	226	54.83
4.5	232	61.05
5	244	66.23
5.5	265	70.89
6	279	73.96
2.5 mm CBR	**25.40%**	

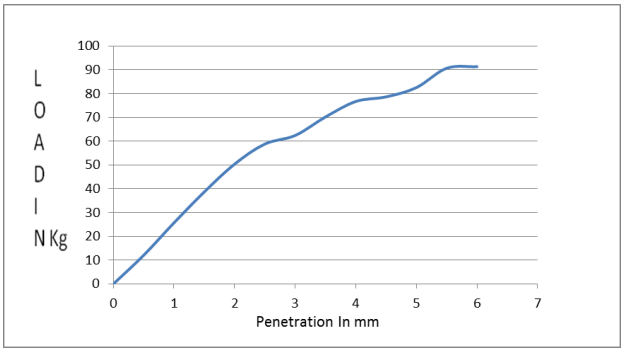

Chart -1: Penetration Vs Load in Kg

In the table no.2 value of load and respective penetration are obtained for plain black cotton soil sample. The CBR value obtained from the table is 4.14% which shows the BC soil possess the lesser strength and stability against the shear failure.

b) CBR TEST ON PLAIN SOIL + 5% STEEL SLAG

Table -3: Penetration and Load value for CBR

Penetration (mm)	Dial Gauge Reading	Load Kg
0	0	0
0.5	43	13.98
1	87	28.28
1.5	127	41.28
2	178	57.85
2.5	197	64.03
3	211	68.58
3.5	237	77.03
4	253	82.23
4.5	273	88.73
5	283	91.98
5.5	292	94.90
6	297	96.53
2.5 mm CBR	**4.67**	

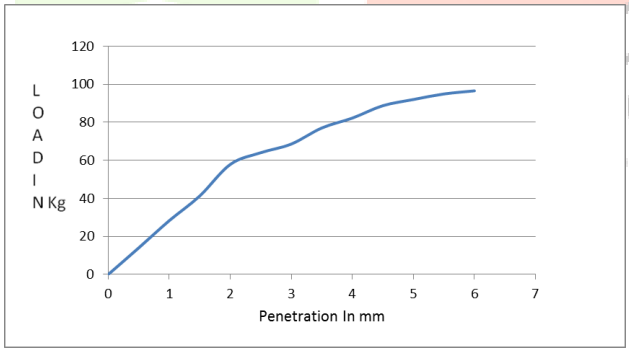

Chart -2: Penetration Vs Load in Kg

In the table no.3 penetration observed for corresponding load in case of BC soil+5 steel slag sample. CBR value obtained from the table no.3 is 4.67%.

c) CBR TEST ON PLAIN SOIL + 10 % STEEL SLAG

Table -4: Penetration and Load value for CBR

Penetration (mm)	Dial Gauge Reading	Load Kg
0	0	0
0.5	56	18.20
1	94	30.55
1.5	132	42.90
2	198	64.35
2.5	256	83.20
3	279	90.68
3.5	302	98.15
4	328	106.60
4.5	352	114.40
5	376	122.20
5.5	397	129.03
6	401	130.33
2.5 mm CBR	**6.07**	

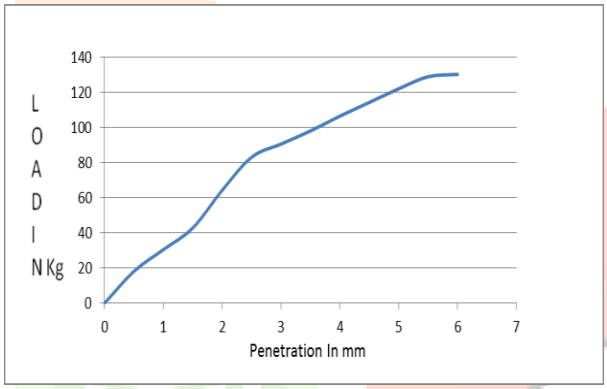

Chart -3: Penetration Vs Load in Kg

Table no. 4 shows the penetration values obtained on corresponding load application for BC soil sample added with the 10% of steel slag. This 10% addition of slag shows considerable improvement in CBR value than that plain BC soil sample.

d) CBR TEST ON PLAIN SOIL + 15 % STEEL SLAG

Table -5: Penetration and Load value for CBR

Penetration (mm)	Dial Gauge Reading	Load Kg
0	0	0
0.5	66	21.45
1	112	36.40
1.5	176	57.20
2	239	77.68
2.5	286	92.95
3	312	101.40
3.5	345	112.13
4	379	123.18
4.5	391	127.08
5	408	132.60
5.5	436	141.70
6	455	147.88
2.5 mm CBR	**6.78**	

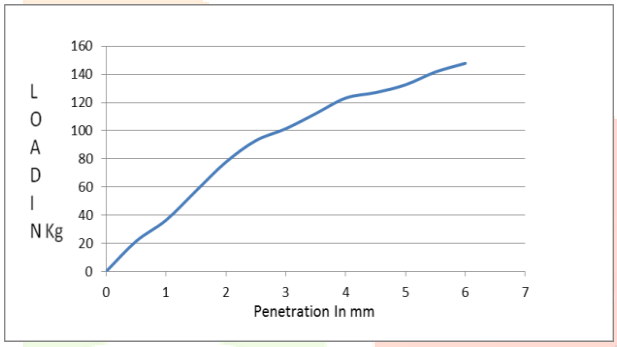

Chart -4: Penetration Vs Load in Kg

On the addition of 15% steel slag in BC soil, CBR value shows the considerable improvement which symbolizes use of steel slag in BC soil make it greater strength with economy.

e) Effect of various percentage of steel slag on BC soil

By calculating CBR value for plain BC soil and also for various percentage of steel slag with it, the comparative analysis has done for evaluating the effect of steel slag on the CBR value of BC in following table no.6

Table -6: CBR value for different BC soil samples

BC SOIL SAMPLE	**CBR VALUE**
PLAIN SOIL	2.40
SOIL+5% STEEL SLAG	4.67
SOIL+10% STEEL SLAG	6.07
SOIL+15% STEEL SLAG	6.78

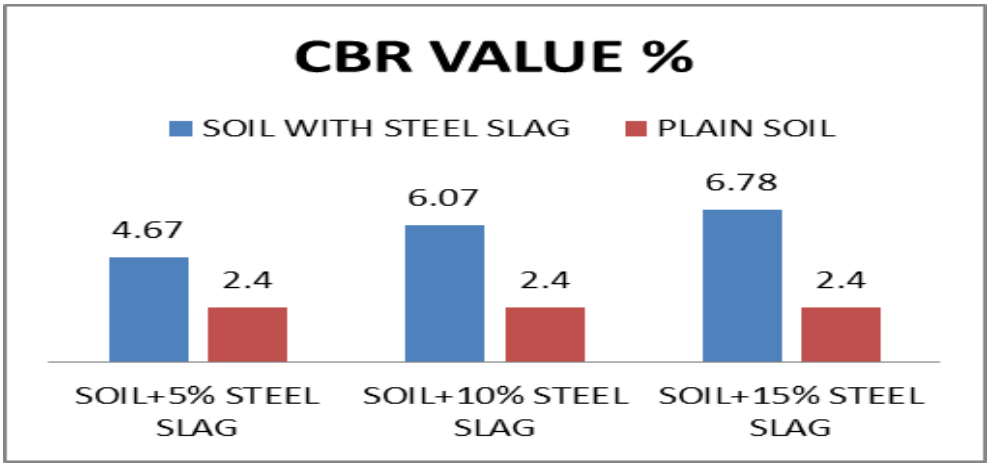

Chart -5: CBR value for plain and various steel slag mixed BC soil sample

From the obtained chart no.5 it is clear that as the percentage of steel slag increases in the soil sample then the bearing capacity of the BC soil against the load also increases

V. CONCLUSION

The study has been conducted to assess the potential of the steel slag to stabilize the Black cotton soil. BC soil was mixed with the various percentage of steel slag (5,10 and 15%). Performance of the black cotton soil is evaluated experimentally by CBR test. The results of CBR for plain BC soil and sample mix with the various percentage of BC soil indicates that, the use of slag significantly improved and strengthened the properties of BC soil in which it was poor. There is significant reduction in swelling behavior of soil. In this study it is found that sample with 5% addition shows 48.60% increment in CBR value of plain BC soil whereas it is 60.46% and 64.60% for the soil sample with addition of slag. 10 and 15% respectively. Present paper concludes that steel slag is one of the economical materials and that can be used as a good stabilizer for BC soils for strengthening its engineering properties.

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