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Examining the Effects of GGBS and Glass Fibre on the Mechanical Properties of Green Concrete for Long-Term Sustainability

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Abstract- Concrete has been an important material in the construction industry for a long time. Concrete requires three different types of aggregate: cement, fine aggregate, and coarse aggregate. Concrete uses cement as a binder, and the production and use of cement results in increased CO₂ emissions. To reduce carbon emissions, fly ash (FACF) and ground granulated blast furnace slag (GGBS), which possesses pozzolanic characteristics, are used in place of some of the cement. The purpose of this research was to examine what happened to the compression, tensile, and flexural strengths of regular concrete when fly ash and GGBS were substituted for some of the cement. Glass fibres, at a rate of 0.5 percent, were added to cementitious material to determine the optimal blend. The productivity of the concrete was evaluated by testing cast specimens at 7, 28, 56, and 90 days. At the end of the day, the optimal percentage of GGBS and fly ash was found to be 25%.

Keywords- Green Concrete, GGBS, Metakaolin, Sustainability, Durability

INTRODUCTION

This For decades, concrete has been an important part of the construction process. The CO₂ evolution in the cement manufacturing process is a major issue in this region. Over the past few decades, researchers have looked into many possibilities for cutting down on cement usage. Over the past few decades, numerous methods have been developed to help lessen the use of cement. Eight percent of all CO₂ emissions in the world come from the construction fabrication industry [1]. In order to cut down on carbon dioxide emissions and preserve

cementitious materials, studies are currently underway. Therefore, a novel strategy for cement substitution is required to lessen cement consumption. Therefore, a novel strategy for cement substitution is required to lessen carbon dioxide emissions. Three distinct combinations of fly ash class F (FACF) and ground granulated blast furnace slag (GGBS) were tested for their effects on cement. The 750 million metric tonnes of annual material output from thermal power plants results in the production of FACF. GGBS is a byproduct of the iron ore industry. To rephrase, GGBS and FACF are employed in construction as eco-friendly options. Costs can be reduced further by switching to GGBS and FACF from cement. Glass fibres are mixed with the optimal percentage to have a significant effect. Glass fibres, up to a specific amount, can control the degree to which concrete cracks, bleeds, shrinks, and permeates. When additional glass fibres are added to concrete, the concrete becomes weaker. The concrete has the appropriate amount of glass fibres added to it. The percentage of glass fibres in cementitious materials is now at 0.5%. The substitution test in water was conducted by W. Chalee et al. [2]. Ocean water has varying cement concentrations and water/cover ratios. He reasoned that less corrosion and chloride contamination in concrete would result from an increase in FACF. After 7 years, 25-50% FACF will replace the cement at a W/B ratio of 0.45-0.65. Tata Power Co. Ltd [3] tested the fresh and hardened qualities of fine FACF and discovered that adding 5%, 10%, or 15% FACF yields credibility comparable to M30 grade of concrete, and that replacing 20% of the concrete with FACF yields concrete strength identical to M20 grade of concrete. Using GGBS concentrations between 10% and 80%, K. Ganesh Babu et al.[4] examined the feasibility of using GGBG as a partial cement alternative. They determined that the concrete's strength was equivalent after 28 days. To improve performance, we raised the cementitious content by 8.5 percent and the cement replacement by GGBS by 65 percent. Venu Malagavelli et al. [5] investigated M30 using GGBS and Robo Sand. After adding SAVEMIX SP111, it was found that the concrete's compressive strength was restored. It is suggested that a mixture of 50% GGBS and 50% robo sand be used as a partial replacement for cement. Using a range of GGBS contents (from 0% to 40%), Yogendra O. Patil et al. [6] studied what would happen if cement were partially substituted with GGBG. As expected, they found that the strength drops with increasing GGBS content. As the ratio of GGBS to OPC rises to 20%, a 4% drop in power is observed (compressive and flexure). The OPC might be cut by up to 14%. The FACF and GGBS variants by A. H. L. Swaroop et al. [7] account for 20% and 40%, respectively, of the total protein replacement of OPC. They determined that 20% GGBS was sufficient to replace OPC's durability in the marine curing process. For example, FACF with a 20% increase in strength are a partly cement substitute, whereas FACF with a 40% decrease in strength are also a partial substitution. The optimal range for FACF replacement to achieve optimal function is between 20% to 40% of OPC. Recycled coarse aggregate in GGBS with MK has superior mechanical properties [8, 9].

RESEARCH BACKGROUND

Literature reviews reveal that cementitious content is supplemented with various cementitious materials. The primary objective of this research is to investigate the cured characteristics of induced fibres in M40 grade concrete. Using this research, we may think about how adding glass fibres to concrete might change the formula.

Materials Cement

To begin, OPC-53 cement is what is often utilised. According to IS 16415:2015 [10], cement must make up at least 40% of the total mass of the concrete. The standards for cement used were

IS16353 and IS12269. A 3.15 specific gravity is typical for cement.

GGBS

JSW supplied us with the GGBS, and it conforms to IS 16714:2018 in all respects. In terms of density, GGBS weighs in at 2.86.

Fly Ash

Class F Fly Ash is utilised for this purpose. We obtained the fly ash and its standards from the Vijayawada VTPS in accordance with IS 3812 part 1. A specific gravity of 2.3 is observed for fly ash.

Coarse Aggregate

Aggregate sizes of 10 mm and 20 mm, as specified by IS 383:2016[11], were used.

Fine Aggregate

River sand is a popular choice for this purpose. The FA is strained through a 4.75 mm mesh. The quality of fine aggregate as defined by IS 383:2016[11].

RESEARCH METHODS

According to W. Chalee [2], the best outcomes in terms of lifetime can be achieved with 25-50 percent FAF and a W/C of 0.65. Up to 40% of cement could be replaced by GGBS, according to J.M. GAO [12]. It completely disappears from the weak spot in the concrete. The parameters for the cement composite combinations were selected from the ranges allowed by IS 16415:2015 [10]. With 100% cement and 0% FAF and GGBS as the starting point, the mix proportions are determined. The cement percentage in the next three mixtures was decreased while the FAF and GGBS percentages were increased. Cement constituted 60% of the proportional mix-1 (PM-1), with FAF and GGBS each accounting for 20%. Cement constituted 50% of the proportional mix-2 (PM-2), with FAF and GGBS each accounting for 25%. The third proportional mix (PM-3) consisted of 40% cement, 30% FAF, and 30% GGBS. Experiments were performed on M40-grade concrete. IS 10262:2009 [13], and IS 456:2000 [14]. The formula is constructed by a series of codes. The W/B ratio for M40 is 0.38, based on a study of the available literature and the total number of trials. Most laboratory trials have employed the additive to increase the workability and strength of the concrete. We were able to get the required slump of 100 mm, as specified by the mix design, with an additive percentage of 0.5% by weight of cement for M40. IS 10262:2009 [13] defines "coarse aggregate." The coarse aggregate is divided into two sizes: 20 mm and 10 mm, which account for 60% and 40% of the overall aggregate, respectively. Sand from a riverbed is used to create FA. The quantities of CM, PM-1, PM-2, and PM-3 per 1 cubic metre are shown in Table-2. In terms of mechanical properties at 7, 28, 56, and 90 days, the experimental procedures and testing are absolutely dependent on IS 516 [15] and IS 5816 [16]. Glass fibers of 0.5 percent are applied to the ideal blend in addition to the cementitious content, and mechanical properties are checked for 7 and 28 days.

Table 1: Quantities for one cubic meter M40 for 1 Cubic Meter

Material (Kg/m ³)	CM	PM-1	PM-2
Cement	416.23	239.044	217.537
Fly Ash	0.000	82.15	113.768
GGBS	0.000	84.25	113.768
C A 20 mm	680.00	680.00	680.00
C A10 mm	465.00	465.00	465.00
Water	147.738	147.738	147.738
Fine Aggregate	745.123	745.123	745.123
Chemical Admixture	2.175	2.175	2.175

RESULT DISCUSSION

Compressive Strength

In Figure 1, we can see how M40 responds to three different mix proportions (M-1, M-2, and M-3) vs the typical mix (CM). It's obvious that CM yields the finest outcomes. The compressive strength, measured as a percentage of the fck value, was seen to be 87% due in part to M-1 and M-3. Thus, it is possible to draw parallels between CM and M-2 results. When we compare the results to the literature, we discover that the strength increases by 20–25%. As was previously mentioned, the ideal ratio of glass fibres is M-2 for M40. The current findings demonstrate that the addition of glass fibres resulted in a 4% reduction in compressive strength. We think this is because chemical reactions involving fly ash take time to attain the required concrete strength, and because glass fibres in concrete absorb a lot of water.

Flexural Strength

The results of the studies tend to mirror those in Fig. 5, with M-2 predominating over M-1 and M-3. Figure 6 shows the ideal distribution of glass fibres, which is M-2 for M40. The recent findings corroborate a 13% drop in flexure strength upon including glass fibres.

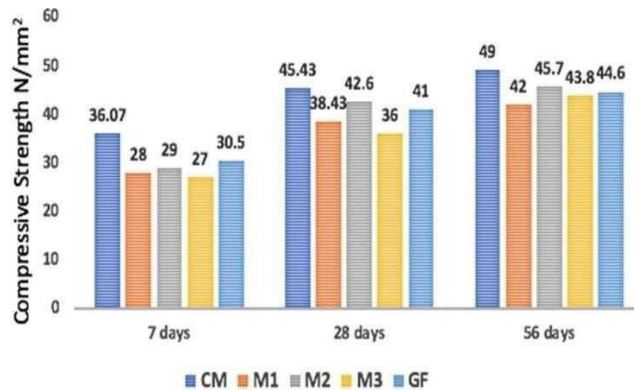


Fig 1. Compressive Strength

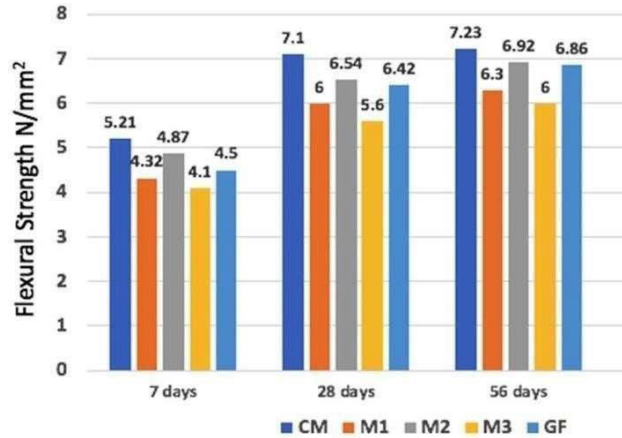


Fig 2. Flexural Strength

Split Tensile strength

As can be shown in Fig. 3, this investigation confirmed the results of the split tensile strength for M40 using the three distinct mix proportions (M-1, M-2, and M-3) to controlled mix (CM). The M-2 upgrade allows for vastly superior efficiency gains. Between 8 and 15 percent of the compressive strength is what the tensile strength of concrete sits at. Figure 4 shows the ideal distribution of glass fibres, which is M- 2 for M40. The current results demonstrate that the break tensile strength is reduced by 14% when glass fibres are added.

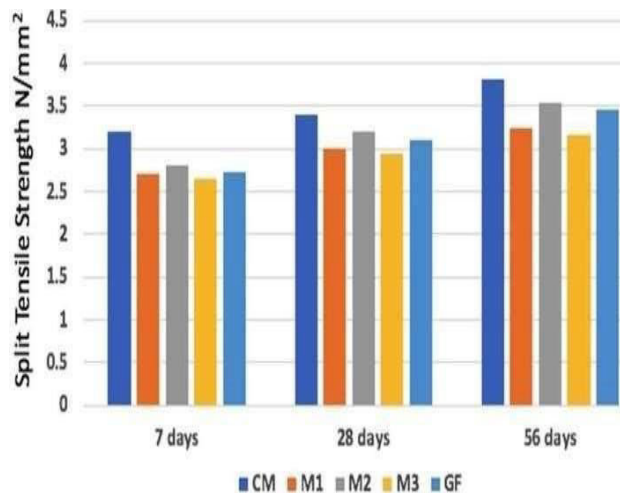


Fig 3. Split Tensile Strength

CONCLUSION

M-2 with 25% GGBS and fly ash had decreased compressive, tensile, and flexural strengths after 90 days compared to the standard blend. This weaker strength, however, exceeds the target mean strength. At 20% fly ash and 25% GGBS, and at 30% fly ash and GGBS, respectively, compressive strength decreases by 0.14 percent, 0.076 percent, and 0.23 percent. It has been found that the characteristics of the hardened material degrade when glass fibres (0.5 percent) are included in the mix. This research suggests that a proportionate mix (M-2) involving 25% fly ash and GGBS each is the most cost-effective.

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