A Comparative Study on Utilization of Waste Materials in GSB Layer

K V Subrahmanyam[1], U Arun Kumar[2], Dr. PVV Satyanarayana[3]
[1](Post graduate student, Department of Civil Engineering, GMRIT Rajam, AP, India)
[2](Associate Professor, Department of Civil Engineering, GMRIT Rajam, AP, India)
[3](Professor, Department of Civil Engineering, AUCOE Vizag, AP, India)

ABSTRACT : *The utilization of non conventional waste materials like steel slag, copper slag, Scrap Tyres, fly ash etc. in road construction activities is gradually gaining significant importance in India. Owing to the increase in construction cost of roads at an alarming rate there is an increase in the cost of conventional road materials. Steel slag is a waste material produced as a by-product during the oxidation of steel pellets in an electric arc furnace. This by-product can be used as replacement of aggregates in pavement layers. Due to increase in the motor vehicles day by day tends to increase in heaps of discarded rubber tyres. One of the main issues associated with the management of scrap rubber tyres has been their proper disposal. A study was conducted to investigate the possibility of using Granulated Blast Furnace Slag (GBFS) and also with Waste Rubber Tyre (WRT) with various blended mixes of conventional aggregates in subbase layer with different percentages separately. 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), Waste rubber tyre (WRT).*

1. INTRODUCTION

Slag is the by product of iron and steel manufacturing Industries which can be broadly categorized into blast furnace slag and steel making slag. 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.

Using waste rubber tyre shreds for civil engineering application has several advantages due to their unique properties. The most important property is that tyre shred is a lightweight material and relatively inexpensive compared to other light fill materials. Utilization of this waste material in road construction helps in disposal problem due to huge dumps of waste material and it will also help to preserve the natural reserves of aggregates.

1.1 Literature Review

Many Tests on GBFS show significant outcomes when it is used as Subbase 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) tried 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) studied the Utilization of Industrial Wastes such as various slag's in Low-Volume Roads. By all these studies it has been observed that by using slag as replacement of natural aggregates gives a significant result for subbase and base layers. Rafat Siddique, Deepinder Kaur (2012) studied 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. whereas by using Waste Rubber Tyre (WRT) in subgrade and subbase shows some significant results. C.N.V. Satyanarayana Reddy, K. Durga Rani (2013) conducted experimentation on potential of shredded scrap tyres in flexible pavement construction. R. M. Subramanian, S. P. Jeyapriya (2009) Studied on Effect of Waste Tyres in Flexible Pavement System. D. S. V. Prasad and G. V. R. Prasada Raju (2009) worked on the performance of waste tyre rubber on model flexible pavement. J. H. Lee, R. Salgado, A. Bernal, and C. W. Lovell (1999) tried shredded tires and rubber-sand as lightweight backfill. M. A. Rahman (1987) conducted a

Comparative study of the potentials of Rice Husk Ash on cohesive and cohesionless soils, and the study shows the effect on index and engineering properties of the soil by using the admixture.

In this present study, Granulated blast furnace slag and Waste rubber tyre materials are 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.

2. ROAD CONSTRUCTION MATERIALS

In this present work, the materials such as Red soil, RHA, Aggregates, Quarry Dust, GBFS and WRT were used. The soil sample used for this study is collected from Addurivalasa village, in 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. Waste Rubber Tyre was collected after processing the same as per required sizes from a Tyre Rebuttoning shop in Rajam town located in Srikakulam District – 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	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

As per Indian Standard Classification system by atterberg limits of soil sample the given soil is inorganic clay of low plasticity (CL).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.

The properties of various construction materials are tabulated as shown below.

Table 2 Engineering Properties of Aggregate

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

Table 3 Properties of GBFS

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 4 Properties of Quarry Dust

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

Table 5 Specific Gravity for materials

Property	Specific Gravity
Red soil	2.33
Red soil + 4%RHA	2.45
GBFS	2.37
Rubber Tyre	1.12

3. RESULTS AND DISCUSSION

To determine the feasibility of GBFS and WRT 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 and WRT material with conventional aggregates separately, 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 as per IS:2720- part 8 was carried out to determine Maximum Dry Density and Optimum Moisture Content for the given sample.

Table 6 Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of Blended Mixes With Different Percentages of GBFS

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

Table 7 Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of Blended Mixes With Different Percentages of WRT

Blend sample type	MDD (kN/m³)	OMC (%)
Aggregate	24.11	2.04
Aggregate replacement with 2%WRT	22.4	3.84
Aggregate replacement with 4%WRT	22.16	4.15
Aggregate replacement with 6%WRT	21.36	3.35
Aggregate replacement with 8%WRT	20.81	4.8

The natural aggregates have the highest MDD and the lowest OMC. It is observed the MDD is significantly decreasing in both cases with increase in percentages of GBFS and WRT. 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 and 1.12 for WRT.

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.

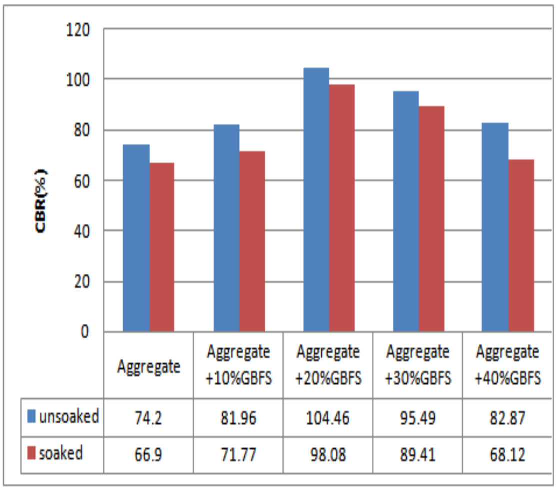

Figure.1 Unsoaked and 4-Day Soaked CBR Values for Each Percentage of Subbase Material

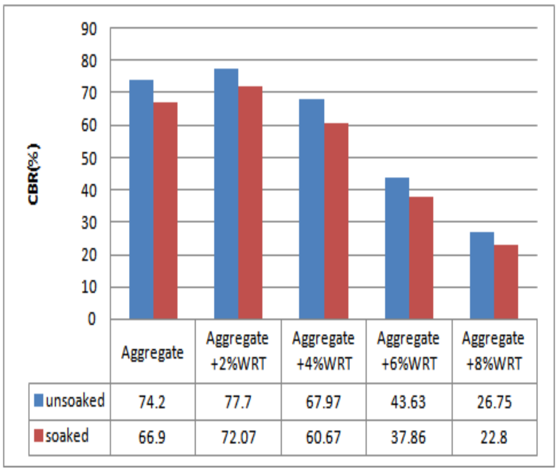

Figure.2 Unsoaked and 4-Day Soaked CBR Values for Each Percentage of Subbase Material

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. CBR value of GSB layer is increased with the addition of WRT at 2% . Further increase in WRT tends to reduce in CBR value in both unsoaked and in 4-day soaked condition.

Impact, crushing and abrasion tests were conducted on aggregate mixed with various percentages of waste rubber tyre pieces by weight. The results obtained are graphically plotted .

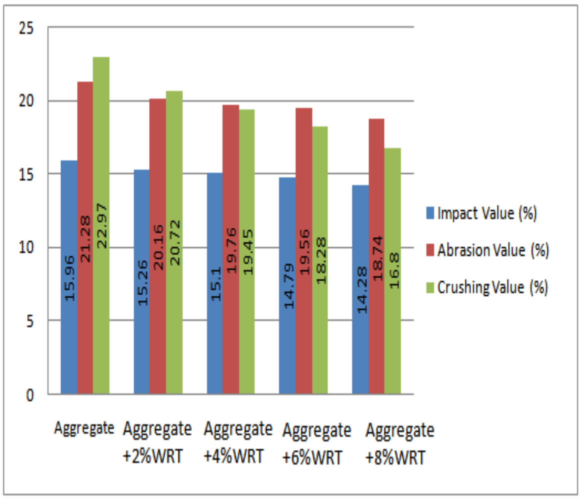

Figure.3 Comparison of Impact Value , Abrasion Value, Crushing Value with Various Percentages of WRT

From Fig.3, it can be seen that there is a decrease in abrasion value, crushing value, impact value with increasing percentage of waste rubber tyre pieces.

4. 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. It has been observed that by replacing aggregates with various percentages of GBFS and WRT the 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% whereas, the CBR value for 4-day soaked is increased by 46.60%.
4. 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.
5. By 2% replacement with WRT the maximum CBR value for unsoaked is increased by 4.71%. whereas, the CBR value for 4-day soaked is increased by 7.7%.
6. By Replacement of aggregate with 2% Waste Rubber Tyre pieces, it has been observed that the aggregate Impact value decreased by 4.38%, Abrasion value decreased by 5.26%, Crushing value decreased by 9.79% .
7. Aggregates when partially replaced by 2% waste rubber tyre pieces showed considerable

decrease in abrasion value, crushing value and impact value which proves them to be better composite material in the subbase layer of the pavement system.

REFERENCES

.

[1] Ahmed Ebrahim Abu El-Maaty Behiry,*Evaluation of steel slag and crushed limestone mixtures as subbase material in flexible pavement, in Elsevier, Ain Shams Engineering Journal* (2013) *4*, 43–53.

[2] Sinha A.K, Havanagi A.K, Ranjan A and Mathur S, *Steel slag waste material for the construction of road, in Indian Highways*, October 2013,pp13-20.

[3] Sudhir Mathur, S. K. Soni, And A.V.S.R. Murty, *Utilization of Industrial Wastes such as various slag's in Low-Volume Roads*, (TRR 1652).

[4] Rafat Siddique, Deepinder Kaur,*Properties of concrete containing ground granulated blast furnace slag (GGBFS) at elevated temperature*", *Journal of Advanced Research* (2012) *3*, 45–51.

[5] Satyanarayana Reddy C.N.V and Durga Rani K,*Potential of Shredded Scrap Tyres In Flexible Pavement Construction, in Indian Highways*, October 2013,pp 07-12.

[6] Subramanian R. M and Jeyapriya S. P, *Study on Effect of Waste Tyres In Flexible Pavement System, Indian Geotechnical Society Chennai Chapter, students Paper Competition*, 2009.

[7] Prasad D. S. V and Prasada Raju G. V. R , *Performance of Waste Tyre Rubber on Model Flexible Pavement, in ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, Vol. 4, No. 6*, August 2009, 89-92.

[8] J. H. Lee, R. Salgado, A. Bernal, C. W. Lovell**,** *Shredded Tires And Rubber-Sand As Lightweight Backfill, in Journal Of Geotechnical And Geoenvironmental Engineering*, February 1999, 132-141.

[9] Rahman M. A, *A Comparative study of the potentials of Rice Husk Ash on cohesive and cohesionless soils, in Pergamon Journals Ltd, Vol. 22, No. 4*, pp. 331-337,1987.

[10] IS 2386 (part IV)-1963: Indian Standard Methods of Test for Aggregates for Concrete, Indian Standards Institution.

[11] IS 2720 - Methods of Test for Soils, Indian Standards Institution.