STABILIZATION OF EXPANSIVE SOIL BY USING STEEL SLAG

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Abstract –*In modern days, the disposal problem of industrial waste is rapidly increasing. Such, hazardous waste is affecting the environment as well as land. The most important part of a road pavement is subgrade soil and its strength. If strength of soil is poor, then stabilization is normally needed. Subgrade is sometimes stabilized or replaced with stronger soil material so as to improve the strength. Suchstabilization is also suitable when the available subgrade is madeup ofweak soil. Increase in sub grade strength may lead to economy in the structural thicknesses of apavement. The use of steelslag improves the bearing capacity and the strength of blackc otton soil and indirectly its aves the construction cost. Different percentage of 0%, 5%, 10%, 15%, 20% and 25% steelslag have been used to stabilize the black cotton soil and to verify its suitability for using it as construction material forroad and expansive soils are always have disadvantage of suddenvolumechange.The structural foundations and roads constructed on such soils may undergo large uplift forces. Many researches have been attempted in past to avoid such failures by enhancing theengineering properties of expansive soil. Black soil and fine steel slag mechanical and engineering properties were evaluating. The effectiveness of the steel slag was judged by the improvement inconsistency limits, compaction, freeswell,direct shearTest(C&Φ),and California bearing ratio(CBR).*

KeyWords:**consistencylimits,compaction,freeswell,directshearTest(C&Φ),andCaliforniabearingratio(CBR).**

1.INTRODUCTION

Almost51.8MHAofarearegioninourcountryarecoveredwit hextensivesoilprimarilydarkdry state, howeverthey lose everything that is in them when inwetstate. Consideringt his property offarreachings oils, these dirtsact issues worldwide that Serve like test to defeat for the geospecialized architects. Sweeping soil is one of the richly accessible soils on greater part portions of Earth. It is a dangerous land development with high capability of contracting or expanding because of progress in dampness content. Thus it is important to discover choices to keepaway from such hindrances. In this examination work, pounded broad soil is supplanted with steel slag at 0%, 10%, 20% and 30%. All the keygeo-specialized tests like plastic cutoff, fluidbreakingpoint,standarddelegateandCBRtest,directsh eartestswereledaccordingtoIScodes.Adjustmentofsoilinclu destheexpansion of admixtures like lime, concrete, fly debris, steel slag, and different materials tochangethepropertiesofthedirttofurtherdevelopitsdesigni ngproperties.Soiladjustmentisoftentimesusedindevelopme ntwiththedevelopmentofstreetasphalts.

Black cotton soil has property of plasticity when it comes in contact with moisture. It is hard and brittle at dry state. So it creates problem on work. To solve this problem some admixtures are used to stabilize this soil. S-slag is a end product at during the manufacturing of steel from iron ore or scrap iron. Mechanical adjustment further develops soil properties by blending other soil materials in with the objective soil to change the degree and along these lines change the designing properties. Synthetic adjustment utilized the expansion of cementations or pozzolanic materials to further develop the soil properties. Soils with mediocre or problematic engineering qualities. Soils stabilised with these compounds have undergone rigorous testing and have shown to have no negative effects on the environment.

1.1 SCOPE OF WORK

In its natural form, soil is weak to shear. As a result, it has a low bearing capacity. Soil stabilization can improve shear strength and bearing capacity, hence the need for soil stabilization can be described as follows:

i. In order to improve shear strength.

ii. To increase shear resistance stability.

iii. To lessen the structure's settlement.

iv. To make the soil more dense.

v. To aid in the reduction of edema and shrinking.

Because of the soft or expanding soil, the constructed buildings are harmed. So, raise the strength about the soft soil &improve the load SBC of the soil, fissures are produced and buildings settle into the ground in this location.

2.LITERATURE REVIEW

ChippadaSrinivas (2017) : Steel slag was used to conduct an experiment on expanding soil stabilization. In this study, it was discovered that as the amount of s-slag in clay soil increased, the WL and Wp increased, and CBR penetration resistance varied randomly as the amount of steel slag in clay soil increased. Steel slag can also be effectively mixed in expansive types of soils to improve engineering properties.

Faisal I. Shalabi, Ibrahim M. Asi, Hisham Y. Qasrawi (2016): In light of huge scope combined shear strength tests, the impact of side-effect s- slag on the designing characteristics of earth soils was found in this examination. The point of inner contact and union capture of earth soils diminishes as steel slag content ascents, however the point of inside grinding and union captures rise. The being of steel slag as a balancing out component further develops the dirt soils' growing potential. With an expansion in steel slag amount, both the level of free swell and the swell pressing factor fall essentially directly.

Shubham More, ApekshaLokhande, ShaikhSabir, PoojaAade, NilambarikaBansode, Omkar Joshi (2018) : Using steel slag to stabilise BC soil, In this project strength characteristics of BC soil with steel slag were investigated. Steel waste could be used in geotechnical engineering applications. The addition of steel scrap to badly graded soil can help to improve the soil's bearing capacity. Also, by employing unwanted as anaddetives, the value of the stabilisation operation can be reduced, and the usage of waste has no negative environmental consequences.

Sujit M. Vaijwade, Dr. Shubhada S. Koranne (2019) : Steel slag and bitumen emulsion were used in an experiment to stabilise expansive soil. The amount of material used is minimised by lowering the thickness of the pavement. As a result, the cost of materials is reduced, and the cost of construction is reduced indirectly. Steel slag is also a waste product of major enterprises, thus it may be bought for a lesser price.

Umar Farook Ali AM, Athipathy M, Clement M, Dr. Krishnakumar P (2019) : Steel slag and fly ash were used in an experiment to stabilise expanding soil. According to the findings of this study, soft soil can be efficiently stabilised by adding steel slag – fly ash mixes. Both industrial waste materials will be employed to lower project costs by being used in a building structure and as fill materials of comparable strength.

HussienAldeekyand Omar Al Hattamleh (2017) : Experiments on the use of fine s-slag for soil stabilisation in high plastic subgrades, The effect of applying FSSA to high plastic subgrade soil to stabilise it is the topic of this study. The MDD increased as the FSSA increased, whereas the optimal water content decreased. As the FSSA content is higher up to 20%, the UCS increases and the strain at failure drops. The impact of 20% FSSA on compressive strength is more noteworthy than the impact of different rates.

D. KoteshwaraRao, G. Sravani. Naga Bharath (2014) : The effect of steel slag on the characteristics of marine clay for footing beds was studied in the lab. Steel slag has around 48 to 50 percent lime in its chemical composition, which when mixed with soil at its OMC generates a cementitious substance that aids in strong bonding between soil particles. It demonstrates a significant improvement in engineering and compaction properties. Steel slag as an additive aids in the improvement of ϕ & c.

3. MATERIALS AND METHODS

3.1MATERIALS

3.1.1BLACK COTTON SOIL: The soil used in this project work was gathered from close to Bannikoppa town in Koppal District, Karnataka State, India. The dirt was uncovered 2 meters underneath the outside of the current (NH63) street. Soil is the most widely recognized material utilized in thruway dike and subgrade development. The kind of subgrade soil and its characteristics impact the plan and execution of the asphalt, especially the adaptable asphalt. Probably the main research center examinations were directed to assess the designing characteristics of the dirts, for example, index properties, Atterberg cutoff points, and strength.

Table: Properties Of Black Cotton Soil

PROPERTIES	BC SOIL
Color when dry	Black
Specific gravity	2.28
Free Swell Index	75%
Atterberg Limits	
Liquid limit w_L (%)	47.9
Plastic limit w_P (%)	24.7
Plasticity Index I_P (%)	23.2
Grain Size Analysis	
Gravel	5.3%
Sand	31.3%
Silt and Clay	64.4%
IS soil classification	
Optimum Moisture Content W_{OMC} (%)	13.82
Maximum Dry Density ρ_{dmax} (g/cm^3)	1.65
CBR(Un socked)	17.75%
CBR(Socked)	1.7%
Direct Shear Test	
C	0.27kg/cm^2
Φ	23^0

2.2 STEEL SLAG: Slag was collected from Kirloskar Ferrous Industries Limited in Bevinahalli Village, Koppal Dist, Karnataka. Steel slag is made at time of the partition of liquid steel from contaminations in steel-production heaters.

Slag is a mind boggling arrangement of silicates and oxides that cement when cooled as a liquid fluid dissolve. Almost all steel is currently produced in integrated steel plants using a basic O2 process plants

utilising an electric arc furnace technology. The steel slag utilised in this project is steel slag that has passed through a 19mm IS sieve. Steel slag was utilised in experiments with soil at concentrations of 0%, 5%, 10%, 15%, and 20%, respectively, and the actual properties of Steel Slag are listed in Table

Fig-: Steel slag

Table: Properties Of Steel Slag

PROPERTIES	STEEL SLAG
Color when dry	Brownish Red
Specific gravity	2.98
Free Swell Index	0%
Atterberg Limits	
Liquid limit w_L (%)	NP
Plastic limit w_P (%)	NP
Plasticity Index I_P (%)	NP
Grain Size Analysis	
Gravel	10.99%
Sand	63.6%
Silt and Clay	25.5%
IS soil classification	
Optimum Moisture Content W_{OMC} (%)	8.2
Maximum Dry Density ρ_{dmax} (g/cm^3)	2.18
CBR(Un socked)	104%
CBR(Socked)	44.22%
Direct Shear Test	
C	0kg/cm^2
Φ	45^0

3.2 METHODAOLOGY

3.2.1ATTERBERG LIMITS: Atterberg limits are the water contents at which the soil transitions from one state to another. The soil samples were tested for WL & WP.

3.2.2 SPECIFIC GRAVITY (G): The Wt. of a given vol. of soil solids at a specific temperature partitioned by the Wt. of an equivalent amount of water at that temperature, the two loads taken in air, is the Sp. gravity

(G) of a soil. The standard temperature for specific gravity is 27 degrees, which may be determined using the formula below.

$$G = \frac{\gamma s}{\gamma w}$$

The voids ratio, porosity, degree of saturation, and critical hydraulic gradient are all determined using the specific gravity of soil particles. It's also utilized in hydrometer analysis to determine particle size.

3.2.3 PROCTOR TEST (LIGHT COMPACTION TEST): In the lab, a compaction test is performed on a soil sample combined with cement kiln dust to calculate the amount of compaction and moisture content necessary in the field. R.R. Proctor (1933) devised the standard proctor test for the construction of earthen dams in the state of California.

3.2.4 CALIFORNIA BEARING RATIO (CBR) TEST: The CBR is an entrance test used to survey the mechanical strength of subgrade, regular ground and establishment courses under construction of new road. The fundamental site test includes utilizing a standard region unclogged to quantify the pressing factor needed to infiltrate soil or total. The pressing factor estimated is then isolated by the constrain important to penetration of a typical squashed rock material at a similar depth.

$$CBR = P / Ps \times 100$$

4. RESULT & DISCUSSION

FREE SWELL INDEX: The effect of steel slag at various dosages on free swell index is shown inthe table below. It observed that proportion of steel slag increases, the free swell index steadily lowers.

Table: Free swell index of soil added varying % steel slag

% of Dosage	FSI
0%	75%
5%	70%
10%	60%
15%	50%
20%	45%
25%	40%

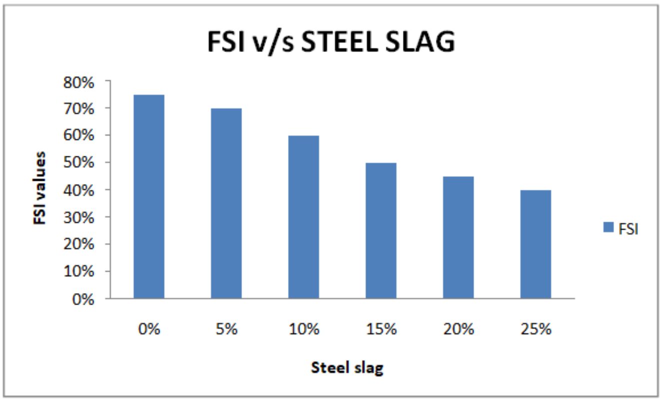

Fig-: FSI v/s STEEL SLAG

CONSISTENCY LIMITS: The effect of Steel Slag at different dosage on consistency limits (WL, WP & PI) of investigating soil has been shown in below table number 4 From Fig-7 it can be observed that the WL, WP get reduced. As the % of the Steel Slag increases, the Consistency Limits also improves.

Table: Consistency limits of soil for different % steel slag

% of Steel Slag	LL	PL	Plasticity Index
0	47.9	24.7	23.2
5	45.2	22.10	23.11
10	43.3	21.43	21.89
15	41.8	20.32	21.5
20	38.2	18.81	19.4
25	35.3	16.23	19.08

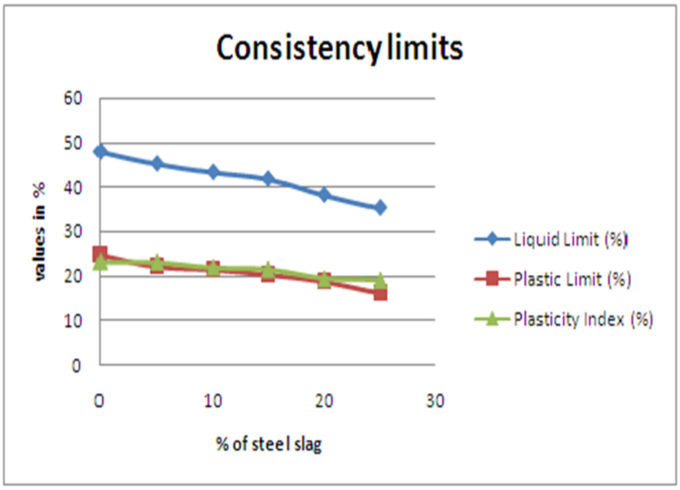

Fig-7: Plot of consistency limits for different % of steel slag

COMPACTION CHARACTERISTICS: The compaction test was performed on BC Soil mixed with changing % of Steel Slag. It is shown that addition of Steel Slag the OMC got reduced and MDD up to 20% of Dosage after 25% MDD Decreases OMC also Decreases.

Table-5: MDD&OMC of soil for different% steelslag

% of Steel Slag	MDD(gm/cm³)	OMC(%)
0	1.65	13.82
5	1.7	13.0
10	1.73	12.4
15	1.75	11.6
20	1.79	10.51
25	1.74	10.01

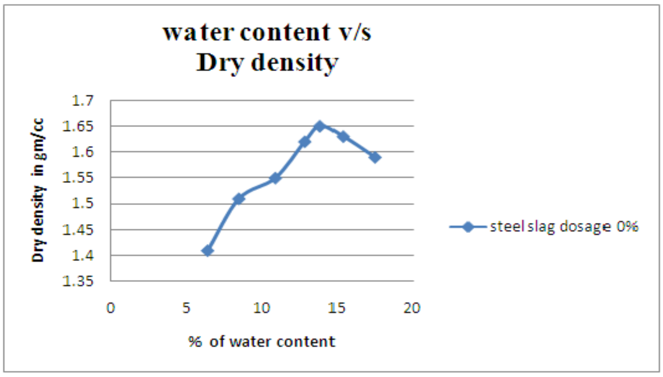

Fig-8: Water content – Dry density for 0% of steel slag

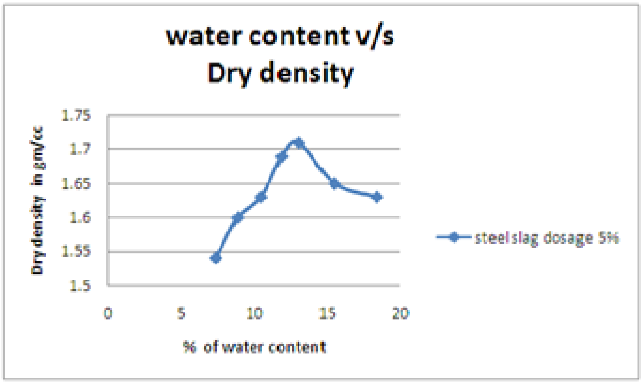

Fig-9: Water content – Dry density for 5% of steel slag

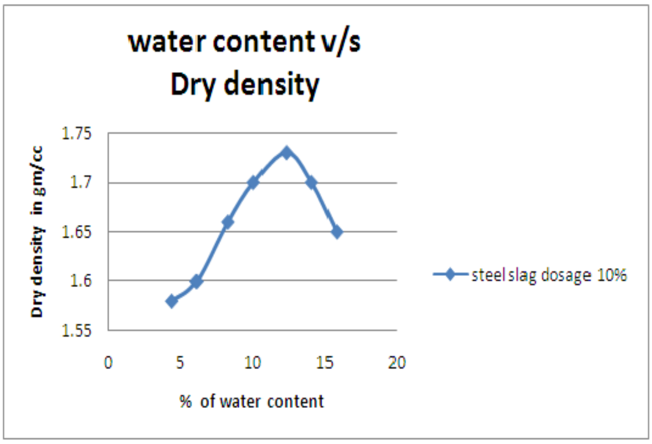

Fig-10: Water content – Dry density for 10% of steel slag

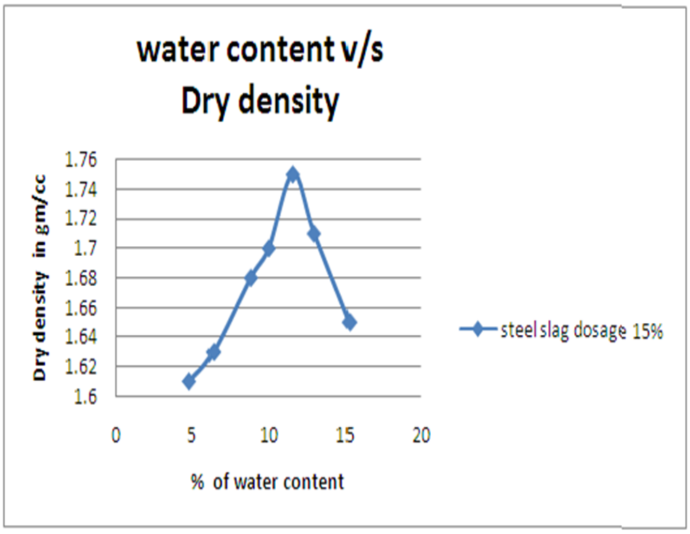

Fig-11: Water content – Dry density for 15% of steel slag

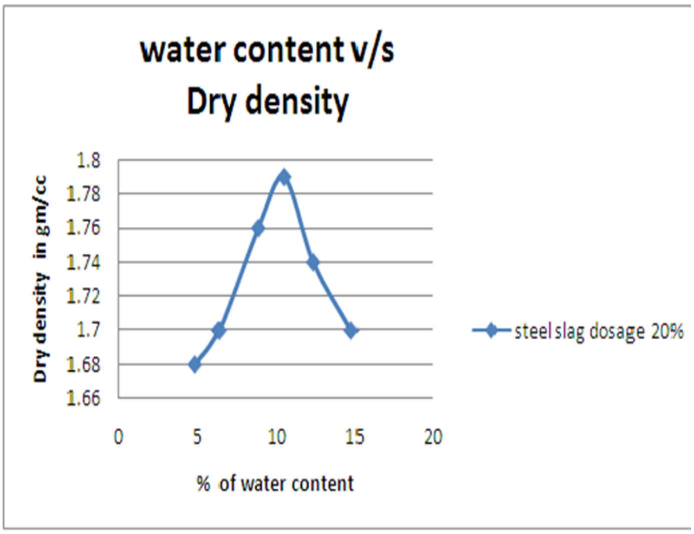

Fig-12: Water content – Dry density for 20% of steel slag

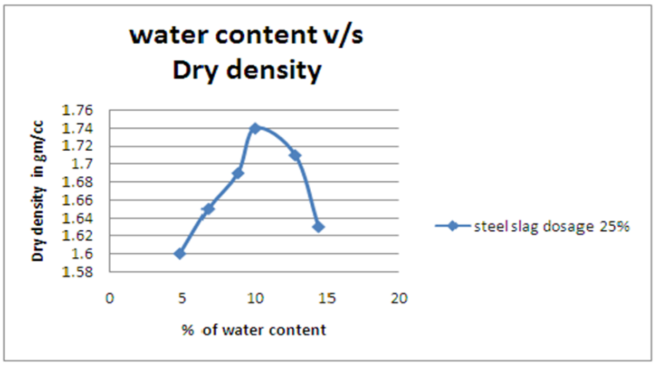

Fig-13: Water content – Dry density for 25% of steel slag

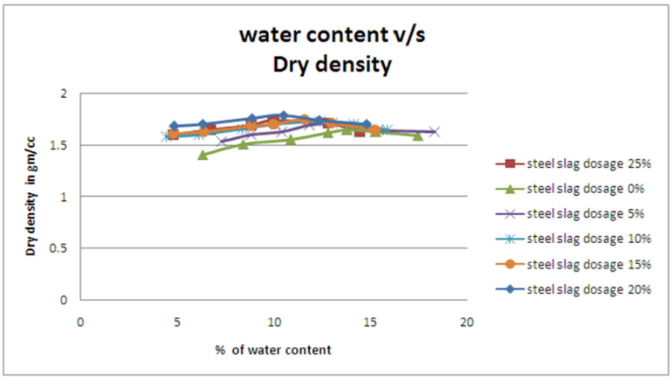

Fig-14: Water content – Dry density for different percentage of steel slag

CALIFORNIA BEARING RATIO (CBR) TEST: As per IS - 2720 (Part 16) the CBR test is performed After the specimen reached equilibrium readings with respect to different penetration and BC Soil mixed with varying percentage of Steel Slag. it is observed that addition of S-slag the CBR value Increases up to 20% after that decreases. Table shows the values of CBR for different dosage of Steel Slag.

Table: CBR value of BC soil treated with varying percentage of S- slag dosage

% of Steel Slag	CBR(Unsocked)	CBR(Socked)
0	17.75	1.7
5	17.90	2.40
10	18.81	4.98
15	21.81	9.03
20	24.45	12.46
25	18.69	11.83

CBRGRAPH FORUNSOAKEDCONDITION

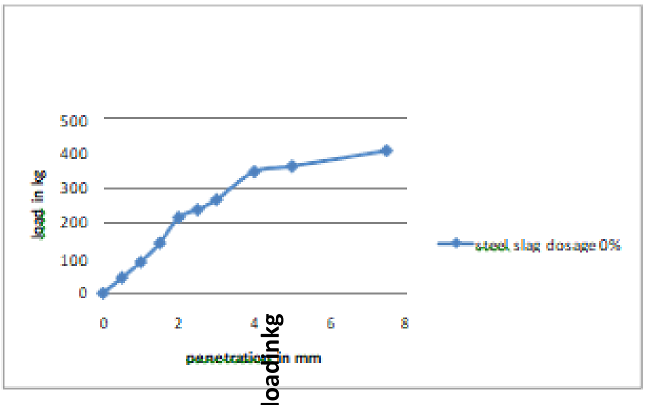

Fig: Penetration- load for 0% of steel slag

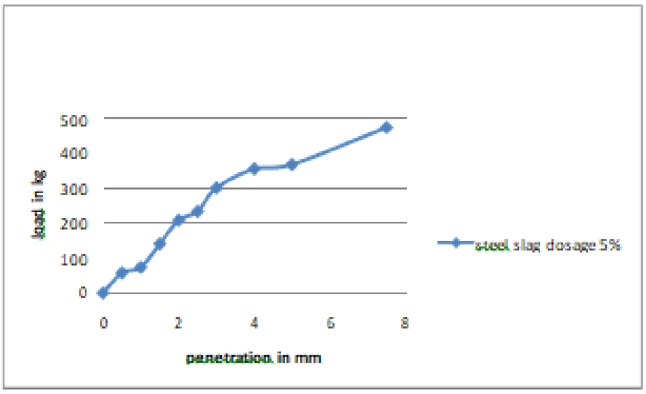

Fig: Penetration- load for 5% of steel slag

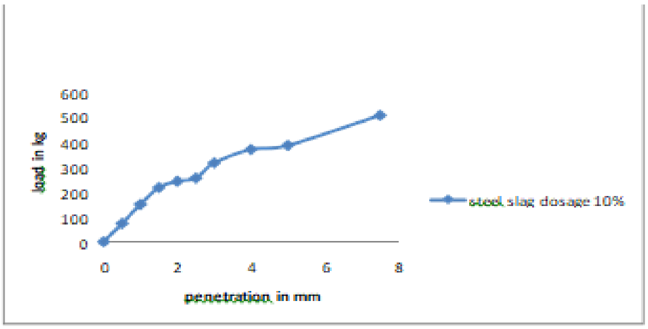

Fig: Penetration- load for 10% of steel slag

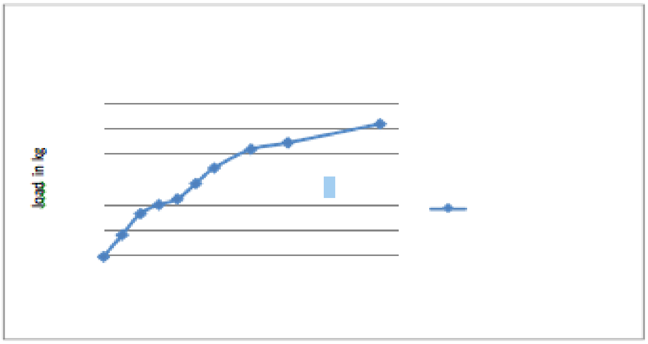

Fig: Penetration- load for 15% of steel slag

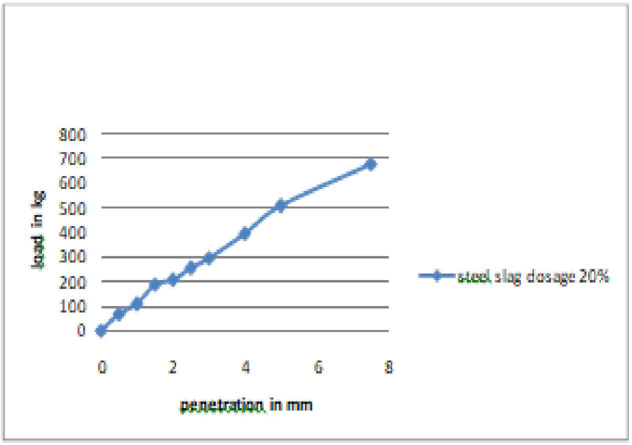

Fig-: Penetration- load for 20% of steel slag

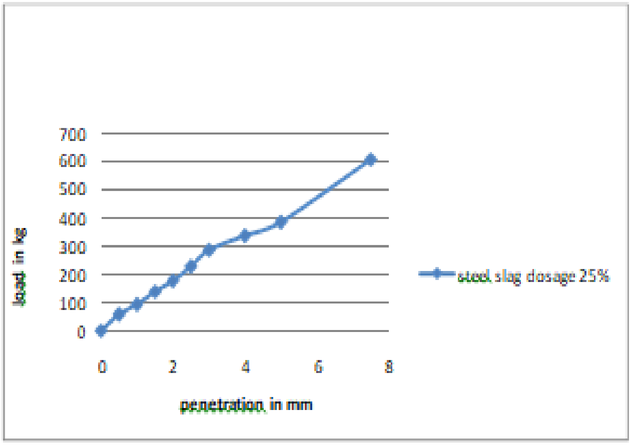

Fig-: Penetration-load for 25% of steel slag

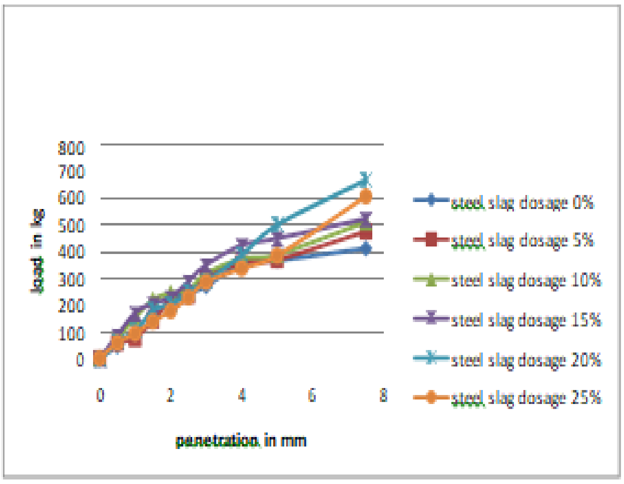

Fig-: Penetration- load for different % of steel slag

CBR GRAPH FOR UNSOAKED CONDITION

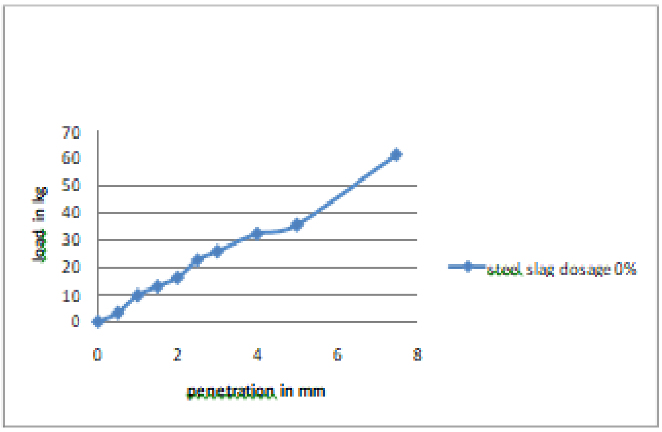

Fig-: Penetration-load for 0% of steel slag

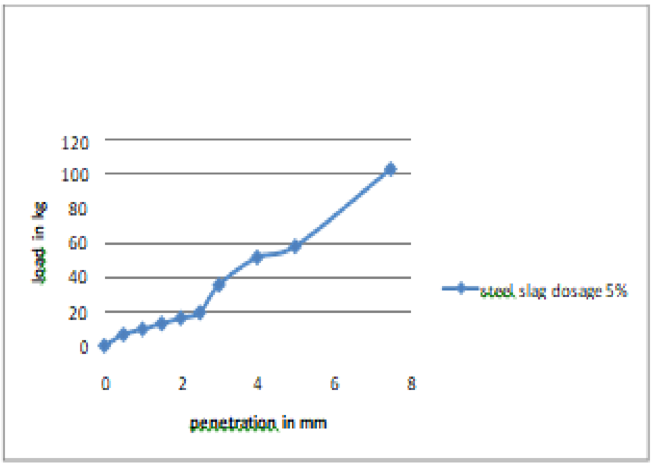

Fig : Penetration-load for 5% of steel slag

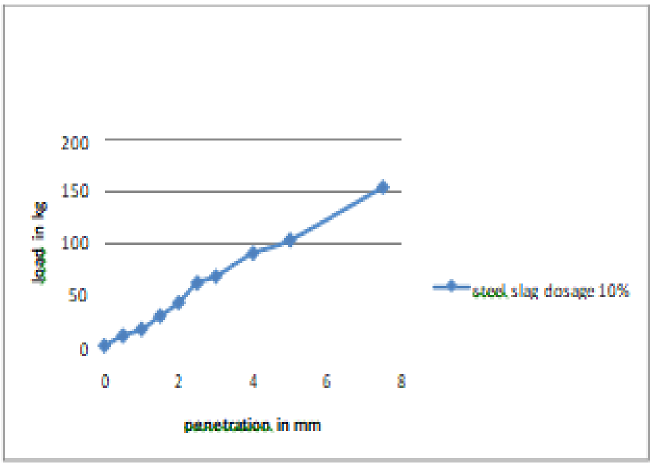

Fig-: Penetration-load for 10% of steel slag

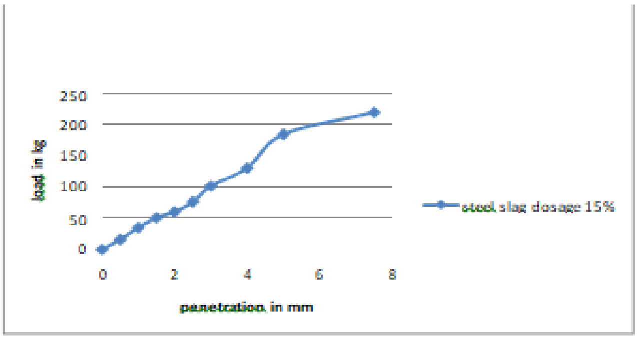

Fig-: Penetration-load for 15% of steel slag

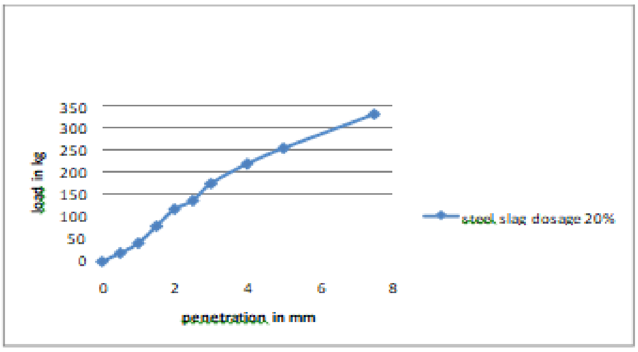

Fig-: Penetration-load for 20% of steel slag

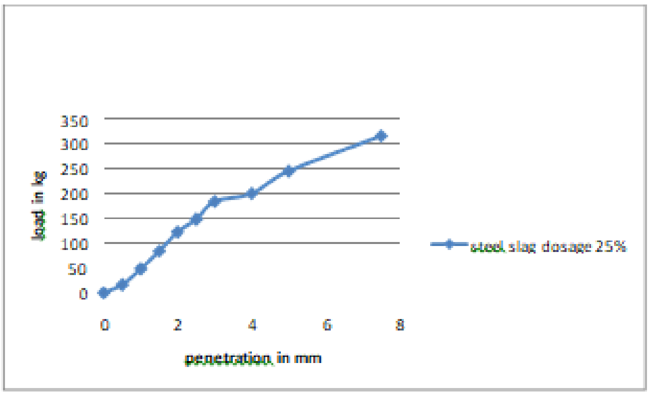

Fig-: Penetration-load for 25% of steel slag

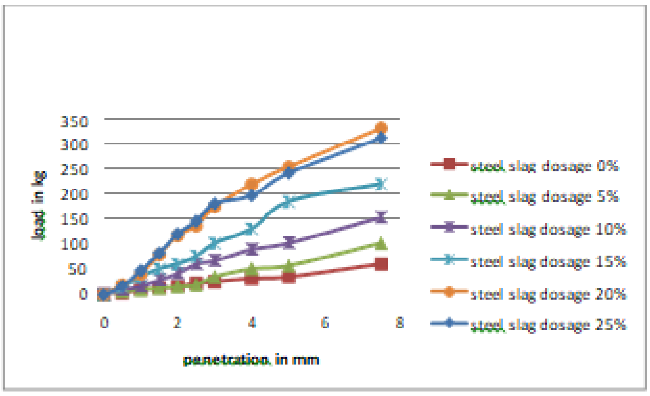

Fig-: Penetration-load for different % of steel slag

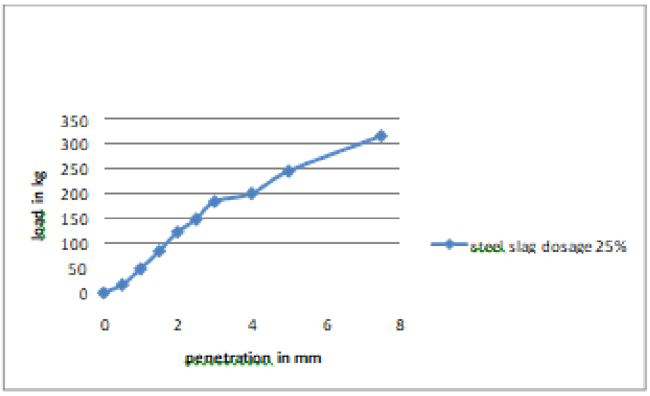

Fig-: Penetration-load for 25% of steel slag

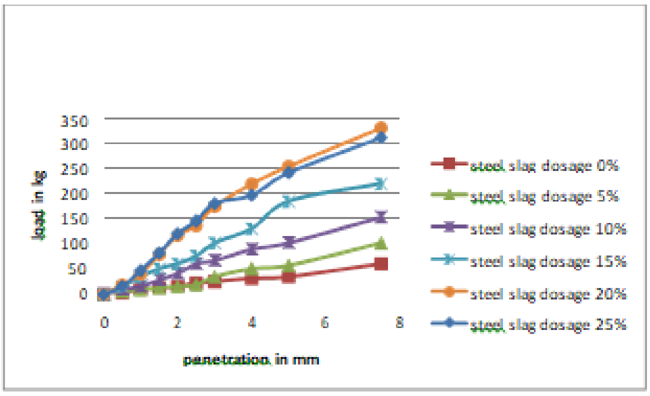

Fig-: Penetration-load for different % of steel slag

DIRECT SHEAR TEST: Direct Shear test where performed on BC soil passes through 4.75mm sieve size and BC soil Mix with varying % of steel slag it is noticed that C value Decreases and Φ value increases up to 20% after that C value got improved and Φ value got reduced. Table shows the results of CBR for various dosage of Steel Slag.

Table: C and Φ of BC Soil for different percentage of Steel Slag dosage

% of Steel Slag	C(in kg/cm2)	Φ (in degrees)
0	0.27	23
5	0.24	24.5
10	0.19	26.5
15	0.13	29
20	0.08	31.5
25	0.11	30

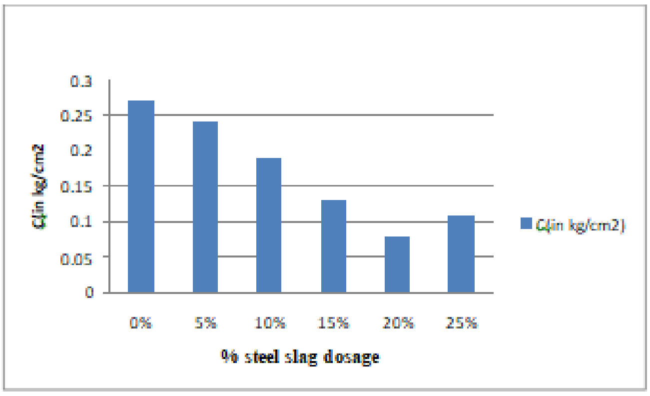

Fig: Cohesive for different percentage of Steel Slag dosage.

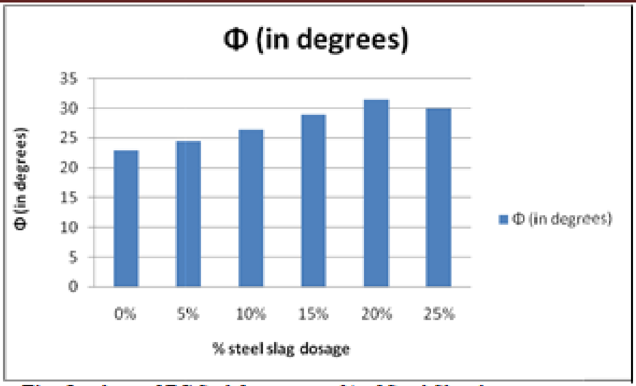

Fig: Φ values of BC Soil for various % of Steel Slag dosage.

CONCLUSION

The effect of employing steel slag as a stabilizer on BC soil was investigated through an experimental programme. In general, the findings demonstrate that S-slag may be utilized effectively to helps to get develop the index and engineering qualities of BC soil when the appropriate percentages are applied. Statistically sound Correlations among the targeted engineering property and S-slag quantity were discovered. The below some of the specific conclusions that can be derived in this research:

1. The PI decreases as increase in steel slag content.

2. The free swell index get decreases as increase of steel slag content.

3. As the steel slag increases the MDD increased & OMC got reduced up to 20 percent after that MDD and OMC Decreased.

4. The optimum percent of polarized steel slag in BC soil is up to 20 percent .Steel slag can be effectively mixed in expensive type of soils to improve the a good binding material in the pavements.

5. Because steel slag is industrial waste, it can improve the CBR of the soil in a greater quantity, allowing the pavement thickness to be reduced and construction costs to be reduced (low Cost).

6. Using steel slag as a binder material aids in the

improvement of shear strength characteristics, such as (C& Φ).

7. According to large-scale shear strength testing, the BC soil's cohesion intercept falls as steel slag content rises, whereas the Φ is projected to rise in the opposite direction.

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BIOGRAPHIES

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