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Performance evaluation of stabilized GSB mix- A quantitative study

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ABSTRACT : *In general the life and strength of pavements depends on the quality GSB layer. GSB layer is usually provided over subgrade and is influential in distribution of stresses within pavement. In general a GSB layer composes blended aggregates, crushed bricks. The strength of GSB is dependent on the mix proprtions adopted in its preparation. In view of its importance in pavements MORT&H has stipulated guide lines in preparing and grading a GSB layer considering CBR as basis. During recent past improvememt of strength of GSB stabilized with waste materials is gaining popularity. Few of the waste materials adoptable for GSB being granulated blast furnace slag(GBFS) and waste rubber tyre chips(WRT). The utlilization of waste materials for improvement not only reduces costly natural aggregate quantity but also helps in bulk consumption of waste. In the present study an attempt is made to study the performance improvement of various GSB mix stabilized with GBFS and waste rubber tyre chips. The filler material used being stabilized locally available soils with Rice husk ash (RHA) satisfying requirements of MORTH. The results indicated that the strength of GSB can be improved with admixtures. However the improvement is limited owing to the properties of admixture itself and the content of admixture in the stabilized mix apart from test conditions. GBFS has proven to be high performing over waste rubber tyre chips. An improvement up to 1.4 times is observed with GBFS when compared with WRT. Further the effect of soaking test conditions is marginal on both the type admixtured soil.*

KEYWORDS : *GBFS, GSB, performance, standard GSB Mix, WRT*

I. INTRODUCTION

Pavements usually require large quantities of material to be used in various layers. The layers of characterized with their strength i.e CBR and their thickness. In majority of pavements sub base and base course layers are constructed using granular material popular as GSB, The Granular sub base layer (GSB) composed of compacted layers made of aggregate or crushed bricks with soil as filler. The strength of this GSB layer has a limitation owing to the material property and gradation. The thickness of this layer is important for gradual transfer of stresses within pavement. In general weaker subgrades needs stronger GSB layer above it. Indian Road congress(IRC) has provided guide lines for minimum thickness of each course which is based on million standard axles(msa), CBR value of GSB and of subgrade. IRC has suggested material to be as filler being soil comprising definite plasticity properties. In view bulk requirements of GSB, to reduce cost and preserve natural materials locally available weak soils as filler and waste material replacing aggregate can be used. (M. A. Utilization of RHA in soil improves index and engineering properties of soil [1,2].The lime clayey soil mixture exhibits higher strength compare to clayey soil fly ash mixture [3]. The influence of fly ash on organic and inorganic clayey soils is different; strength improvement with varying percentage of fly ash for inorganic soils is high compared to organic soils [4]. Influence of waste sand on engineering properties on clayey soils varies with varying percentages and CBR value increased by 20% with the addition of 20% of waste sand [5]. The influence of sand on cohesive soil is significant and with addition of 15% of fine sand strength of soil is doubled [6]. The lab performance studies are comparable with field for stabilized soft subgrade [7]. Studies using waste material has given good response for GSB improvement [8,9,10,11]. The effect of higher temperatures in concrete pavements and hot mix asphalt can be reduced with admixtures [12,13]. Waste Rubber Tyre (WRT) admixture has also proved its influence in subgrade and subbase and back fills [14,15,16,17].

II. OBJECTIVE AND SCOPE OF PRESENT STUDY

[1] To improve the Index properties of the soil with Rice Husk Ash as an admixture for utilizing as a filler material in GSB mix.
[2] To identify different proportions of admixtures for preparation of standard GSB mix as MORTH norms
[3] Studies on various GSB mix modified using admixtures GBFS and Waste Rubber Tyre chips for engineering properties and optimum dosage of admixture.
[4] Studies on Performance improvement with GBFS and WRT

III. MATERIALS USED AND METHODOLOGY ADOPTED

In this present work, locally available Red soil, Rice husk ash (RHA), Aggregates, Quarry Dust, GBFS and WRT were used. Aggregates of 20 mm size passing (IS sieve) and Quarry Dust were procured from a nearby crusher. Granulated Blast Furnace Slag collected from steel plant, Visakhapatnam, Andhra Pradesh. Waste Rubber Tyre chips are extracted locally from a tyre shredding plant. The methodology adopted is presented in Fig. 1

IV. DETAILS OF SAMPLES AND PREPARATION OF DESIGN MIX

The tests are carried out on admixture modified coarse aggregate (graded) through replacement of coarse aggregate sample with admixtures. In total three types of admixtures are used in study namely, rice husk ash, GBFS and Waste rubber tyre chips. Rice hush ash is used as admixture to soil for preparing filler material and GBFS & rubber tyre chips are for coarse aggregate. Procedures listed by IS specifications and manuals of MORTH specifications for Road and Bridge works are adopted for carrying out tests. The details of IS codes and MORTH manual are listed in References. Tests are conducted on nine (9) types of samples prepared as per MORTH standards by maintaining their gradation using various blending material, admixture and filler. Of the samples five are prepared using GBFS and the remaining using WRT. The sample preparation and testing is carried out in the following phases as i) Soil samples with varying rice husk ash content are tested for their plasticity properties and sample with Liquid limit below 25 and plasticity index below 6 is selected . This sample is later used as filler, ii) The graded aggregate is prepared by blending quarry dust to coarse aggregate. To the aggregate mix thus prepared filler material is added. The composite mixture is tested with varying admixtures namely GBFS and WRT.iii) The blending materials and admixtures are quarry dust varied from 25 to 40 (%), filler from 1 to 6% , GBFS from 0 to 40% and WRT from 0 to 8% respectively. iv) The performance studies are carried out for CBR maintaining optimum conditions of aggregate proportion, GBFS/ WRT and filler content determined through modified proctor test. The cross section of the CBR mould consists of Aggregate mix with the admixtures GBFS and WRT chips have been show in the Fig.2 and Fig.3 and test set up is shown in Fig. 4(a) and (b) respectively.

V. RESULTS AND DISCUSSION

The results are presented in Tables 1 to 7 and Fig 5 to 8. Results are presented through performance ratio as discussed in subsequent headings.

5.1 Details of performance ratio's and their notation.

Performance ratio are computed as follows.

$$R_f = \frac{\text{modified with Admixture}}{\text{unmodified value}} \;\ldots\ldots\ldots \quad (1)$$

$$R_{fm} = \frac{\text{modified MDD value with Admixture}}{\text{unmodified MDD value}} \;\ldots\ldots(2)$$

$$R_{fo} = \frac{\text{modified OMC value with Admixture}}{\text{unmodified OMC value}} \;\ldots\ldots(3)$$

$$R_{fcu} = \frac{\text{modified CBR unsoaked value with Admixture}}{\text{unmodified CBR unsoaked value}} \quad \ldots\ldots(4)$$

$$R_{fcs} = \frac{\text{modified CBR soaked value with Admixture}}{\text{unmodified CBR soaked value}} \quad \ldots\ldots\ldots(5)$$

Presentation of OMC and MDD Performance Improvement Ratio: Effect of Admixture In the experimental study tests are carried out on admixtures modified aggregate samples for their engineering properties. The Performance improvement ratio for MDD, R_{fm} and OMC, R_{fo} is presented in Table 4 to 5 and from Fig. 5 to 6. It is observed that the effect of admixture on MDD is marginal. Whereas R_{fo} show's a considerable improvement with admixture. This may be due to the increase in absorption by GBFS, Quarry dust and filler combination. The R_{fm} is found to be decreased from 1 to 0.88 . R_{fo} is found to be increased from 1 to 1.99. Similar results are noticed with WRT admixture also. The same is presented in Fig. 6 and Table 5. The R_{fm} is found to be decreased from 1 to 0.86. R_{fo} is found to be increased from 1 to 2.35 with waste rubber tyres.

Presentation of CBR Performance Improvement Ratio: Effect of Admixture.

The Performance improvement ratio for CBR unsoaked, R_{cu} and CBR soaked, R_{fcs} is presented in Table 6 to 7 and from Fig. 7 to 8.

The Variation of R_{fcu} and R_{fcs} with various percentages of admixture is presented in Table 6 and Fig. 7. The trend is similar in soaked and unsoaked performance with admixture. It is observed that the with admixture the CBR performance for both unsoaked and soaked values has been increased upto 20% and later decreased. The increase in CBR is mainly due to the Granulated blast furnace slag possesses cementitious properties by the virtue of hydration. The R_{fcu} is found to be increase by 1 to 1.41 and then decreases, R_{fcs} is found to be increased by 1 to 1.47 and then decreases.The Variation of R_{fcu} and R_{fcs} with various percentages of admixture is presented in Table 7 and Fig. 8. The trend is similar in soaked and unsoaked performance with admixture. It is observed that the with admixture the CBR performance for both unsoaked and soaked values has been increased upto 2% replacement further increment of admixture tends to decrease in the improvement performance this is due to bad interlocking between the graded sample. The R_{fcu} is found to be increased by 1 to 1.05 and then decreases, R_{fcs} is found to be increased by 1 to 1.07 and then decreases. Upon comparison GBFS is more effective than WRT for obtaining improvement in CBR. It is seen that the optimum improvement with GBFS is 1.34 times to that of WRT. Based on the content of GBFS and WRT at optimum Results i.e., 20% and 2% it will be economical to use GBFS than WRT.

VI. CONCLUSIONS

1. Red soil being in abundant quantity can be used as filler for pavements. However due to the limitation in its plasticity properties, can be used in combination with Rice Husk ash. The combined soil has exhibited reduction in plasticity and is satisfying the MORTH standards. An optimum content of 4% rice husk ash has given the desired plasticity required as per MORTH.

2. The influence of Granulated blast furnace slag and waste rubber tyre chips is marginal on MDD and high for OMC. The OMC is found to increase by 1.9 times with GBFS and 2.3 times with WRT as compared with unmodified aggregate. An optimum filler content of 5% with GBFS and 2% with WRT is recommended for best results.

3. It is concluded that the efficacy of GBFS is higher to that of WRT. At optimum conditions CBR increase with GGBS from 40.78% and 46.60% at 20% GBFS content is very high to that with WRT i.e from 4.71% to 7.7% at 2% .

4. From the results on mix proportions, considering economical aspects and preparation of mix, it is concluded that mix of 1:0.43:0.29 &1:0.54:0.46 with GBFS and 1:0.43:0.03 with WRT will be suitable and adoptable as per MORTH specifications for pavements.

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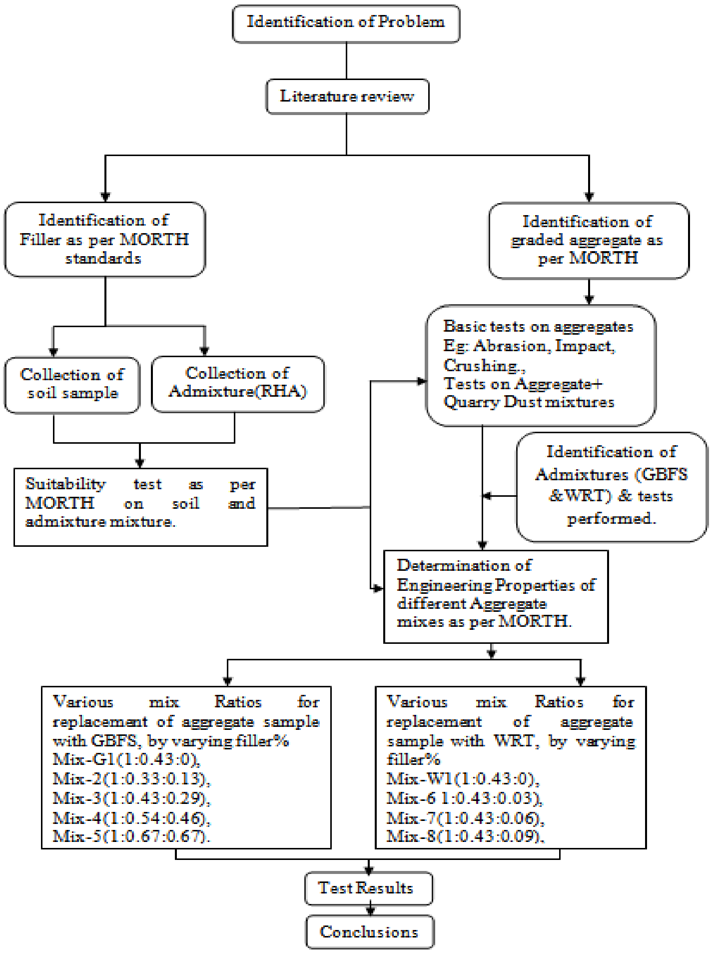

Figure.1 Methodology

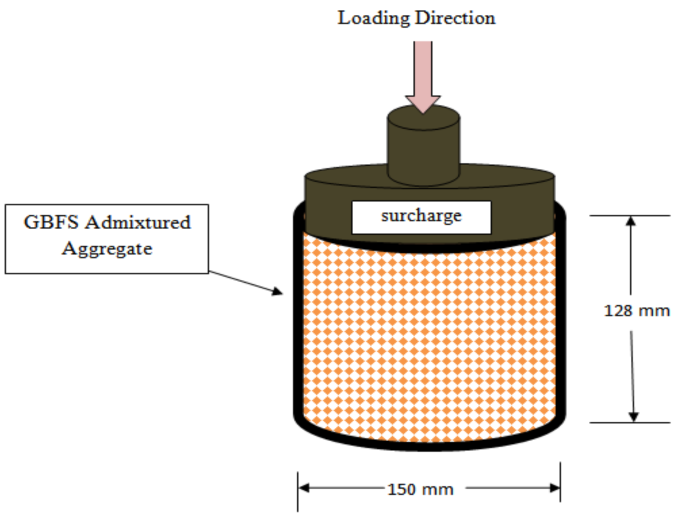

Figure.2 Schematic Cross section of CBR sample with admixture GBFS

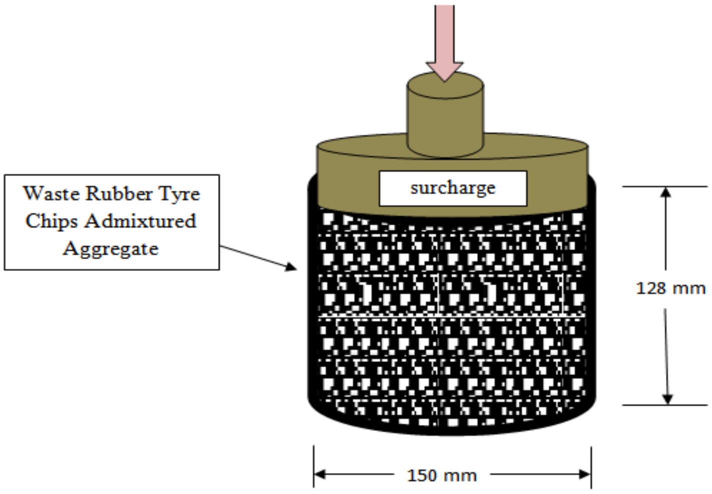

Figure. 3 Cross section of CBR sample with admixture Waste Rubber Tyre Chips

(a)

(b)

Figure. 4 (a) Author preparing sample Mix (b) Author performing CBR test

Table-1 Properties of materials

Property	Red Soil	Red Soil+4%RHA	GBFS	WRT	Quarry Dust
Specific Gravity	2.33	2.45	2.38	1.13	2.40
Liquid Limit(%)	28	25	NP	-	NP
Plastic Limit(%)	18.13	21.05	NP	-	NP
Plasticity Index(%)	9.87	3.95	NP	-	NP

Table-2 Details of mix using GBFS admixture according to the MORTH

Sample	Aggregate % (Retained on 4.75mm) & mix proportion	Quarry dust% (Passing 4.75mm) & mix proportion	GBFS %& mix proportion	Filler %	
				Composition	Optimum obtained
S0-4	70 & (1)	30 &(0.43)	0& (0)	2,4,6	4
S10-5	75 & (1)	25 & (0.33)	10& (0.13)	4,5,6	5
S20-5	70 & (1)	30 & (0.43)	20 & (0.29)	3,4,5,6	5
S30-3	65 & (1)	35 & (0.54)	30 & (0.46)	1,2,3,4	3
S40-2	60 & (1)	40 & (0.67)	40 & (0.67)	1,2,3,4	2

Table-3 Details of mix using WRT admixture according to the MORTH

Sample	Aggregate% (Retained on 4.75mm) & mix proportion	Quarry dust% (Passing 4.75mm) & mix proportion	WRT%& mix proportion	Filler%	
				Composition	Optimum obtained
S0-4	70 & (1)	30 & (0.43)	0 & (0)	2,4,6	4
S2-2	70 & (1)	30 & (0.43)	2 & (0.03)	1,2,3,4,5	2
S4-4	70 & (1)	30 & (0.43)	4 & (0.06)	3,4,5	4
S6-4	70 & (1)	30 & (0.43)	6 & (0.09)	3,4,5	4
S8-4	70 & (1)	30 & (0.43)	8 & (0.11)	3,4,5	4

Table-4 MDD & OMC performance improvement ratio with GBFS

Blend Sample Type	R_{fo}	R_{fm}
S0-4	1	1
S10-5	1.32	0.97
S20-5	1.8	0.95
S30-3	1.96	0.94
S40-2	1.99	0.88

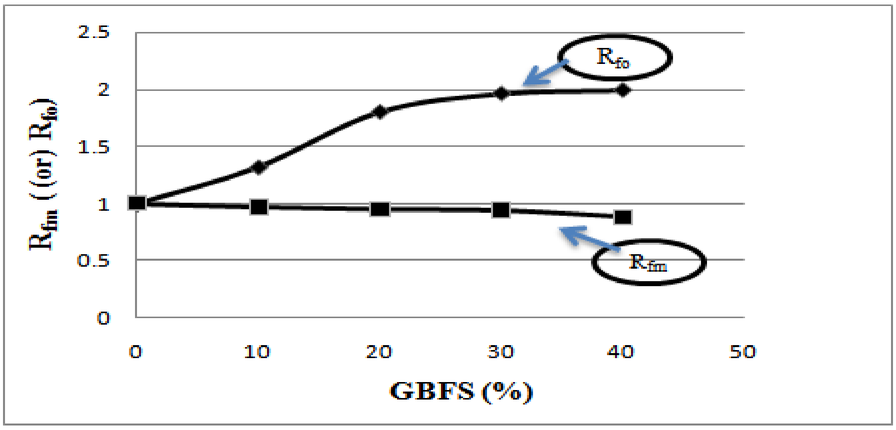

Figure. 5 Performance improvement ratio of MDD & OMC with GBFS

Table-5 MDD & OMC performance improvement ratio with WRT

Blend Sample Type	R_{fo}	R_{fm}
S0-4	1	1
S2-2	1.88	0.93
S4-4	2.03	0.92
S6-4	1.64	0.89
S8-4	2.35	0.86

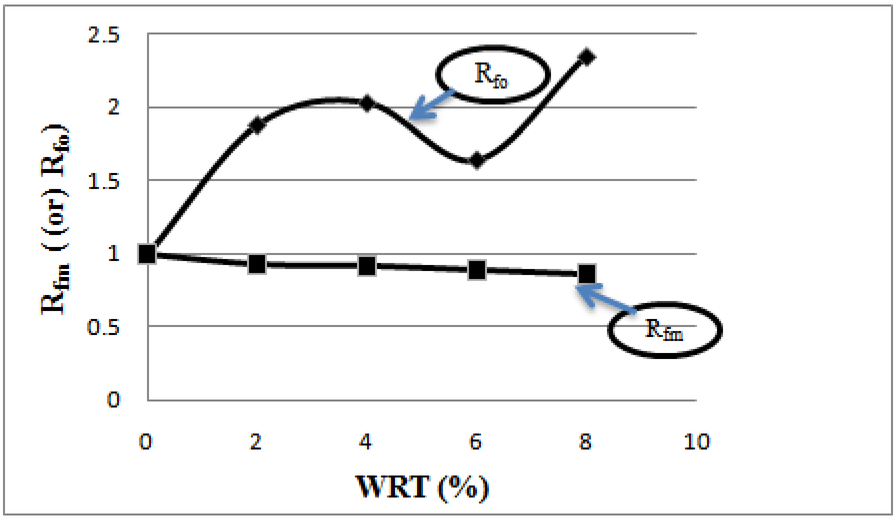

Figure. 6 Performance improvement of MDD & OMC with WRT

Table-6 CBR performance with GBFS in both Unsoaked and Soaked

Blend Sample Type	CBR (%)	
	R_{fcu}	R_{fcs}
S0-4	1	1
S10-5	1.1	1.07
S20-5	1.41	1.47
S30-3	1.29	1.34
S40-2	1.12	1.02

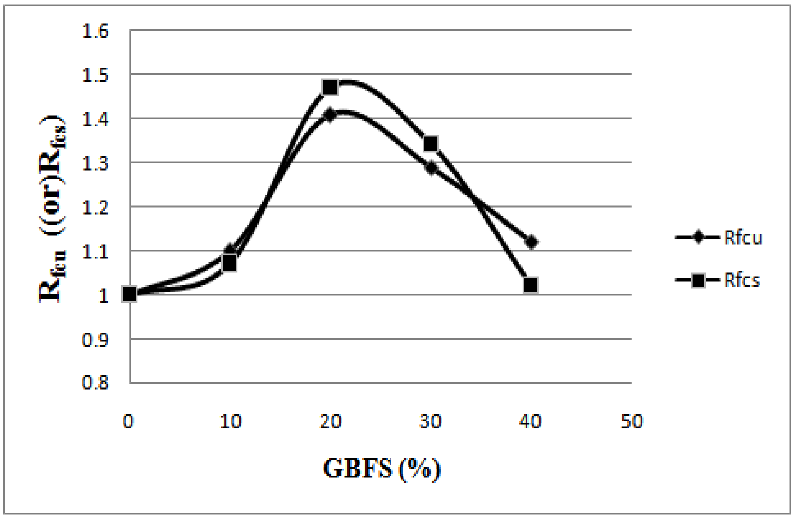

Figure. 7 Performance improvement of CBR with GBFS

Table- 7 CBR performance with WRT in both Unsoaked and Soaked

Blend Sample Type	**CBR (%)**	
	R_{fcu}	R_{fcs}
S0-4	1	1
S2-2	1.05	1.07
S4-4	0.92	0.91
S6-4	0.59	0.57
S8-4	0.36	0.34

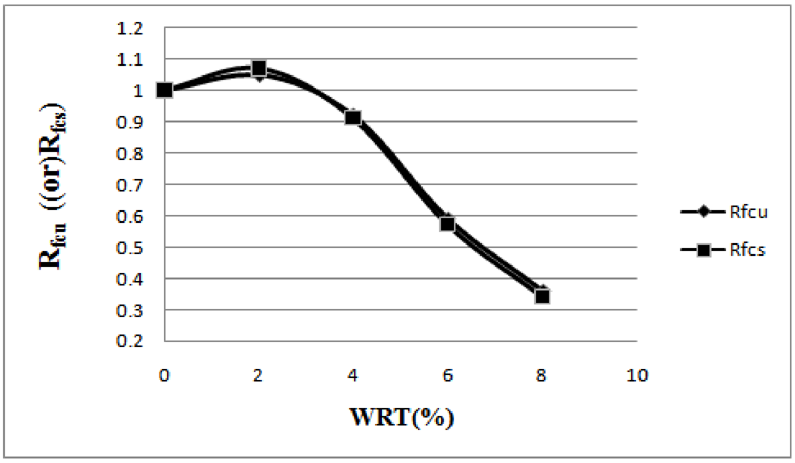

Figure. 8 Performance improvement of CBR with WRT

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