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Use of steel slag in construction of flexible pavement

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Abstract -*The large amount of Industrial wastes as increased year by year and disposal becomes a very serious problem. It is necessary to utilize the steel slag waste affectively with technical development in each field. Commonly murrum soil has been used for construction of all categories of roads in our country. Although murrum is a good construction material, due to scarcity they increase the construction cost at some parts of the country , several types of murrum soils are found to be unsuitable for road construction in view of higher finer fraction and excessive plasticity properties. Such as used industrial material like steel slag in construction of road pavement. Its disposal causing severe health and environmental hazards in road construction industries is gradually gaining significant importance in India considering the disposal, environmental problems and gradual depletion of natural resources like soil and aggregates. Steel slag is a waste material generated as a by-product during the manufacturing of steel from steel industries. The quantity of generation is around 24 lacs MT per year from (Ref.Report.CRRI-2010) different steel industries in the India. Presently, it has no applications and dumped haphazardly on the costly land available near the plants. In this study, a typical steel slag was collected from an M/s Jindal Steel Iindustry Pvt.Ltd Sinnar MIDC, (M.S) in India and its feasibility for use in different layers of road construction was investigated. To improve its Geotechnical engineering properties, the Steel Slag material was mechanically stabilized with locally available soil in the range of 5 – 25%. Geotechnical parameters of these stabilized mixes were evaluated to investigate their suitability in the construction of different layers of road Technical specification of steel slag is developed for utilization in the construction of embankment, sub grade and sub base layer of Flexible pavement.*

Key word- **Compaction test, CBR test, Index Properties, Moisture Absorption test.**

I. INTRODUCTION

The iron and steel slag that is generated as a byproduct of iron and steel manufacturing processes can be broadly categorized into blast furnace slag and steel making slag. Blast furnace slag is recovered by melting separation from blast furnaces that produce molten pig iron. It consists of non-ferrous components contained in the iron ore together with limestone as an auxiliary materials and ash from coke. Depending on the cooling method used, it is classified either as air-cooled slag or granulated slag. Steel making slag consists of converter slag (Basic oxygen furnace slag) that is generated by converter and electric arc furnace slag that is generated during the electric arc furnace steel making process that uses steel-scrap as the raw material. In the present study, solid waste which is generated as a by-product, during the melting process of mixed materials viz. steel scrap, sponge iron, pig iron, ferro-silicon, silico-manganese and Al-shots is termed as granulated blast furnace slag. The waste material is neutral and non hazardous in nature as per chemical analysis report of Central Pollution Control Board India (CPCB) (Hazardous waste rules, 2008, Ref. No-19). The quantity of generation of this slag is around 24 lacs MT per year from different steel industries in India (CRRI, 2010). Steel slag may be used as a land fill cover liner (Inga, 2010, Ref. No-18.) Pazhani and Jeyaraj (2010, Ref. No-20) studied feasibility of Granulated Blast Furnace slag (GBFS) for production of high performance concrete. Use of steel slag in asphaltic concrete minimizes potential expansion and takes advantage of the positive features in giving high stability, stripping resistant asphalt mixes with excellent skid resistance (Emery, 1994 and Mullick2005, Ref. No-21).

Presently, this Steel Slag is not utilized and is dumped on the costly land available near the plants. Study was carried out to utilize the slag in different layers of road construction. Being cohesion less material, it was mixed with local soil in the range of 5-25% and their geotechnical characteristics were evaluated. Technical specifications of slag were developed for utilization in the construction of embankment, sub grade, sub base layers of road pavement. Slag was investigated for its feasibility in bituminous layers.

Pictorial View of Steel Slag Sample
(Ref. from M/s.Jindal Steel Industries MIDC Sinnar,)

II. MATERIAL

Slag sample was collected from M/s Jindal Steel Pvt .Ltd Industry in Sinnar MIDC Nashik, State of Maharashtra, India. It was selected from different locations of the heap and mixed thoroughly before using it for laboratory study. Local soil was also collected from Field National Highway No-6`,Use of local soil should be collected and different layers in field to check Geotechnical properties of Local soil and Steel Slag in various percentage mixes.

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III. GEOTECHNICAL CHARACTERISATION OF SLAG, LOCALLAY AVAILBALE SOIL AND THEIR MIXES

The geotechnical characteristics of Steel Slag Locally Available Soil and their mixtures were investigated to study their feasibility in different layers of road pavement. Construction of road embankment using slag alone would not be feasible as it is cohesion less material. Such embankments would be highly erodible. Therefore, it was blended with local soil in the range of 25-75 % and their geotechnical characteristics were investigated. Different mix proportions with their corresponding mix designations are given in Table 1.

Table 1 Mixes and their Mix Designation

Mix Designation	Mixes
100LS	100% Local soil
5S+95LS	5 % Steel Slag + 95 % Local Soil
10S+90LS	10 % Steel Slag + 90 % Local Soil
15S+85LS	15 % Steel Slag + 85 % Local Soil
20S+80LS	20 % Steel Slag + 80 % Local Soil
25S+75LS	25 % Steel Slag + 75 % Local Soil
100S	100% Steel Slag

Blending of slag and soil – slag and soil were blended manually as per percentage by weight in the laboratory for investigation. Important geotechnical characteristics namely Index Properties like Specific Gravity, Moisture Absorption Test, Grain Size Analysis, Atterberg limit, Modified Proctor compaction Test, CBR Test. were carried out. Based on the results, potential mixes were selected for embankment fill, sub grade and sub base applications

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IV. EXPERIMENTAL WORK

A. *Specific Gravity Test*

Specific gravity test was carried out as per IS 2720 Part 3 (1980). Specific gravity of steel slag and local soil was observed to be 4.28 and 2.10 respectively.

Grain Size Analysis

Grain size analysis was carried out of slag and local soil as per IS 2720 part 4 (1985). Slag and local soil samples were observed to be coarse grained materials. Slag was crushed by roller and grain size analysis was also carried out. Cu and Cc Values find out.

Table-2.Values of Cu and Cc

Coefficient of uniformity (Cu)	12.87
Coefficient of curvature (Cc)	1.94

C. *Atterberg Limit Test*

Atterberg limit test was carried out as Part 5 (1985). Oven dried samples (Passing 4 micron) were used to determine the Liquid Limit (LL) and Plastic Limit (PL). Slag and their mixes were observed to be non plastic in nature. The Liquid Limit (LL) and Plastic limit (PL) of local soil were determined as 51% and 29% respectively.

D. *Moisture Absorption Test*

To know the voids in slag, moisture absorption test is carried out as per BIS 2386 Part 3 (1997). Moisture absorption value of Steel Slag was obtained as 10%.

E. *Modified Proctor Compaction Test*

To assess the compaction properties of selected materials, their mixes and effect of varying relative proportion of two materials, modified Proctor compaction test was carried out as per IS:2720-part 8 (1983). The Maximum Dry Density (MDD) of slag and local soil was found to be 23.5 kN/ $M^3$and 19 kN/M^3 respectively and OMC of 8% and 12%respectively.

Table .3 Values of OMC and MDD for various Mixes

Type of Mix	OMC (%)	MDD (KN/m^3)
100LS	12.0	19.00
5S+95LS	10.10	19.30
10S+90LS	9.50	19.63
15S+85LS	9.00	19.90
20S+80LS	11.12	20.20
25S+75LS	12.00	20.80
100S	8.45	23.50

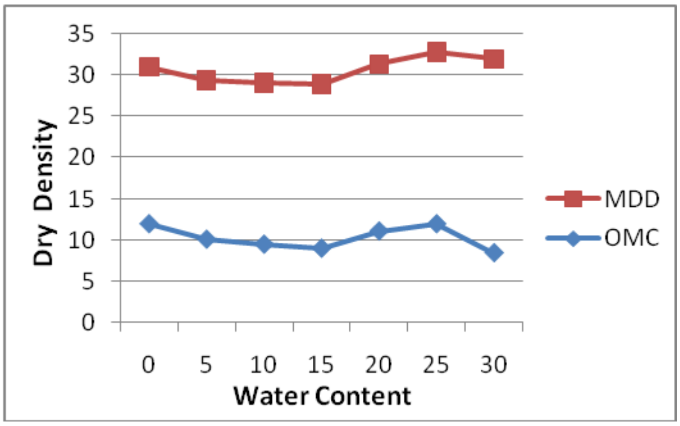

Fig. 4.1 Water Content Versus Dry Density for various % Slag

F. *California Bearing Ratio Test*

California Bearing Ratio (CBR) test was carried out as per IS: 2720-Part 16 (1979). Samples were compacted statically compacted in the CBR mould at its corresponding optimum moisture content to achieve maximum dry density. CBR values of slag and local soil were tested optimum mixes find respectively. Variation of CBR values with Curing Period :It

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was found out that the CBR values of both the mixes increased with the increase in curing period. From the load penetration curves after applying the corrections the CBR value of Locally Soil and Steel slag was found to be 5. The tests were then conducted on the Three optimum mixes i.e. 15S+ 85LS, 20S+80LS,25S+ 75LS. and find variation of CBR for the given curing period. The samples were first cured in humidity chamber at 30 degree temperature and 85% relative humidity for a period of 0, 7, 14, days and then soaked in water for 4 days prior to testing.

Table 4. CBR values of the optimum mixes

Curing Period	Soaked CBR values (%)		
(days)	15S + 85LS	20S + 80LS	25S + 75LS
0	10	23	35
7	14	27	39
14	26	32	43

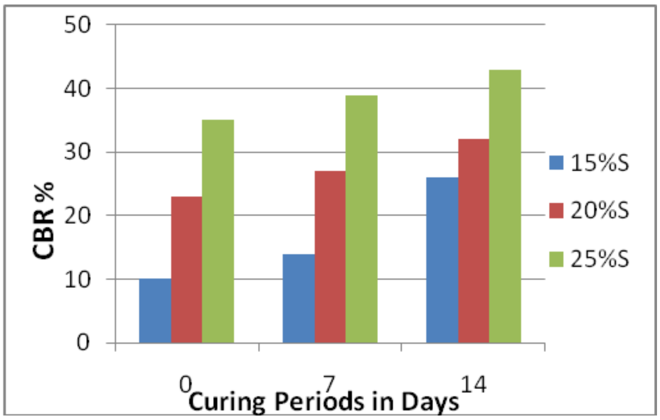

Fig.4.2.Variation of CBR Values with Curing Period

V. CONCLUSION

The feasibility of utilizing of Steel Slag and Local soil in construction of flexible pavement with variation of Percentage in soil. The following conclusions have been drawn.

1 Local soil is a material having specific gravity of 2.10 and Steel Slag having specific gravity 4.28.

2 Steel Slag was found to be non plastic in nature and liquid limit 42% and Local Soil is plastic Limit 29% and Liquid Limit 53% and The plasticity index the soil is determined as PI 24% indicating medium plastic in nature According to IS classification, soil is classified as GC i.e. Gravel with clay content. According to IS: 1498 (1970) classification Steel Slag is classified as GP i.e. Poorly graded gravel

3 It is observed that in the Local Soil and Steel Slag mix, with the increase in Steel Slag content there is an increase in MDD with the corresponding decrease in OMC.

4. High specific gravity and maximum dry density (20.8KN/M^3) of slag as compared to Local soil may be due to high percentage of iron oxide present in the slag.

5. Slag was observed to be highly crushable while soil was non crushable. When generated slag is being rolled by a roller, it is observed that gravel size material gets changed to sand size material. The material is also observed to be porous as indicated by moisture absorption test (10%).

6. The CBR values for the mixes of 25S+75LS increased with the increase in curing period.

7.The CBR value increases with Steel Slag content in Local Soil hence by using Steel Slag content it improves geotechnical properties of Locally available Soil which will be helpful for civil Engineering.

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