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A Review on Glass Fibre Reinforced Concrete Used In Construction

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Abstract – *A Fibre reinforced Concrete is a revolutionary topic in the history of concrete industry. It is a concept of thinking about the environment into concrete considering every aspect from raw materials manufacture over mixture design, construction, and service life. Glass Fibre products are used as a partial substitute for cement, charges for the disposal of waste are avoided and durability is greater. Glass Fibre Reinforced concrete is a type of concrete which resembles the conventional concrete but the production or usage of such concrete requires care and causes least harm to the environment. The CO2 emission related to concrete production, is between 0.1 and 0.22 t per tonne of produced concrete. However, since the total amount of concrete produced is very large the environmental impact are very high. Since concrete is the second most consumed after water it accounts for around 5% of the world's total CO2 emission. The solution to this environmental problem is not to substitute concrete for other materials but to reduce the environmental impact of concrete and cement. There will be other material technology can be developed, which can minimize the problem related to concrete production. It is known that glass fibres have properties which are suitable for concrete, there is a large potential in investigating the possible use of these for concrete. The concrete industry realized at an early stage that it is a good idea to use fibres in concrete and due to strength demands. The environmental aspects are not only interesting from an ideological point of view, but also from an economic aspect. Glass fibre reinforced concrete has various advantages over the conventional concrete.*
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Keywords- GFRC, glass fibre, compressive strength, crack resistance

I- INTRODUCTION

Ordinary Portland cement concrete possesses a very low tensile strength, limited ductility, small resistance to cracking, very low coefficient of thermal expansion and shrinks as it matures. These drawbacks can overcome by providing steel bars at necessary locations at the time of casting of structural members. Steel bars in concrete are used to take up the tensile stresses and sometimes the compressive stresses if required**.** Reinforcement consists of continuous deformed steel bars or pre-stressing tendons. The supremacy of using deformed steel bars as reinforcement and pre- stressing technology, the steel reinforcement will provide high tensile strength which helps in overcoming the inability of concrete in tension but the durability and resistance to cracking does not improves. These properties can be strengthen by the use of glass fibres in the concrete. It has been seen that by the various research on concrete reinforcement with a permissible amount of glass fibre addition in the concrete shows better performance in compression, flexure and in toughness, the improvement also depends on the type of glass fibre used in the mixture. In addition to that glassfibres also helps in restraining the development of micro-cracks in the concrete interface thus developing into a strong composite with superior crack resistance, improved ductility **.**

II-LITERATURE REVIEW

Most of the reported works on GFRC to till date were related to the properties of glass fibre reinforced concrete, measured by using small size specimens. In addition, the complete details of the mixture compositions of the glass fibres based paste were not reported.

J.G. Ferreria and F.A. Branco(2005) In this paper, the results of a research project were presented where glass fibres were applied to the fabrication of structural elements,30 m high telecommunication towers. The lightness and tensile strength advantages of the GRC were associated with carbon and stainless steel reinforcement, leading to an innovative material with high durability. It concluded, The use of GRC reinforced with carbon fibers or stainless steel bars can be used as a structural material, with reduced weight and good durability properties.

GRC application in telecommunication towers is viable and confers strength and deformability levels adequate for the needs of these structures. The numerical models that have been developed for the determination of the strength, deformability and dynamic behavior of the towers show a good correlation with the experimental behavior and may be used for the design of this type of tower

A.J. Majumdar(1974) In this paper an attempt was made to study the use of glass in concrete, the concrete had been studied over a period of three years under different environmental conditions and measured the variations in the mechanical properties of these composites with age. The experimental results were interpreted in terms of the micromechanics of failure for these composites and an assessment was made of the role of the interface in controlling the behavior of the composite at various stages of its life. It concluded that the properties of the interface in GRC change with time, partly due to chemical attack on the fibre which weakens the reinforcement but also due to changes in the physical properties of the fibre bundle and porosity and volume changes in the matrix as it sets and hardens.

When an alkali resistant glass fibre was used, the bending strength shows an initial increase over a period of months and then a slight reduction in strength is observed. The magnitude of the decrease in strength was dependent on the conditions used in storing the material and there are indications that this trend was absent when pfa was included in the mix. The strength results were interpretable in qualitative terms on the basis of the changes taking place in the interfacial zone between the fibre and the matrix. These changes were brought about by the interaction of the glass fibre with the cement matrix as well as the continued hydration of the cement itself. These factors, together with multiple cracking of the matrix, control the mechanical properties of composites such as glass fibre reinforced.

M. Levitt (1997) examined that when cement, mortar or concrete is splashed or otherwise brought into contact with window glass, etching occurs. This is because the alkali in cement attacks some of the silicates that are used in glass manufacture. The stock used in making glass fibres has better alkali resistance than window glass because zirconia is used as one of the constituents.

M.W. Fordyce and R.G. Wodehouse (1983) examined that the main difference between dewatered and non-dewatered GRC is the difference in density which has two effects. Firstly although the fibre content by weight is the same, the higher density of the dewatered board gives a higher fibre volume fraction giving higher strengths. Secondly the dewatered board has better compaction and reduced porosity giving better fibre/matrix bond strength.

Perumelsamy N. Balaguru and Surendra P. Shah (1992) examined that the tests conducted on GFRC in laboratory have shown good resistance for fire, since the major use of GFRCs is for architectural building panels. In these buildings, fire resistance becomes an important factor in design.

Dr. P. Perumal and Dr. J. Maheswaran (2006) examined that the mixes with 1.5% volume of fibres gave optimum composite properties in terms of compressive strength with 25.39% strength improvement. The highest increase in split tensile strength was observed in mixes with 1.5% of volumes of fibres and found to be 5.76% higher strength than reference concrete. Similarly, the highest flexural strength was observed in mixes with 1.5% of volume of fibre and found to be 72.5% more than reference concrete.

R .N. Swamy (1978) research includes not only an assessment of fibre content and matrix strength, but also such details as fibre distribution, orientation, and effectiveness of bonding. Possible manufacturing or materials faults can also be diagnosed. Also it shows that the MOR and LOP in drying condition test have higher result than wet condition around (1- 5) MN/m2 difference.

Surendra P. Shah, James I. Daniel, DarmawanLudirdja (1987) examined that the use of alkali resistant glass fibre and E glass fibre in combination with a latex fibre when exposed to the accelerated aging environment the flexural strength reduces. MOR after 52 weeks of accelerated aging was just half of the unaged. Toughness value was very small $1/60^{th}$.

Bentur and Kovler (1997), has observed that the use of low percentages of synthetic fibers is significantly effective in floor slab applications. Low fiber content is defined as less than an equal to 0.3 percent by volume of concrete mix. The paper is the results of the experimental investigation of the effect of low percentages of nylon and polypropylene fibers on slump, inverted slump cone time, air content, compressive and flexural behaviour and impact resistance of concrete. Three percentages of fibres, viz., 0.15%, 0.22%, and 0.30% by volume of concrete mix with one fiber length (25 mm) were used. It is observed that the addition of fibers reduces workability of the concrete and there is no significant effect on the compressive strength of concrete. Marginal increase in flexural strength of the order of 10 to 22% with nylon fibers and 8 to 15.5% with polypropylene fibers is observed. Nylon and polypropylene fibers also exchanges the ductility of concrete. Both the fibers increases the impact strength considerably. The increase in impact strength is 206 kN to 373 kN with nylon fibers.

Banthia et al (1997) studied the performance of E-glass and AR-Glass fibre reinforced composites with the cementitious matrices. The results were compared with those of ordinary Portland cement composites. It was shown that by adjusting the composition of the matrix, there is a potential for developing highly durable fiber – cement composites, even with E – glass, which is probably the most sensitive to corrosion of the man – made high strength fibers.

Chandramouli et al (2010) had conducted experimental investigation to study the effect of using the alkali resistance glass fibres on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. The mechanical properties of glass fibre reinforced polyester polymer concrete were evaluated. The author observed that the modulus of rupture of polymer concrete containing 20 per cent polyester resin and about 79 per cent fine silica aggregate is about 20 MPa. The addition of about 1.5 per cent chopped glass fibres (by weight) to the material increases the modulus of rupture by about 20 per cent and the fracture toughness by about 55 per cent.

Chawla and Tekwari (2012) outlines the experimental investigation conducted on the use of glass fibres with structural concrete. CEM-FILL anticrack high dispersion, alkali resistance glass fibre of diameter 14 micron, having an aspect ratio 857 was employed in percentages varying from 0.33 to 1 percent by weight in concrete and properties of this FRC, like compressive strength, flexural strength toughness, modulus of elasticity, were studied.

Muthuswamy and Thirugnanam (2013) described the experimental work on Hybrid Fibre Reinforced High Performance concrete using three types of fibres namely, steel, glass and polyester fibres of a reputed brand. Slica fume was added as a mineral admixture to partially replace the cement in concrete and a super plasticizer was used to get the desired workability. A comparison with steel fibre reinforced concrete and plain concrete showed significant improvement in the strengths of the hybrid fibre reinforced concrete due to the inclusion of both fibres and silica fume.

Naaman (1977) described the range of tensile properties currently achievable using HPFRCC (High Performance Fibre Reinforced Cement Concrete) focusing in particular on the trade-off between strength and strain capacity and the importance of large strains. Also, a brief summary of three representative applications involving the use of HPFRCC in repair and rehabilitation is given namely, the use of fibres in the tensile zone of reinforced concrete beams to control cracking and improve durability‟, the use of Simcon for repair and reinforced concrete beams and columns to satisfy seismic requirements and the use of Simcon as a jacket in reinforced concrete columns, also to improve seismic resistance.

Sinha et al (2013) studied the effect of ternary blends on the strength characteristic of steel fibers reinforced concrete. Both binary and ternary blends were made using SCMs such as fly ash, ground slag, silica Glass Fibre Concrete: Investigation On Strength And Fire Resistant Properties fume, granulated blast furnace, and metakaolin. Thirty percent of cement was replaced by one SCM or combination of two SCMs. The results of compressive strength and tensile strength are presented.

Siddique (1997) has stated that the effectiveness of fibers in controlling shrinkage and thermal cracking in cement based materials is well recognized. For any cement based composite, however, the type of fiber and its aspect ratio are the two most important factors controlling such cracking. In this investigations four types of polyolefin fibers namely, l/d = 19/15, 25/15, 25, 38 and 50/63 were used wherein l is the length of the fiber and d is the equal diameter. Type 19/15, for example is 19 mm long and 0.15 mm in equal diameter and manufactured by the 3M Corporation. A novel technique developed at UBC was employed for the purpose. In this technique fibre reinforced concrete to be tested is laid on top of a fully hardened base concrete which provided the bottom restraint, and resulted in cracking in the overlay which was then monitored as a function of time. It was noted that while the polyolefin fibers are generally effective in reducing the amount and size of the shrinkage cracking of the fibers as they have a decisive influence on the result.

III-ADVANTAGE, DISADVANTAGE AND PRACTICAL APPLICATION

After careful review of the various literatures, it was found that there are a number of advantages of using glass fibre reinforced concrete along with their practical applications. Also, if there are advantages of certain type of concrete, it is always accompanied by certain demerits which can be seen from the study of litreatures. The advantages, disadvantages and the practical applications are discussed below:

ADVANTAGES :

- Glass Fibre has high tensile strength thus prevents the cracking on the surface of concrete.
- Glass Fibre has high fire resistance thus reducing the damage loss during the fire accidents.
- Glass Fibre contains chemicals and minerals which helps in performance of concrete.
- Glass Fibre are small in lengths and dispersed randomly in the concrete which increases the impact strength of the concrete.
- The concrete made up of glass fibres has lower density than the ordinary concrete.
- It has got good resistance against freezing and thawing.
- It can be used as a shock mitigation in earthquake zone.
- Glass fibre reinforced concrete can also be used as sound insulators.

DISADVANTAGES :

- Cost of GFRC is more than that of concrete.
- It may loose its strength, over excessive mixing of fibre. So this point should be mentioned at design stage.
- It is made precast rather than on site, so future planning is needed.
- It is applied by pouring and mixing.
- It is not easy to mix by your own.

APPLICATIONS :

- Several construction elements, mainly non constructional ones, like facade panels, piping for sanitation, decorative non recoverable form work and other products.
- This concrete can be used for retrofitting of existing concrete structures.
- This concrete can be used for the building renovation works.
- This concrete can be safely used for the water and drainage works.
- This concrete used for the bridge and tunnel lining panels.
- It has good use for architectural cladding, acoustic barriers and screens.

IV- CONCLUSION

After an extensive study of the various literatures on glass fibre reinforced concrete, it was found that it is an excellent concrete that can be used for various applications. It can be seen from the work of a numerous of researchers that the workability of the concrete increased up to a certain percentage of addition of glass fibres and then gradually decrease. However, the compressive strength significantly increased, flexural and tensile strength which resisted at a certain point which was clearly defined in the literatures. It was also seen that the use of super plasticizers enhance the workability of the matrix and the addition of low alkali cement added the durability characteristics. Thus, GFRC is significantly used in building works, construction or renovation of exterior facades of building, drainage works, architectural works.

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