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The Influence of GGBS and Glass Fibers on Flexural Strength of Concrete Pavement

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ABSTRACT: *The present paper deals with study offlexuralstrength of rigid road pavements by replacing 15% of fine aggregate with M sand. Water binder ratio of 0.30isused where cement is partially replaced by Ground Granulated Blast Furnace Slag by0%, 10%, 20% and 30% which is a mineral admixture and Glass Fibresare added by 0.5% and 0.75%. To improve workability of mixes, super plasticizerConplast SP-430is used (0.8%).This study examines flexuralstrength of concrete mixtures containing various combinations of GGBS based Glass Fibre reinforced concrete pavement mixes designed by Absolute Volume Method. Beams of 100x100x500 mm are cast, cured for 7 & 28 days before testing. The results are analyzed and useful conclusions are drawn.*

Keywords:*GGBS, M Sand, Concrete Pavement, Glass Fibres, Flexural Strength, Sand Replacement, Rigid Pavement.*

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I. INTRODUCTION

Rigid pavements are those which possess noteworthy flexural strength or flexural rigidity. The rigid pavements are generally made of Portland cement concrete (CC) and are therefore called 'CC pavements'. Plain cement concrete pavement slabs made of specified strength characteristics are laid, with or without steel reinforcement at the joints. Most common material used for the design and construction of rigid pavements is high quality plain cement concrete meant for the pavement, generally called 'Pavement Quality Concrete' (PQC). The CC pavements slabs can made of PQC are generally expected to sustain up 45 kg/cm2 of flexural stresses.

The surface of the road should be stable and non–yielding, to allow the heavy wheel loads of road traffic to move with least possible rolling distance. The road surface should also be even along the longitudinal profile to enable the fast vehicles to move safely and comfortably at the design speed. At high moisture contents, the soil becomes weaker and soft and starts yielding under heavy wheel loads, thus increasing the resistance to traction. The earth road may not be able to fulfil any of the above requirements, especially during the varying conditions of traffic and the weather changes. Therefore a pavement consisting of superior and stronger materials is laid over the prepared earth surface which could fulfil the above requirements.

The objective of laying a pavement is to support the wheel loads and to transfer the load stresses through the wider area on the soil sub- grade below. Thus the magnitude of the stresses transferred to the sub grade soil through the pavement layers are considerably lower than the contact pressure or flexural stresses directly under the wheel load applied on the pavement surface. In this regard a good flexural strength bearing concrete pavement is a necessacity.

II. LITERATURE REVIEW

Ashok PG, Akmalali Khan et al,did much research on workability and mechanical properties of concrete. Their research aimed to find the workability and mechanical properties of glass fibre reinforced concrete in fresh and hardened state using mineral admixture Ground Granulated Blast Furnace Slag and Metakaolin using varying percentage of Glass Fibre from about 0 % to 0.5% with about 6mm and 12mm length of glass fibre by weight of concrete with 0.8 % of super plasticiser.In the following work, slump flow, T 50 slump flow, V funnel and L box test were conducted on fresh concrete and compression test, split tensile test, flexural strength test with load deflection characteristics and modulus of elasticity with stress-strain relationship on hardened concrete were tested. Slump flow, V funnel and L box test were conducted to know the workability of fibre reinforced concrete (FRC) and it was found that slump was 660 to 600mm from 0 to 0.5 % of fibre by weight of concrete respectively , and V funnel was around 7 to 11 seconds of flow for 0 to 0.5% of fibre by weight of concrete respectively and blocking ratio values was 0.98 to 0.82 which is all good as per codal provision for a good concrete mix for a FRC and mechanical properties such as flexural test, split tensile test and flexural strength test and young's modulus GFRC were determined and was found that there was an increase in flexural strength up to 125% for 0.25 % of fibre added to concrete mix as compared to normal conventional concrete.

Dhanya Radhakrishnan, Ganapathy Ramasamy et al, dealt with the study of the strength parameters of concrete by partial replacement of cement by ground granulated blast furnace slag (GGBS). The tests were conducted as per Bureau of Indian standards (BIS) to evaluate the suitability of GGBS as a partial replacement of cement. The glass fiber was used to increase the toughness of the concrete. Various strength parameters such as flexural strength, split tensile strength of concrete for a grade of M25 was tested and recorded. The partially replaced concrete showed an increase in strength as compared to conventional concrete. Various mix combinations with a partial replacement of 10%, 20%, 30% and 40% by the weight of cement by GGBS was taken and 0.5%, 1% and 1.5% steel fiber of hooked end type of aspect ratio 50-60 were used. The test results show that the partial replacement of cement by both GGBS and steel fiber has an increase in the strength of concrete. Considering all the strength parameters into account it was found that a 30% replacement of GGBS with 1% steel fiber is optimum for M25 mix.

III. MATERIALS

The details of the various materials used in this investigation are given in the following sections.

3.1Cement

Ordinary Portland cement of 43 grade of Ultratech brand conforming to IS: 12269 standards were used in this investigation. The specific gravity of the cement was 3.08. The initial and final setting times were found as 45 minutes and 575 minutes respectively.

Table 1:Properties of Cement

SL.NO	Material properties	Results
1	Sp gravity	3.08
2	Fineness	4%
3	Normal consistency	28%
4	Initial setting time	45mins
5	Final setting time	9hrs 35 mins

3.2 Fine Aggregate

Fine Aggregatesusedwas collected in and around Bellary conforming IS 383-1970 passing 4.75 mm

Table 2:Properties of Fine Aggregate

SL.NO	Properties	Natural sand	M sand
1	Sp gravity	2.60	2.56
2	Bulk density	1.75 kg/m^3	1.77 kg/m^3
3	Impurities	5 to 10%	Nil
4	Fineness modulus	2.60	3.10

3.3 Coarse Aggregate

Crushed granite aggregate available from local sources has been used.

Table 3:Properties of Coarse Aggregate

SL.NO	Properties	Coarse aggregate
1	Sp gravity	2.70
2	Bulk density	1.650 kg/m^3
3	Fineness modulus	7.19

3.4Water Used

Potable fresh water available from local sources was used for mixing and curing of mixes.

3.5Mineral Admixtures

Ground Granulated Blast Furnace Slag (GGBS) is used as mineral admixture and its specific gravity is 2.85.

3.6Glass Fibres

Glass fibers of length 12mm and a high dispersion capacity of 200 million filaments per kilogram are used in this study.

IV. METHODOLOGY

The main aim of the experimental program is to study the Flexural Strength of concrete. Cement is partially replaced with GGBS in the proportion of 0%(Reference mix), 10%, 20% and 30% by weight. Glass fibers in two percentages i.e 0.5% and 0.75% were used. Natural River Sand is replaced by M Sand of 15%. To improve workability of mixes, super plasticizerConplast SP-430is used by 0.8%.The materials are weighed and dry mixed thoroughly after the measured amount of water for Water cement ratio of 0.3is added and the material is mixed thoroughly until it becomes uniform. Concrete produced are filled in 100x100x500mmbeammoulds. After 24 hours of casting, the specimens are de-molded and kept for curing.The specimens were tested after 7 and 28 days of curing for the Flexural strength in accordance with Bureau of Indian Standards. For each trail, 3 beams were cast and tested at the age of 7 and 28 days. The average values of flexural strength were adopted in each case.

V. RESULTS AND DISCUSSIONS

5.1 Effect of variation of GGBS for various percentages of Glass Fibres on flexural strength of pavements

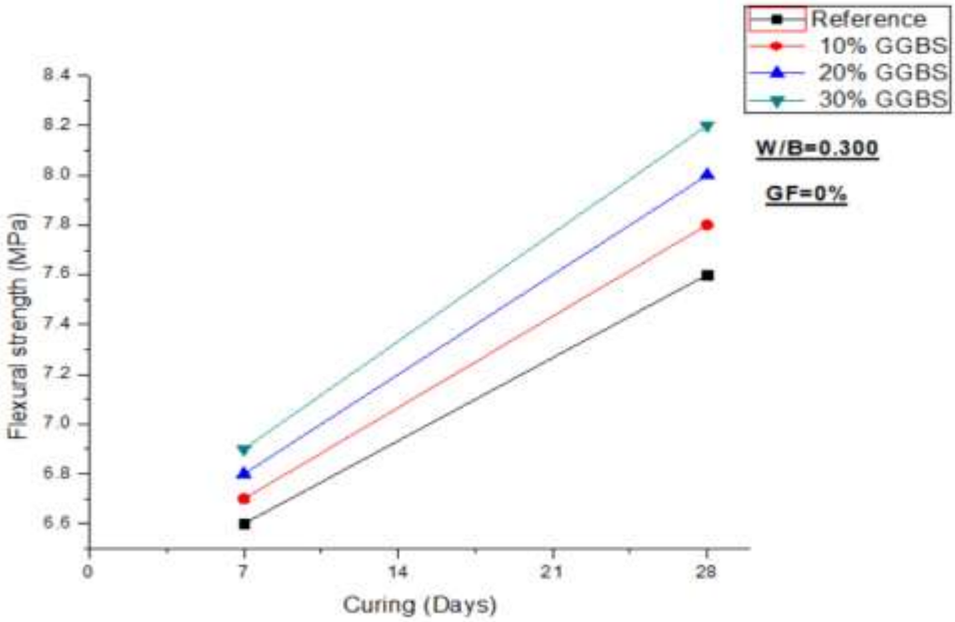

Figure 1:Flexural Strength for various Percentages of GGBS for 0% G.F

The above graph shows 7 days and 28 days Flexural Strength for variation in GGBS percentages for W/B=0.3 and G.F=0%. It can be observed that for all the percentages of GGBS the flexural strength increases from 7 days to 28 days. For 10% GGBS replacement, flexural strength is increased by 14.10% for 28 days with respect to 7 days strength. For 20% GGBS replacement, flexural strength is increased by 15% for 28 days with respect to 7 days strength. For 30% GGBS replacement, Flexural strength is increased by 15.85% for 28 days with respect to 7 days strength.

From figure 1, it can be observed that flexural strength increases with increase in GGBS percentage for both 7 days and 28 days. 7 Days Flexural strength increases by 1.49% for 10% GGBS, 2.94% for 20% GGBS and 4.34% for 30% GGBS compared to reference mix. 28 Days Flexural strength increases by 2.56% for 10% GGBS, 5% for 20% GGBS and 7.31% for 30% GGBS compared to reference mix.

Maximum 28 Days Flexural strength obtained is 8.2 MPa and is for mix with 30% GGBS and is increased by 7.31% compared to reference mix.

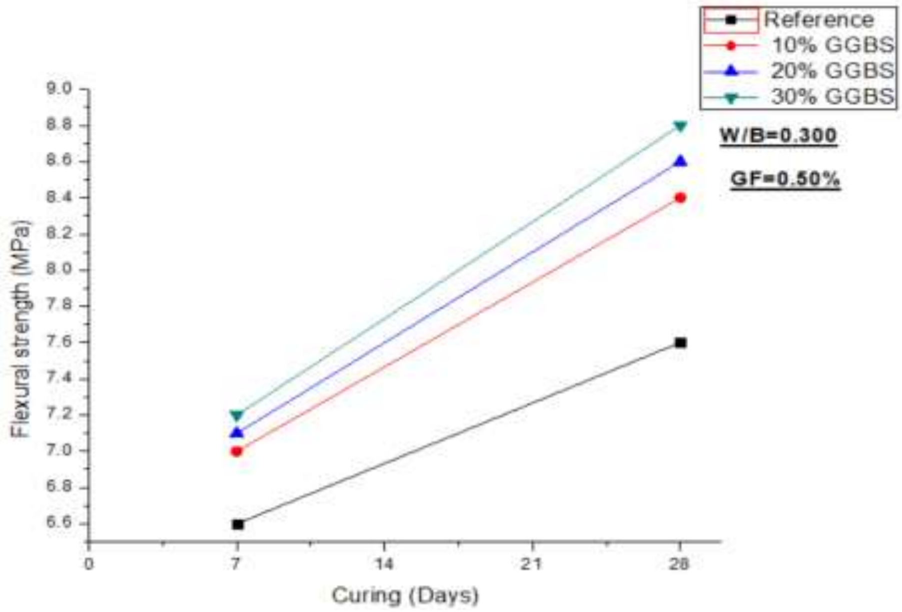

Figure 2: Flexural Strength for various Percentages of GGBS for 0.5% G.F

The above graph shows 7 days and 28 days Flexural Strength for variation in GGBS percentages for W/B=0.3 and G.F=0.5%. It can be observed that for all the percentages of GGBS the flexural strength increases from 7 days to 28 days. For 10% GGBS replacement, flexural strength is increased by 16.67% for 28 days with respect to 7 days strength. For 20% GGBS replacement, flexural strength is increased by 17.44% for 28 days with respect to 7 days strength. For 30% GGBS replacement, Flexural strength is increased by 18.18% for 28 days with respect to 7 days strength.

From figure 2, it can be observed that flexural strength increases with increase in GGBS percentage for both 7 days and 28 days. 7 Days Flexural strength increases by 5.71% for 10% GGBS, 7.04% for 20% GGBS and 8.33% for 30% GGBS compared to reference mix. 28 Days Flexural strength increases by 9.52% for 10% GGBS, 11.62% for 20% GGBS and 13.63% for 30% GGBS compared to reference mix.

Maximum 28 Days Flexural strength obtained is 8.8 MPa and is for mix with 30% GGBS and is increased by 13.63% compared to reference mix.

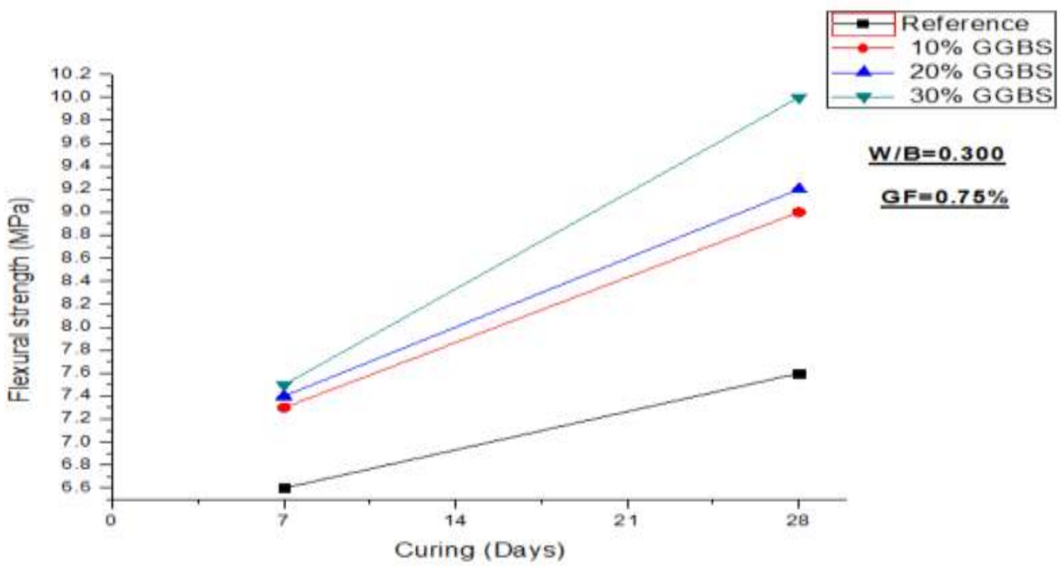

Figure 3:Flexural Strength for various Percentages of GGBS for 0.75% G.F

The above graph shows 7 days and 28 days Flexural Strength for variation in GGBS percentages for W/B=0.3 and G.F=0.75%. It can be observed that for all the percentages of GGBS the flexural strength increases from 7 days to 28 days. For 10% GGBS replacement, flexural strength is increased by 18.89% for 28 days with respect to 7 days strength. For 20% GGBS replacement, flexural strength is increased by 19.56% for 28 days with respect to 7 days strength. For 30% GGBS replacement, Flexural strength is increased by 25% for 28 days with respect to 7 days strength.

From figure 5.1.3 it can be observed that flexural strength increases with increase in GGBS percentage for both 7 days and 28 days. 7 Days Flexural strength increases by 9.58% for 10% GGBS, 10.81% for 20% GGBS and 12% for 30% GGBS compared to reference mix. 28 Days Flexural strength increases by 15.55% for 10% GGBS, 17.39% for 20% GGBS and 24% for 30% GGBS compared to reference mix.

Maximum 28 Days Flexural strength obtained is 10 MPa and is for mix with 30% GGBS and is increased by 24% compared to reference mix.

VI. CONCLUSIONS

On the basis of the present experimental investigation, the following conclusion is drawn.

1. Maximum 28 Days Flexural strength obtained is 8.2 MPa for mix with 30% GGBS for 0% Glass Fiber and is increased by 7.31% compared to reference mix.
2. Maximum 28 Days Flexural strength obtained is 8.8 MPa for mix with 30% GGBS for 0.5% Glass Fiber and is increased by 13.63% compared to reference mix.
3. Maximum 28 Days Flexural strength obtained is 10 MPa for mix with 30% GGBS for 0.75% Glass Fiber and is increased by 24% compared to reference mix.
4. It can be observed that flexural strength increases with increase in GGBS percentage for both 7 days and 28 days.
5. Increase in percentage of Glass Fiber Percentage also increases flexural strength for both 7 days and 28 days.
6. 10 MPa is the maximum Flexural Strength obtained in this analysis and is for mix with 30% GGBS and 0.75% Glass Fiber and is increased by 24% compared to reference mix.

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