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Utilization of Industrial Waste Material in GSB Layer

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ABSTRACT
India has series of steel plant clusters located along its length and breadth of the territory. Several million metric tons of iron and steel are produced in these plants annually. Along with the production of iron and steel, huge quantities of solid wastes like blast furnace slag and steel slag as well as other wastes such as flue dust, blast furnace sludge, and refractories are also being produced in these plants. These solid wastes can be used as non-traditional/non-conventional aggregates in pavement construction due to acute scarcity of traditional/conventional road construction materials. A study was conducted to investigate the possibility of using Granulated Blast Furnace Slag (GBFS) with various blended mixes of traditional/conventional aggregates in subbase layer with different percentages. This study also presents the result of experimental investigation on the influence of Rice husk ash (RHA) on the index properties of Red soil which is used as filler material in subbase layer.

Keywords **-** California bearing ratio (CBR), Granular Subbase (GSB), granulated blast furnace slag (GBFS), Rice husk ash (RHA).

I. INTRODUCTION

The iron and steel slag that is generated as a by product of iron and steel manufacturing Industries 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. Blast furnace slag is dependent on method of cooling. There are four main types of blast furnace slag: i.e. granulated; air-cooled; expanded and palletised. Chemically, the blast furnace slag mainly contains silica (30–35 %), calcium oxide (28–35 %), magnesium oxide (1–6 %), and Al_2O_3/Fe_2O_3 1.8–2.5 %.

1.1 Literature Review

Many Tests on GBFS (Slag) show positive outcomes when it is used as Subbase level material. Ahmed Ebrahim Abu El-Maaty Behiry (2013) studied the effect of using steel slag that combined with limestone aggregates. A.K. Sinha, V.G. Havanagi, A. Ranjan And S. Mathur (2013) Steel slag waste material for the construction of road in various layers. Sudhir Mathur, S. K. Soni, And A.V.S.R. Murty (TRR 1652) Utilization of Industrial Wastes such as various slag's in Low-Volume Roads. By all this studies it has been observed that by using slag as replacement of natural aggregates gives a significant results for subbase and base layers. Rafat Siddique, Deepinder Kaur (2012) Properties of concrete containing ground granulated blast furnace slag (GGBFS) at elevated temperatures. Concrete containing GGBFS could possibly be used in applications involving elevated temperatures. Perviz Ahmedzade, Burak Sengoz (2009) Evaluation of steel slag coarse aggregate in hot mix asphalt concrete. The steel slag mixtures have the excellent engineering properties and good electrical conductivity.

In this study, Granulated blast furnace slag is used as Replacement of coarse aggregates in place of conventional aggregates in Subbase layer and modified Red soil is used as a filler material in subbase layer.

II. ROAD CONSTRUCTION MATERIALS

In this present work, the materials such as Red soil, RHA, Aggregates, Quarry Dust and GBFS were used. The soil sample used for this study is collected near Addurivalasa village, Parvathipuram mandalam, Vizianagaram district. Rice Husk Ash (RHA) used for this study is collected from Rajam town, Srikakulam district. Aggregates of 20 mm size passing (IS sieve) and Quarry Dust were procured from Ponduru a place nearer to Rajam town located in Srikakulam District–Andhra Pradesh. Granulated Blast Furnace Slag was produced from Sri Vishnu Sai Saravana Enterprises, Vizag- Andhra Pradesh.

2.1 Testing of the materials

The index properties of the Unmodified Red soil and Modified Red soil by using admixture (RHA) is determined by Atterberg's limit test as per IS: 2720 (part 5) and the results were tabulated as shown below.

Table 1 Atterberg Limits for Unmodified Red Soil/Red Soil With RHA

S. No	Property	Unmodified Red soil	Red soil+4% RHA
1	Liquid Limit (%)	28	25
2	Plastic Limit (%)	18.13	21.05
3	Plasticity Index (%)	9.87	3.95
4	Specific Gravity	2.33	2.45

According to MORT&H standards for a coarse graded GSB material. The material passing through 425 micron (0.425 mm) sieve, when Tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively. The modified red soil which satisfies the MORT&H standards in this study is used as a filler material in GSB layer.

2.2 Soil Classification

As per Indian Standard Classification system by atterberg limits of soil sample the given soil is inorganic clay of low plasticity (CL).
The properties of Aggregates, GBFS and Quarry Dust are as shown below.

Table 2 Engineering Properties of Aggregate

S.No	Property	Unmodified Aggregates
1	Impact value (%)	15.96
2	Crushing value (%)	22.97
3	Abrasion value (%)	21.28
4	Specific gravity	2.76
5	Water Absorption	1.44

Table 3 Properties of GBFS

S.No	Property	GBFS
1	Specific Gravity	2.37
2	MDD (kN/m³)	14.34
3	OMC (%)	20.60
4	Gravel size particles (%)	0.5
	Sand size particles (%)	97
	Fine size particles (%)	2.5

Table 4 Properties of Quarry Dust

S.No	Property	Quarry Dust
1	Liquid Limit(%)	NP
2	Plastic Limit(%)	NP
3	Specific Gravity	2.40

III. RESULT AND DISCUSSION

To determine the feasibility of GBFS material as a replacement of coarse aggregate in the Granular Subbase (GSB), coarse graded III according to MORT&H standards , gradation design was carried out by mixing the GBFS material with conventional aggregates, Quarry dust in different proportions and with different percentages of filler material (such as modified Red soil) is tried for evaluating the mix proportion by trial and error method. Modified Proctor's Compaction test was carried out to determine Maximum Dry Density and Optimum Moisture Content for given sample.

Table 5 Optimum Moisture Content (OMC) And Maximum Dry Density (MDD) of Blended Mixes With Different Percentages

Blend Sample Type	MDD (kN/m³)	OMC (%)
Aggregate	24.11	2.04
Aggregate replacement with10%GBFS	23.27	2.7
Aggregate replacement with 20%GBFS	22.86	3.67
Aggregate replacement with 30%GBFS	22.78	4
Aggregate replacement with 40%GBFS	21.23	4.05

The natural aggregates has the highest MDD and the lowest OMC. The MDD is significantly decreasing with increase of GBFS percentage (Fig.1) and OMC is increasing with increase of GBFS percentage (Fig.2). Since this difference is mainly attributed to the physical properties of natural aggregates which has the highest Specific gravity of 2.76 where as it is 2.37 for GBFS.

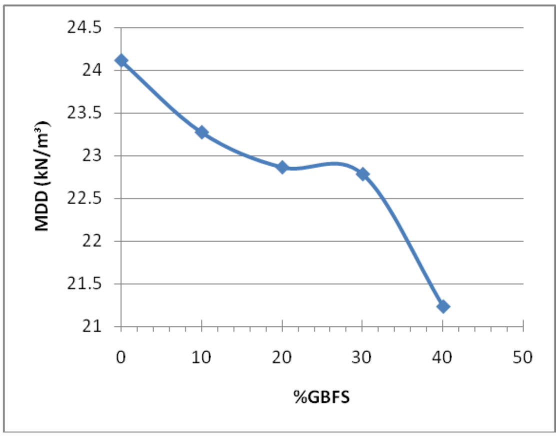

Fig.1 Max Dry Density For Various (%) GBFS

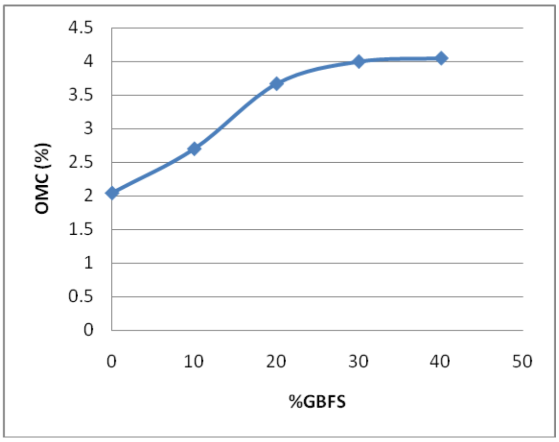

Fig.2 Optimum Moisture Content For Various(%) GBFS

To determine the strength of the GSB mixes, CBR test was carried out as per IS:2720- part 16. CBR test is carried out in both unsoaked and 4-day soaked conditions. The results are summarized in Table 6.

According to MORT&H standards the grading for coarse graded granular subbase materials of Grading III, the minimum CBR values for subbase is 20%. CBR value of GSB layer is increased with the addition of GBFS up to 20% . Further increase in GBFS tends to reduce in CBR value in both unsoaked and in 4-day soaked condition. The increase in CBR is mainly due to the Granulated blast furnace slag possesses cementitious properties by the virtue of hydration.

Table 6 CBR Values (Unsoaked And 4-Day Soaked) For Each Subbase Material

Blend Sample Type	**CBR (%)**	
	Unsoaked	**4-Day Soaked**
Aggregate	74.20	66.90
Aggregate replacement with10%GBFS	81.96	71.77
Aggregate replacement with 20%GBFS	104.46	98.08
Aggregate replacement with 30%GBFS	95.49	89.41
Aggregate replacement with 40%GBFS	82.87	68.12

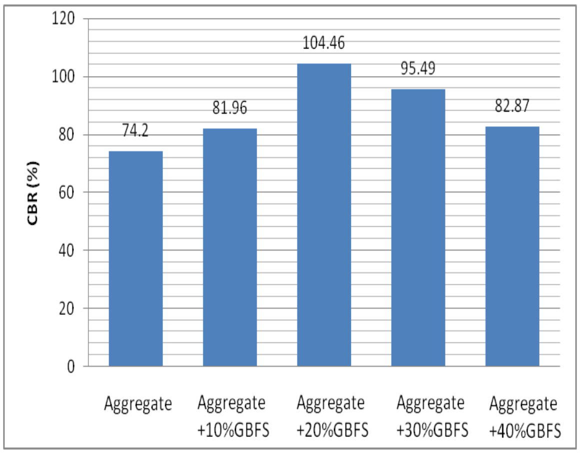

Fig.3 Unsoaked CBR Values For Each Subbase Material

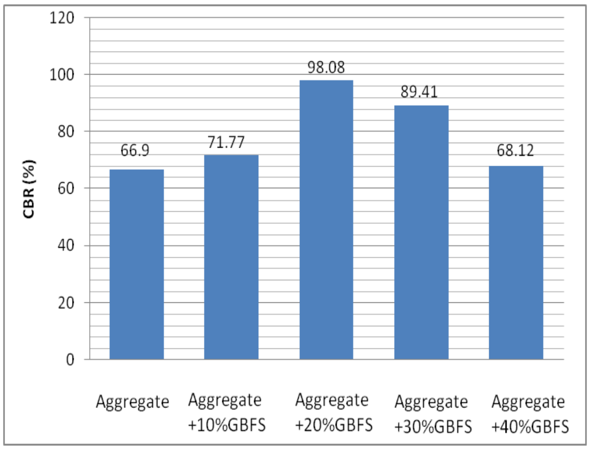

Fig.4 4-Day Soaked CBR Values For Each Percentage Of Subbase Material

IV. CONCLUSIONS

1. It is observed from the study that, with the addition of Rice Husk ash to the Red soil, the Liquid limit of the soil has been decreased and Plastic limit of the soil has been increased and the plasticity index decreased.
2. By Replacing aggregates with various percentages of Granulated Blast furnace Slag it has been observed that Max Dry Density of various blended mixtures has been gradually decreased.
3. By 20% replacement with GBFS the maximum CBR value for unsoaked is increased by 40.78%.
4. By 20% replacement with GBFS the maximum CBR value for 4-day soaked is increased by 46.60%.
5. Granulated Blast Furnace Slag can be used for the partial replacement of unmodified aggregate upto 20-30% in the construction of granular sub base layer.

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