The Experimental Study on Compressive Strength of Concrete using AR Glass Fibers and Partial Replacement of Cement with GGBS with Effect of Magnetic Water

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ABSTRACT
In the whole world concrete is mostly used in mass quantity for a construction. It is expected that in the near future, the civil engineering community will have to produce structures in harmony with the concept of sustainable development. A number of studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement material for cement in the production of concrete using various different materials like fly ash, silica flume, GGBS etc. Glass Fiber Reinforced Concrete or (GFRC) is a composite that has glass fibers instead of steel strands for its reinforcement. AR Glass Fibers are designed specifically for use in concrete. It is found that by the partial replacement of cement and glass fiber with effect of magnetic water helped in improving the strength of the concrete sustainably compared to normal mix concrete. The OPC is responsible for the majority of the embodied carbon content of concrete. Significant reductions in environmental impacts occur for GGBS.

The present study investigates the effects on compressive strength of concrete of 50% cement replacement with granulated ground blast furnace slag using alkali resistant glass fibers with varying percentage i.e. 0.2%, 0.3%, 0.4% & 0.5% respectively for 7 days and 28 curing days and effect of magnetic water used in mixing and curing concrete and compare the results with different percentage of fibers and curing days. Twenty mixes were tested and studied with different percentage of glass fiber with and without effect of magnetic water. Among the mixes the mix with replacement of 50% GGBS and 0.3% of AR glass fiber is better with respect to strength.

Keywords Concrete, GGBS, Alkali resistant glass fiber, magnetic water, compressive strength, workability.

1. INTRODUCTION
Concrete is most widely used man-made construction material in the world. It is obtained by mixing of two components i.e. aggregate and paste. Usually the paste is mix of Portland cement and water, binds the aggregate (usually sand and gravel or crushed stone) into a rocklike mass known as Concrete. The hardening is because of the chemical reaction of the cement and water, which continue for long period leading too stronger with age. The usefulness, elegance and the durability of concrete structures, built during the first half of the last century with ordinary portland cement (OPC) and plain round bars of mild steel. The easy availability of the ingredients (compromising quality) of concrete was used. Strength was emphasized without a thought of the durability of structures. As a consequence of the liberties taken, the durability of concrete was highly affected. After 1970 or thereabout the use of high strength tensile bars with surface deformation started. Significant changes in constituents and properties of concrete were initiated and Engineers started using supplementary cementitious materials and admixtures in concrete, often without adequate considerations.

1.1. Alkali Resistant Glass fiber
Glass fibers are very numerous extremely fine fibers of glass. Ordinary glass fiber cannot be used in portland cement mortars or concretes because of chemical attack by the alkaline cement paste. Zirconia and other alkali-resistant glass fibers possess better durability to alkaline environments, but even these are reported to show a gradual deterioration with time. Similarly, most natural fibers, such as cotton and wool, and many synthetic polymers suffer from lack of durability to the alkaline environment of the portland cement paste.
It is well known that the addition of any type of fibers to plain concrete reduces the workability. Since fibers impart considerable stability to a fresh concrete mass, the slump cone test is not a good index of workability. For example, introduction of 1.5 volume percent steel or glass fibers to a concrete with 200 mm of slump is likely to reduce the slump of the mixture to about 25 mm, but the placeability of the concrete and its compatibility under vibration may still be satisfactory. Therefore, the Vee be test is considered more appropriate for evaluating the workability of fiber-reinforce concrete mixtures.

1.2. Ground granulated blast-furnace (GGBS)

Ground granulated blast-furnace slag also called slag cement, is made from iron blast-furnace slag; it is a non-metallic hydraulic cement consisting essentially of silicates and alumina silicates of calcium developed in a molten condition simultaneously with iron in a blast furnace. The molten slag at a temperature of about 1500°C is rapidly chilled by quenching in water to form a glassy sand like granulated material. Which is ground to less than 45 microns, has a surface area fineness of about 400 to 600 m²/kg. The relative density (specific gravity) for ground granulated blast furnace slag is in the range of 2.85 to 2.95. The bulk density varies from 1050 to 1375 kg/m³.

1.3. Magnetic water

One of the most recent important technologies to enhance concrete workability and compressive strength is using magnetized water instead of normal water within concrete mixes. This technology changes the main effective aspects of water with no change to other components of concrete mix. Water effective properties could be well controlled within flow rate velocity, magnetic field strength and exposure time. This technology has increased compressive strength up to 20% and more which make it very important within concrete production and uses. The homogenous and workable concrete that mixes with magnetic water gave further property of maintaining equipment’s from hardening process through transportation of fresh concrete. Using magnetized water in the concrete mix is the best in terms of higher density and lower porosity with no additives needs. The implementation of magnetized water technology in concrete mix had increased rapidly on the eighties and nineties decades due to the development of magnetic devices and its physical water effluents at concrete properties. The importance of mechanical properties of this concrete mix has been dispersed in many fields of civil and military construction like airports and jetties. Most researchers concentrate their attention on producing economical concrete with higher strength using new philosophies of design methods, through modern technique, like using water which has magnetically treated. When ordinary water flows through magnetic field, the water physical properties are changed therefore, the number of molecules in water clusters will decreased to 6 or 5 molecules which causing decrease in surface tension and increase the percentage of molecules contribution of hydration process. When water treated in a magnetic field is added to concrete. In a magnetic field water molecules will lose their attractive-repulsive forces and become oriented on a magnetic pole or electric charge. “Neutralized” molecules of water are much more easily attracted to numerous electrostatic fields naturally contained by cement grains. Hydration of cement is faster and more complete than with untreated water.

Figure 1.1: Electromagnetic Device
1.4. Objectives of Study

1) To study the compressive strength and workability of concrete.
2) To check and reduce the quantity of cement in manufacture of concrete using the industrial waste GGBS to partial replacement cement.
3) To check compressive strength of concrete with partial replacement (50%) of cement using GGBS.
4) To check compressive strength of concrete using percentage variation of alkali resistant glass fibers (0.2%, 0.3%, 0.4% and 0.5%) and partial replacement of cement with GGBS using normal water for mixing and curing.
5) To check compressive strength of concrete using percentage variation of alkali resistant glass fibers (0.2%, 0.3%, 0.4% and 0.5%) and partial replacement of cement with GGBS using magnetic water for curing.
6) To check compressive strength of concrete using percentage variation of alkali resistant glass fibers (0.2%, 0.3%, 0.4% and 0.5%) and partial replacement of cement with GGBS using magnetic water for mixing and normal water for curing.
7) To study and compare the strength of concrete with normal water and magnetic water effect with percentage variation of fiber content.

2. LITERATURE REVIEW

- ACI Committee 233 (2000) reported that workability of concrete containing 50 percent GGBS returned improved characteristics when compared with normal concrete. Compressive and flexural strength is lower in initial days (1 to 3 days) after that it shows superior values compared to normal concrete. GGBS has commonly used as an ingredient of portland blast-furnace slag cement and as a separate cementitious constituent to reduce the temperature rise in mass concrete. The permeability of hardened concrete containing GGBS is significantly reduced it also improve the sulphate resistance of concrete. It reduces to potential expansion due to alkali-silica reaction. It also shows resistance to corrosion of reinforcement.

- Nan Su, Yeong-Hwa Wu, Chung-Yo Mar (2000). In this author has investigated on the compressive strength and workability of mortar, which is mixed with magnetic field treated water (MFTW) was obtain by passing tap water through magnetic field. Test variables included the magnetic strength of water, fly ash content in place of cement, water-to-cementitious material ratio (W/CM) and curing age. Results show that the compressive strength of mortar samples mixed with MFTW is higher than those prepared with tap water. The best compressive strength of concrete is achieved when the magnetic strength of treated is of 0.8 and 1.2T. The compressive strength increases of concrete prepared with MFTW is more significant at early age.

- Nan Su, Chea-Fang Wu (2003). In this author has investigated on the compressive strength and workability of mortar, which is mixed with magnetic water and granulated blast-furnace slag (GBFS). The test variables included the magnetic strength of water, the content of GBFS in place of cement, and the water-to-binder ratio (W/B). Results showed that the compressive strength of mortar samples mixed with magnetic water increased by 9–19% more than those mixed with tap water. It is also found that magnetic water improved the fluidity of mortar and the degree of hydration of concrete.

- M Gholizadeh and H Arabshahi (2005). In this paper they describe the effect of magnetic water on workability and compression test on the concrete. They concluded that the slump was increased by 7cm when magnetic water was added for mixing. So decrease in water content can be possible. The compressive strength of concrete was increased by 23%. Also they noted that concrete made in this way is more resistant against freezing and more impermeable. They also found the decrease in water surface tension in magnetic water by 10% in comparison with ordinary water.

- Adnan Flayih Hassan (2008). In this paper author has investigated the influence of magnetized water on the initial and final setting time, consistency and compressive strength of cement mortars cubes at very ages of 1 and 7 days. The results indicated that the use of magnetized water in preparing cement mortars
increases the compressive strength and the initial and final setting time of cement mortar decreased. Results also showed that the optimum water/cement ratio for obtaining the best compressive strength under the conditions of this study was 0.45.

- **Saddam M. Ahmad (2009)** tested the concrete with 0.03% glass fibers by concrete volume with different grades including M20, M30, M40 and M50. They observed that the addition of fibers reduced the bleeding which improves the surface integrity of concrete. It gives 20 to 25% increase in compressive strength and 15 to 20% increase in flexural strength.

- **Candramouli K., Srinivasa Rao P, Pannirselvam N., Seshadri Sekhar T. and Sravana P. (2010)** tested the concrete with 0.03% glass fibers by concrete volume with different grades including M20, M30, M40 and M50. They observed that the addition of fibers reduced the bleeding which improves the surface integrity of concrete. It gives 20 to 25% increase in compressive strength and 15 to 20% increase in flexural strength.

- **Venu Malagavelli (2010)** investigated that the compressive strength can be increased with the use of partial replacement of cement with GGBS and natural sand with ROBO sand. He found that the percentage increase of compressive strength of concrete is 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBS and 25% of sand with ROBO sand.

- **V.S.Tamilarasan (2010)** concluded that the concrete with partial replacement of cement with GGBS the chloride permeability value decreases which improves the chloride penetration resistance of the concrete and durability of concrete. The chloride permeability value also depends upon the grade of the concrete.

- **H. Afshin, M. Gholizadeh and N. Khorshidi (2010)** studied that due magnetic water some of the physical properties of concrete change and, as a result of such changes, the number of molecules in the water cluster decrease from 13 to 5 or 6, which causes a decrease in the water surface tension. Using magnetized water in concrete mixtures causes an improvement in the workability and compressive strength of concrete. Also, this processed water causes a reduction in the cement content required for the specified compressive strength value. In this research, in the concrete laboratories of Sahand University of Technology, the effects of magnetic water on some mechanical properties of high strength concrete, such as workability and compressive strength have been studied. For the production of magnetic water, a magnetic treatment device has been used. This device mostly is used for the softening of water and, for the research; it has been used by the authors for the production of concrete.

3. METHODOLOGY

3.1 Concrete Mix design

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the Aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking. The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of
concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix.

3.2 M25 Concrete Mix

For this study M25 concrete mix has been prepared mix proportion for one cubic meter concrete is given as below:

Table 3.1: Mix proportion for 1 m³ concrete

<table>
<thead>
<tr>
<th>Mix Proportions for One Cum of Concrete</th>
</tr>
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<tbody>
<tr>
<td>1 Mass of Cement in kg/m³</td>
</tr>
<tr>
<td>2 Mass of GGBS in kg/m³</td>
</tr>
<tr>
<td>3 Mass of Water in kg/m³</td>
</tr>
<tr>
<td>4 Mass of Fine Aggregate in kg/m³</td>
</tr>
<tr>
<td>5 Mass of Coarse Aggregate in kg/m³</td>
</tr>
<tr>
<td>Mass of 20 mm in kg/m³</td>
</tr>
<tr>
<td>Mass of 10 mm in kg/m³</td>
</tr>
<tr>
<td>6 Mass of AR Glass Fibers in g/m³ (1%)</td>
</tr>
<tr>
<td>7 Water Cement Ratio</td>
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</tbody>
</table>

3.3 Casting of concrete Specimens

The moulds are of 150mm×150mm×150mm confirming IS: 10086-1982. Once the proper mixing is done, the concrete blocks were prepared by pouring the concrete into cubes. In assembling the mould for use, the joints between the sections of mould was thinly coated with mould oil in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould were thinly coated with mould oil to prevent adhesion of the concrete.

In total there were four glass fiber dosages and one control batch with no added fibers. As per IS456 the total samples required for each mix should be 30. This shows grand total of 600 concrete cubes.

4. RESULTS AND DISCUSSION

4.1 Slump test results

Slump test were carried out for different % of fiber content and workability is as shown in below graph:

Graph 4.1: Showing Slump test results
4.2 Compressive strength of specimens:
For compressive strength testing total 600 concrete cubes are casted. For M25 mix.
And it is categories as its contents i.e. cases as below.

1) Case 1 - Cement+GGBS+NW+NWC
2) Case 2 - Cement+GGBS+NW+MWC
3) Case 3 - Cement+GGBS+MW+NWC
4) Case 4 - Cement+GGBS+MW+MWC

And the results are given in a graphical presentation form as below:

**Graph 4.2:** showing Compressive strength for 7 days

**Graph 4.3:** showing Compressive strength for 28 days
Graph 4.4: showing percentage comparison in NW+NWC & MW+NWC

Graph 4.5: showing percentage comparison in NW+NWC & NW+MWC

Graph 4.6: showing percentage comparison in NW+NWC & MW+MWC
5. **CONCLUSION**

1) The use of GGBS and magnetic water effect improves workability of concrete by 16.6 mm in average. Maximum slump is 95 mm hence its workable. Due to addition of glass fiber the workability of concrete substantially reduces.

2) A reduction in bleeding is observed by addition of AR glass fiber in concrete mix, which improves the surface integrity of concrete, improves homogeneity and reduce probability of cracks.

3) Cement replacement with 50% GGBS achieves required strength. GGBS is much cheaper and environment friendly than OPC, so it is economical option for cement replacement.

4) The mix with 50% GGBS and 3% AR glass fiber attained maximum strength with or without magnetic effect.
5) Due to effect of magnetic water both for curing and mixing the compressive strength increased by 32% for 7 days and 20% for 28 days compared to normal or tap water.

6) For 3% ARG fiber mix, normal water concrete cubes cured in magnetic water, shows an 11% increase in compressive strength at 7 days and this increase is 9.5% for 28 days.

7) For 3% ARG fiber mix, magnetic water concrete cubes cured in magnetic water, shows an 32.14% increase in compressive strength at 7 days and this increase is only 19.83% for 28 days.

8) The concrete cubes casted with normal water and cured with magnetic water shows very small increase compared to magnetic water casted cubes cured in magnetic water at early ages of hydration.

9) From all observation we can say that this study proves that cement replacement with 50% GGBS and using 3% alkali resistant fibers with magnetic water effects for both mixing and curing achieves maximum compressive strength.

6. REFERENCES
1) ACI Committee 233, Ground Granulated Blast-Furnace Slag as a cementitious constituent in concrete, 2000.
3) A.A. Ramezanianpour, S. Aatarodi, M. Sami, “Durability of concrets containing ground granulated blast furnace GGBS against sulfate attack”, Third international conference on sustainable construction material and technologies.