Behaviour of Concrete Utilizing AR Glass Fibre as a Partial Replacement of Cement

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Abstract:
Concrete is the construction material without the life of construction industry cannot be imagined. It has been known that concrete is stronger in compression and weaker in tension. Weak tensile strength combined with brittle behaviour, which results in sudden tensile failure of structural member without any warning. The aim of this investigation is to decrease environmental pollution & energy consumption use in cement production and to improve the tensile behaviour of concrete by using AR glass fibre as a partial replacement of cement in concrete. In this research work cement was replaced by AR glass fibre in different percentages- 0%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% and the various mechanical and durability properties of concrete were determined. Super plasticizer was used to maintain the workability of concrete. The effects on different properties of concrete with AR glass fibre were evaluated in this study.

Key words: AR Glass fibre, Compressive Strength, Flexural Strength, SP-431

1. INTRODUCTION
Concrete is the most widely used construction material in the world. It is the homogenous mixture of binding material, sand and aggregates. The simplest reason for its extensive use in the construction of almost all civil engineering works is that the properties can be controlled which a wide range by using appropriate ingredients. It has been known that concrete is stronger in compression and weaker in tension. Fibres are commercially available and manufactured from steel, plastic, glass and other natural materials. The effect of the fibre in the composite leads to an increase in the tension and impact strength of the concrete glass fibre is a light weight, strong and waste materials. Fibre Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, sand, cement and discontinuous, discrete, uniformly dispersed suitable fibres. Fibre reinforced concrete is of different types and properties with many advantages. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres. It reduces the air voids and water voids the inherent porosity of gel in concrete and it increases the durability of the concrete. Fibres such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibres have a significant influence on the creep performance of rebars/tendons. Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fibre and the concrete as the matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized. Various types of fibres which can be used to produce concrete like steel fiber, polypropylene fiber, GFRC glass fiber, asbestos fibres, carbon fibres, organic fibres etc. Its properties would obviously, depends upon the efficient transfer of stress between matrix and the fibres. Factors affecting properties of fibre reinforced concrete includes relative fibre matrix stiffness, volume of fibres, aspect ratio of fibres, orientation of fibres, workability and compaction of concrete, size of aggregates and mixing. Literature shows that the use of fibre improves some properties like tensile strength, flexural strength, shock absorption capacity etc. It increases the tensile strength of the concrete.

2. LITERATURE REVIEW
2.1 Gupta et al (2017) evaluated the behaviour of light weight concrete containing glass fibre and fly ash. Replacement of Cement by Glass fibres in different fractions with 0%, 1%, 1.5%, 2%, 2.5%, 3% and 30% of Fly ash has been used, which satisfies the various structural properties of concrete like compressive strength, flexural strength. Workability was enhanced by the inclusion of super plasticizer in concrete which was adopted up to 0.5% by the weight of cement. As per Indian Standards, standard sizes of cubes and beams were casted and tested for compressive strength, flexural strength at age of 7days, 14 days and 28 days. From result it can be concluded that compressive strength does not improved but the flexural strength was improved with the addition of fibre.

2.2 Hifzurrahman et al (2017) determined the behaviour of Glass Fibre Reinforced with Partial Replacement of Cement with Fly Ash. For that the glass fibres in different volume fraction with 20%, 30% and 40% replacement of cement by fly ash have been to study the effect on compressive strength, split tensile strength, of concrete and compared it to the conventional concrete. For each mix standard sizes of cubes, cylinders and as per Indian Standards were cast and tested for compressive strength and split tensile strength at age of 28days. Due to the addition of glass fibre split, tensile strength increased and is optimum when 20% cement replaced with fly ash along with 2% glass fibre.

2.3 Raja et al. (2014) investigated the mechanical behavior of fly ash impregnated E-glass fibre reinforced polymer composite (GFRP). Initially, the proportion of fibre and resin were optimized from the analysis of the mechanical properties of the GFRP. It is observed that the 30 wt% of E-glass in the GFRP without filler material yields better results. Then, based on the optimized value of resin content, the varying percentage of E-glass and fly ash was added to fabricate the hybrid
composites. Results obtained in this study were mathematically evaluated using Mixture Design Method. Predictions show that 10% weight addition of fly ash with fibre improves the mechanical properties of the composites.

2.4 Kumar (2013) evaluated the mechanical properties of glass fibre reinforced concrete. Glass fibre improves the strength of the material by increasing the force required for deformation and improve the toughness by increase the energy required for crack propagation. The addition of about 1.5% chopped glass fibre (by cement weight) to the material increase the modules of rupture by about 20 % and fracture toughness by about 55%.many studied the effect of glass fibre on the mechanical properties of M35 grade of concrete.

2.5 Patel et al. (2013) analysed the effect of glass fibre in form of additive to increase the tensile strength of a concrete because it is weak in tension and glass fibre possess such properties that its particle connect to the particle of concrete and sealed together & not to be separated. Experiment concluded that the compressive strength, flexural strength increases with the addition of glass fibre and the optimum result was obtained at 0.1% glass fibre.

2.6 Murthy et al (2012) The experimental work dealt with the use of glass fibre in concrete which was obtained from the glass industry as a waste product. It was found that the compressive strength of concrete did not increase much but the flexural strength showed almost 30% increase in strength. The slump value found to be decreased with increase in fibre content. It was found that the use of fibre glass in concrete not only improved the properties of concrete but also small cost cutting.

3. Materials and Methodology

3.1 Materials: In this systematic experimental study, various ingredients like cement, fine aggregates, coarse aggregates, water and glass fibre were used to obtain concrete mixes, suitability of which were checked at laboratory by performing various tests. The properties of materials obtained in the laboratory are as follows:

3.1.1 Cement
The Ordinary Portland Cement of 43-grade was used for casting the specimens of all the concrete mixes.

3.1.2 AR –Glass Fibre
AR-glass fibre has been used to produce fibre concrete in construction work and laboratory for experiments. High-quality alkali-resistance glass fibre containing a high percentage of zirconia (zro₂), which enhances its resistance to alkali in cement composites, can be used as an asbestos replacement available in a variety of strand lengths and sizing to meet specific applications and processing requirements excellent workability characteristics.

3.1.3 Fine Aggregates: Locally available fine aggregates were used for this study. The fine aggregate used for investigation was procured from the local fine aggregate suppliers. It should not contain organic matter, loam, silt, salt and clay. It stiffens the binder and fills the voids in the coarse aggregate

3.1.4 Coarse Aggregates: Coarse aggregate of size 20mm and 10mm was used in this study which was procured from the local coarse aggregate supplier as per IS: 383-1970.

3.1.5 SuperPlasticisers: Super plasticisers are increasing the workability of concrete as well as strength of concrete

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**Table.1. Physical Properties Of Ar-Glassfibre**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Properties</th>
<th>Approximate Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td>2.68</td>
</tr>
<tr>
<td>2</td>
<td>Elastic modulus (GPa)</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>Tensile strength (MPa)</td>
<td>1700</td>
</tr>
<tr>
<td>4</td>
<td>Diameter (micron)</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Length (mm)</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>No of fibre (millions / kg)</td>
<td>235</td>
</tr>
</tbody>
</table>

![Figure.1. Effect And Production Of Ar- Glass Fiber](http://ijesc.org/)

The physical properties of AR glass fiber like specific gravity, length, diameter is given below:
without increase the amount of water. Shaliplast SP-431 super plasticizer was used to produce workable concrete and the amount of super plasticizer was 0.5% by weight of cementing material.

![Image](http://ijesc.org/)

**Figure 2. Super Plasticisers Shaliplast**

3.1.6 **Water**: Water quality plays a vital role in the production of concrete. The impurities in water may affect the setting of the cement and the final strength of the concrete.

### 3.2 Methodology:

**Table 3. Mix Proportion Of Concrete Containing Ar Glass Fibre**

<table>
<thead>
<tr>
<th>Specimen no.</th>
<th>w/c ratio</th>
<th>Cement kg/m³</th>
<th>% of replacement cement by Glass Fiber</th>
<th>Glass Fibre as partial replacement of cement Kg/m³</th>
<th>Fine aggregates Kg/m³</th>
<th>Coarse aggregates Kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.40</td>
<td>405</td>
<td>0</td>
<td>0.0</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A2</td>
<td>0.40</td>
<td>402.9</td>
<td>0.50</td>
<td>2.02</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A3</td>
<td>0.40</td>
<td>400.9</td>
<td>1.0</td>
<td>4.05</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A4</td>
<td>0.40</td>
<td>398.8</td>
<td>1.5</td>
<td>6.07</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A5</td>
<td>0.40</td>
<td>396.8</td>
<td>2.0</td>
<td>8.1</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A6</td>
<td>0.40</td>
<td>394.8</td>
<td>2.5</td>
<td>10.1</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>A7</td>
<td>0.40</td>
<td>392.8</td>
<td>3.0</td>
<td>12.12</td>
<td>660</td>
<td>1122</td>
</tr>
<tr>
<td>B1</td>
<td>0.50</td>
<td>405</td>
<td>0</td>
<td>0.0</td>
<td>660</td>
<td>1122</td>
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<td>1122</td>
</tr>
</tbody>
</table>

**Table 4. Concrete Sample Testing Details**

<table>
<thead>
<tr>
<th>Test</th>
<th>Shape and Dimensions of the Specimens</th>
<th>Time Duration (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength</td>
<td>Cube : 150mm×150mm×150mm</td>
<td>28</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>Beam : 150mm×150mm×500mm</td>
<td>28</td>
</tr>
</tbody>
</table>

4. **RESULT AND DISCUSSION**

4.1 **Workability Test**: Workability of control concrete and the concrete containing glass fibre was determined slump cone test (slump test as per Indian standard procedure IS:1199-1959).
Figure the results of the slump test for the concrete containing super plasticizers at various replacement levels of glass fibre at w/c ratio of 0.40 and 0.50. It can be seen from figure 3, that for the given w/c ratio the slump value has been decreased with the increase % of AR glass fiber in concrete.

4.2 Compressive Strength

Figure 4 shows the compressive strength at 28 days of curing of concrete for w/c ratio 0.40 and 0.50 with replacement of cement by 0%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% glass fiber.

The compressive strength increases with increase in the percentage of AR glass fibre up to 2.0% replacement level after that it starts to decreases. The compressive strength for concrete at 2.0% replacement of cement by AR glass fibre was obtained as 42.05 N/mm² for w/c ratio 0.40 and 41.6 N/mm² for w/c ratio 0.50. Compressive strength increases with 15.5% by additional replacement of cement by AR glass fibre up to 2% for w/c ratio 0.40 and 18.01% increases was obtained at 2% replacement level of AR glass fibre as compared to controlled concrete. Hifzurrahman et al (2017) also reported that an increase in compressive strength was observed with an increasing fibre percentage.

4.3 Flexural Strength:

The flexural strength of concrete at 28 days of curing at w/c ratio 0.40 and 0.50 was shown in figure 5. The flexural strength of concrete for control mix was obtained as 6.6N/mm² and 6.45 N/mm² for w/c ratio 0.40 and 0.50 respectively. The flexural strength of concrete increases with increase in the percentage of AR glass fibre up to 2% replacement level after that it started to decreases. The flexural strength of concrete increases to 8.2 N/mm² and 7.95 N/mm² for w/c ratio 0.40 and 0.50 respectively at 2% replacement level of cement by AR glass fibre. Flexural strength of concrete at (3%) maximum replacement level of AR glass fibre was observed as 7.45 N/mm² for 0.40 w/c ratio and 6.3 N/mm² for 0.50 w/c ratio.

Figure 3. Slump Value At Various Replacement Levels

Figure 4. Compressive Strength At 28 Days Of Curing

Figure 5. Flexural Strength At 28 Days Of Curing
The increase in flexural strength is due to increases in compressive strength. The fibre shows resistance against bending. Increases in flexural strength with increases in percentages of glass fibre (Gupta et al, 2017)

5. SUMMARY AND CONCLUSION

- The workability of concrete was found to be decreased with increase in the percentage of AR glass fibre but sufficient workability was achieved by the use of super plasticizers in concrete.
- The compressive strength of concrete containing AR glass fibre increases with the increasing amount of glass fibre up to 2% after that it started to decreases for both w/c ratio 0.40 as well as for 0.50.
- The flexural strength of concrete containing AR glass fibre continuously increases with increase in the percentage of glass fibre up to 2% after that it started to decreases for both w/c ratios.

Most of the properties of modified concrete were very comparable to reference concrete. This modified concrete can be used in situation which requires light weight concrete as well as for high strength concrete.

6. REFERENCES


[5]. IS 1199, 1959: Methods of sampling and analysis of concrete.


