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Review on Replacement of Steel Reinforcement to Glass Fiber Reinforcement Rebars

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ABSTRACT

As we know Plain Concrete has limited ductility, strength in tension as well as low cracking resistance. Micro cracks are present in concrete and these propagates at a great extent and results in extensive brittle fracture. Experiments in past and numerous researches in the last decade were focused merely on developing novel techniques of improving tensile strength of concrete. Among these mostly used is GFRP (Glass Fiber Reinforced Polymer) is easily available, which is low in cost than CFRP (Carbon Fiber Reinforced Polymer), and that's why various studies is done to strengthening of concrete by using GFRP particularly in countries like India.GF is latest introduction cum revolution in production FRC. It overpowers all the synthetic fibers, due to its excellent strength, extreme durability, supreme wear-tear resistance and exceptional tensile and impact strength. At this time GFRC (Glass Fiber Reinforced Concrete) excelled as a great remedy for civil engineers. Tensile strength of GFRC lies between 1024 and 4080 N/mm2. It is the benefit of using glass fibers in reinforcement of concrete. Construction Industry is accelerating day-by-day. Today is the scenario of sky scrapping and complex infrastructures, which results in increasing demand of basic civil engineering material i.e. cement. Engineers are looking for alternative of expensive construction since long. Cement, binder in concrete, is an expensive and exorbitant civil engineering material and it increases the Constructional budget. Not only this, but also cement marks the highest consumption throughout the world after water. The carbon credits to the environment during cement production, is an alarming issue. If it keeps following the exact pace as today, it is probable to reach annual cement production up to about 600 metric tons by 2025 in India alone and the globe will change into hot air balloon. Cement industry alone contribute to 2.4% to the total carbon emissions round the globe. To eradicate this converse effect of cement industry on the environment, engineers are working hard to find efficient substitutes which are in-expensive, eco-friendly and can possess better cementing properties. Agricultural and commercial wastes are the best choice and have the characteristics favoring their utilization in concrete production. These by-products are complete waste and if re-used in any sort releases a huge burden from environment.

Keywords: Glass Fiber, Workability, Compressive strength, Compaction factor, Slump test

INTRODUCTION

GF is latest introduction cum revolution in production FRC. It overpowers all the synthetic fibers, due to its excellent strength, extreme durability, supreme wear-tear resistance and exceptional tensile and impact strength. At this time GFRC (**Glass Fiber Reinforced Concrete)** excelled as a great remedy for civil engineers.GF Rebar is non-corrosive, having high tensile strength as well as light weight and it also possesses a very high strength to weight ratio. Glass Fiber are added at various percentages like 0.2%, 0.4%, 0.6%, 0.8 % and 1.0% by the weight of cement to concrete mix and rest the specimen for 28 days for curing to find out the workability as well as compressive strength of the specimen by testing on it the basis of various researches is done, various conclusions has been drawn these are as following: The addition of 0.2% fibre poses high compressive strength and this have good workability of concrete. The maximum compressive strength is takes by adding 1% fibre into it and 0.8% is best plasticizer when it is compared with the reference mix.

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To eradicate this converse effect of cement industry on the environment, engineers are working hard to find efficient substitutes which are in-expensive, eco-friendly and can possess better cementing properties. Agricultural and commercial wastes are the best choice and have the characteristics favoring their utilization in concrete production. These by-products are complete waste and if re-used in any sort releases a huge burden from environment [3].

At this time GFRC (**Glass Fiber Reinforced Concrete)** excelled as a great remedy for civil engineers. Tensile strength of GFRC lies between 1024 and 4080N/mm^2. It is the benefit of using glass fibers in reinforcement of concrete. This type of modified concrete can explicitly be used in many significant arenas of construction industry. Some of which are detailed as below:

- Renovation/repair of building
- Hydraulic works/construction of water headwork
- Lining the internal surfaces of tunnels
- Construction of decks of Bridge
- Cladding and form work
- Sound insulations

LITERATURE REVIEW

It served as a foundation stone to the present investigation. Many substitutes of cement in concrete production are developed and investigated by numerous engineers in the past, some of which are relevant to the present work and provided pace to current investigation. Some of these works are reviewed and briefed as under:

1. In the study of Kumar J.D, He observed 1-5% increase in compressive strength with varying percentage content of glass fiber.
2. In the study of N. Pannirselvam, he investigated experimentally the workability and load bearing properties of concrete blended with waste glass fiber as additive/admixture into the conventional control mix and he observed 28.57% to 40% increment of ultimate load for 3 mm thick Glass Fiber Reinforce Polymer (GFRP) sheet and 28.57% to 128.57% increment of ultimate load for 5 mm thick Glass Fiber Reinforce Polymer (GFRP) sheet.
3. In the study of Dr. P. Srinivasa Rao, he observed that the concrete produced through incorporation of glass fibers @ 1 to 5%, can induce characteristic feature in concrete like

Enhanced durability, negligible chances of bleeding and excellence resistance to acid attack.

4. In the study of Nadeem A. Siddiqui, (2009) in his paper highlighted certain engineering properties of concrete blended with waste glass fibers as admixture. He investigated experimentally the workability and load bearing properties of concrete blended with waste glass fiber as additive/admixture into the conventional control mix.
5. In the study of Kannan et al, 2010, he observed that the permeability and workability of cement improved as the proportion of water and binder is reduced due to addition of glass fiber.
6. In the study of S. S. Pimplikar, in his research proposed an easy alternative to utilization of Glass-fiber reinforced concrete (GRC) as a partial substitute of cement.
7. Sherif H. Al-Tersawy. (2013), in his work investigated and explored the potential of carbon fibre reinforced polymer as a partial substitute of cement. They used vertical strands of CFRP with varying orientation to replace cement. They suggested better way to replace cement with a prior material which is available at free of cost and improves strength of concrete. As per the justification proposed by his investigation the permeability and workability of cement improved as the proportion of water and binder is reduced due to addition of CFRP. He suggested that only small fiber content is sufficient to make the concrete impermeable and positively influencing the compressive strength of concrete as compared to the conventional mix. From experimentations he inferred that shear can be bore more is inclined fibres are used in place of vertical fibres.
8. Firmo J et al, (2015) in his paper highlighted certain engineering properties of Concrete blended with waste glass fibers as admixture. He investigated experimentally the workability and load bearing properties of concrete blended with waste glass fiber as additive/admixture into the conventional control mix. Main focus was on analytical and experimental interpretation of fire resistance. He fortified RC beam with carbon FRP lamination. With this modification the fire resistance of only 23 minutes of RC beam is accentuated to an earmark high i.e. 70 minutes. He studied both qualitative and quantitative aspect of FRC with varying content of fibres.
9. M.A. Saafan (2006) focused mainly on calculation of failure pattern of both shear and flexure. The quantitative approach is explained by calculation of crack width of different patterns and comparing them with available data. Beams were tested for validation of his research. In his work in carbon fibre reinforced polymer as a partial substitute of cement. The fiber reinforced concrete showed minute cracks than control RC beam.
10. Thomas E. Boothby in 2005 in their work suggested a better method of utilization of carbon fiber sheet, coir, glass fiber sheet, steel fibers and polypropylene fibers for laminating conventional concrete beams. They prepared 28 beams of cross section 150mm x 150mm and length of 1000mm. The wrapped the conventional concrete by layer of these fibers and tested the beams for their resistance to deflection, cracking and ductility and inferred from various experimentations that GFRP enhanced the ultimate strength, induced self-reparability in modified concrete and improved ductility.
11. Bilal S. Hamad (2004) along with his colleagues examined the nature of fiber Reinforced polymer (FRP) wraps to confine steel reinforcement in a tension la splice region anchored in high-strength reinforced-concrete beams. Seven beam specimens were reinforced on the tension side with three deformed bars spliced at midspan Glass fiber reinforced polymer (GFRP) sheets were used. The main test variables were the GFRP configuration in the splice region (one strip, two strips, or a continuous strip), and the number of layers of the GFRP wraps placed

around the splice region (one layer or two layers). All GFRP wraps were U-shaped. Except for the epoxy adhesive, no other anchorage mechanism or bonding procedure was applied for the GFRP wraps on the concrete beam. The test result showed that the GFRP can increase the bond strength and ductility of tension lap splices. They concluded that the GFRP wraps were effective in confining the tension splice region. The mode of failure in all beam specimens was a face-and-side split failure. The mode of failure as compared to beam without GFRP was more ductile and more gradual although the final mode of failure was splitting of the concrete cover. They also found strength increment ranging 8% to 33% with respect to control beam. The use of GFRP wraps did not affect the cracking load. Overall conclusion of their research indicate that the use of GFRP wraps to confine bond critical regions in beams leads to change the nature of failure from brittle mode to a ductile one, allowing more bar lugs along the spliced bars to Participate in the stress transfer between steel and concrete, and increasing the Average splitting bond strength.

12. M.C. Sundarraja (2009) proposed an analytical study on flexure failure of concrete. From various experimentations proposed a modification of conventional concrete using FRP primarily glass fibre.
13. Anumol Raju and Liji Anna Mathew (2013) in their work suggested a better method of utilization of carbon fiber sheet, coir, glass fiber sheet, steel fibers and polypropylene fibres for laminating conventional concrete beams. They prepared 30 beams of cross section 150mm x 150mm and length of 1000mm. The wrapped the conventional concrete by layer of these fibers and tested the beams for their resistance to deflection and inferred from various experimentations that GFRP increased the ultimate strength by 89%. A couple of studies have been completed on the remains got legitimately from the enterprises to examine the properties of Glass Fiber Rebar and they have been discussed above.

OBJECTIVE

There are two types of objectives associated with the present work namely Specific objective and Derived objectives.

Specific objectives

The prime objectives or the foremost goals for which this investigation is carried out are as follows:

- To understand the characteristic features of GFRP Concrete.
- To investigate impact of GFRP on important engineering property i.e. compressive strength of hardened concrete[5].

Derived objectives

Other objectives which are achieved by their own after successful achievement of specific objectives are:

- To lessen the problem of disposal of Glass fiber
- To lessen the release of CO_2 during manufacturing of cement.

EXPERIMENTATIONS

In this research was carried out mainly to justify the usage of GFRP as a modifier of conventional concrete. This modification is validated by detailed experimental program on hardened concrete. These properties studied through tests are listed as below:

- Yield Strength
- Cracking Strength
- Ultimate Strength

When any component of concrete is replaced with some other material which enhances the properties of resulting mix or when some extra additive is added to conventional concrete then the resulting concrete is known as modified concrete. In the present investigation modifiers used are GFRP rebar. 2 No. 12mmΦ bars are used in longitudinal reinforcement and 2 No. 10mmΦ bars are used in compression zone. PPC-43 is used in this research [6].

The mix proportion of all the six beams was pre-fixed by proper mix designing and limit state method of IS 456-2000 was employed. Specimens of 150 x 150 x 100 mm size were prepared. Concrete of M40 grade was designed and the concrete was machine mixed. Total 6 beams were moulded, out of which 1 specimen was conventional/control beam and rest 5 specimens were sheathed with GFRP laminate [7].

Preliminary tests for determination of physical and engineering properties of material used are carried out conforming to IS code.

Tests for cement include:

- Specific gravity,
- Fineness,
- Consistency, and
- Initial setting time

A test for fine aggregates and coarse aggregates includes:

- Sieve analysis,
- Specific gravity,
- Impact value,
- Crushing value and
- Abrasion value

Values of these tests were used in mix-design.

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Following steps were adopted for casting of beams as follows:

1. On preliminary oil/grease the entire mould assembly so that the specimen should not stick to the walls of the mould and can be demoulded easily after casting.
2. Place the 20mm cover blocks, so as to ensure specify cover to the reinforcement, before placing the bars for casting of beam.
3. Pour the concrete mix in 3 layers with sufficient compaction through vibrators or tamping rods. Fill the mould completely in the same pattern with proper compaction so as to avoid air voids.
4. After 24 hours the beam started to gain its plastic stage from fresh stage, after that the specimen can be demoulded and properly cured for 28 consecutive days.
5. Total 6 beams were casted out of which 1 was controlled beam and rest 5 beams were wrapped with Glass Fiber Reinforced Polymer (GFRP) laminate.

TESTS

Compressive Strength Test of Cubes

The strength of mix proportioned sample against compression is ascertained by this experiment. The results are tabulated in table below and results from table are compared in the

S.NO	SPECIMEN NO.	COMPRESSIVE STRENGTH
1.	C 1	53.33 Mpa
2.	C 2	48.8 Mpa
3.	C 3	53.33 Mpa

Table 1: Compressive Strength of Cube after 7 days

proceeding bar graph:

Arithmetically, the value of strength of any material against compression is **Comp. Strength = Failure load/area of cross-section** as the GFRP rebar are originated from fibers thus they lack compressive strength, hence their use is deferred as compression members. These are strong in tension, thus most abundant as tension members. Their compressive strength is only 40-60% of their tensile strength. Compression modulus is par lesser than tension modulus because of the fact that lesser corresponding compressive strength. Typical values of compressive and tensile modulus are as follows:

Compression modulus = 40GPa to 55GPa

Tension modulus =210 GPa

Compressive Strength = Load / Cross-sectional Area.

Figure 1: Cubes for Testing

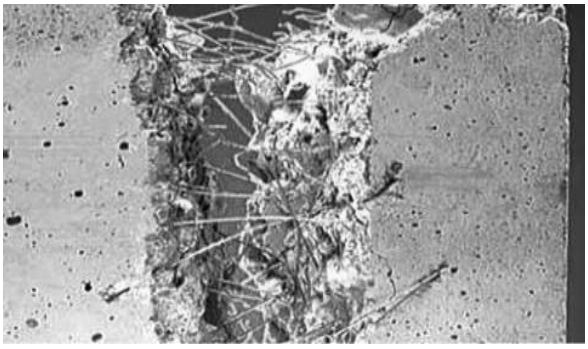
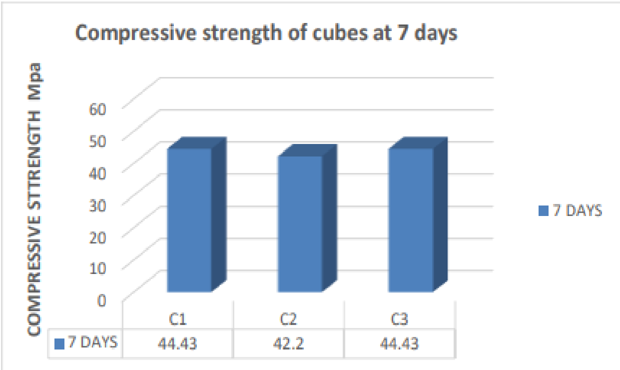


Figure 2: Cube after Testing



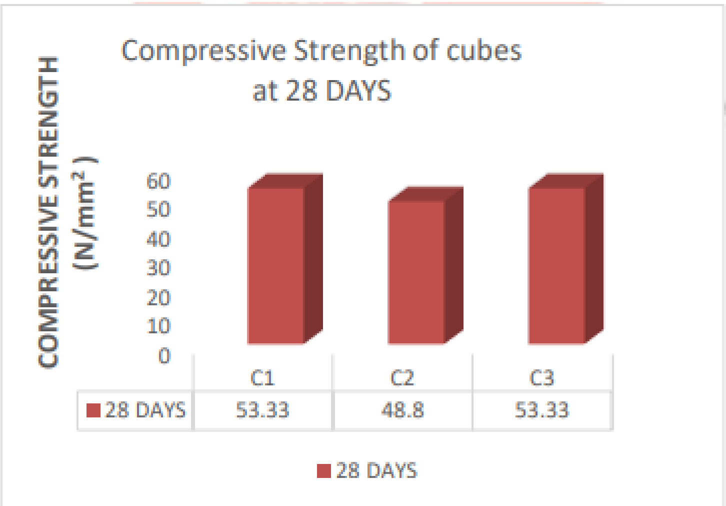
Graph 1: Compressive Strength of Cube at 7 days

The inferences of compressive strength test of cubes for 7-day strength shown in table:

Inference: Strength of cube against compres sion after 7 days = 44.3Mpa

The compressive strength of cubes for 28-day strength shown in table:

Strength of specimen in compression **on 28 days = 51.82 Mpa**



Graph 2: Result of Compressive Strength of Cube at 28 days

Load Carrying Capacity

From the experimentations it was inferred that there notices an extensive improvement in load carrying capacity of GFRP coated RC beam (or HB0L5) as compared to conventional control beams, these inferences were as follows:

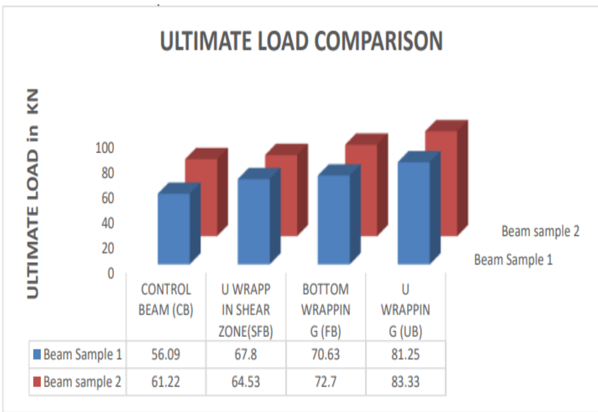
- Strength at first crack – improved by 31%
- Yield strength – improved by 41%, and
- Ultimate strength – improved by 33%

These improvements are highest in case of yield strength, but after yield to ultimate strength the improvements decline thus resulting in de-bonding of the specimen. But this time the specimen fails via ductile failure, encompassing the conventional brittle failure.

Yet 31% improvement in ultimate strength of RCC specimen is a triumph for a civil engineer and he can took this improvement advantageously in improving structural design members. Also mode of failure either brittle or ductile is of great importance for structural engineer; ductile failure can be advantageously used in structural elements

S.NO	SPECIMEN NO.	COMPRESSIVE STRENGTH
1.	C 1	44.43Mpa
2.	C 2	42.2Mpa
3.	C 3	44.43Mpa

Table 2: Compressive Strength of Cube after 28 days



. **Graph 3: Ultimate load Comparison among all Beams**

CONCLUSION

With the help of the obtained experimental test result, the strong and rigid GFRC gives full lateral support on both sides of the studs, and it prevent them from buckling and twisting laterally. The result of this, the panel is lightweight in comparison with traditionally reinforced concrete, yet is strong and durable and can be easily handled. Higher load carrying capacity with improved resistance to deformation is observed in case GFRP coated HFRC beams and There is no proper maintenance required during the addition on the concrete, Fibers at lower quantity and at reasonable cost fulfill all the required condition of the concrete The concrete mix design should not affected after the addition of fibers. Thus to sum up the properties like bleeding is reduced to a great extent along with the chances of segregation and effect of freeze thaw cycles are extremely diminished with this proposed modification. From these concluding notes briefed as above it can be inferred that the content of glass fiber enhances the structural strength of the composite. The most common place you have to see this type of material is in the construction industry. It's used in most commonly cases such as in architectural cladding that's hang several storeys above sidewalks or even more for aesthetics such as interior furniture pieces like GFRC Coffee tables.

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