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Study on the Strength Behaviour and Performance Evaluation of Fiber Reinforced Concrete

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Abstract - Concrete is one of the most widely used construction material in today's world. Cement being one of the essential constituents of the concrete. Glass fibre has been used over 30 years in several construction members. Plastic fiber-reinforced concrete offers significant advantages in improving crack resistance, durability, and impact resistance, making it a valuable material in construction, especially in non-structural or lightly loaded applications. This study was done to find out the strength parameters of concrete using glass fiber and plastic fiber in concrete in different grades of concrete. The use of Glass fiber as partial replacement of cement, fine & coarse aggregates gives an increment in strength at certain percentage GFC & PFC as partial replacement of coarse aggregates in concrete. In this study it is found that there is a marginal increase of strength in 7- & 28-day's the compressive strength for 3% addition of GFRC & PFRC in concrete, initially the compressive strength start increasing but, as the increment of FRC in concrete percentage the strength gets decrease and similarly the same behaviour with flexure strength and split tensile strength also found the similar strength parameters.

Key Words: optics, photonics, light, lasers, templates, journals

1.INTRODUCTION

Infrastructure development across the world created demand for construction materials. Concrete is the premier civil engineering construction material. Concrete manufacturing involves consumption of ingredients, aggregates, water and admixture. Concrete is a composite material which composed of aggregates, cement and water. Different waste material like rubber, fly ash, glass, bottom ash, artificial sand etc. has been used as alternative for replacing natural aggregates. Fibers prevent micro cracks from widening. Addition of fibers makes components ductile and tough. Conventional concrete cracks easily. When concrete is reinforced with random dispersed fibers, we get favorable behaviour for repeated loads. Advanced cement-based materials and improved concrete construction techniques provide opportunities for the design of structures to resist severe load resulting from earthquakes, impact, fatigue, and blast environment. Concrete compound material produced by composition of coarse aggregate, fine aggregate, lime/cement, and water and some admixture, which is bonded together to produces a good strength Effort have been made in the concrete industry to use GFC & PFC as partial replacement of coarse aggregates in concrete.

OBJECTIVE OF RESEARCH

- To decrease the depletion of natural resources to keep ecological balance.
- To determine the optimum level of replacement of coarse aggregates with the FRC as aggregates.
- To achieve the sustainable issues in the construction field by changing the percentage of natural aggregates with the FRC as aggregates.
- To reduce the structural cost by using the FRC as the coarse aggregates.
- To determine the suitability of FRC as the coarse aggregates with respect to strength and durability.

LITERATURE REVIEW

S.Sharmila et al. (2013): The authors indicated that: The effect of adding hybrid fibers influence the behavior of beams by increasing the ductility characteristic GFC+PFC by 80% and energy absorption characteristic GFC+PFC by more than 160%. Instead of adding single fiber, the combination of different types of fibers (Hybrid fibers) increases the energy absorption capacity substantially.

Ali et al. (2018) investigated the performance of FRC with partial reinforcement of cement with Metakaoline. Nylon fibre of length 50 mm and diameter of 0.35 mm (aspect ratio 143) was used with different percentages ranging from 0.5% to 1.5% by weight in cement. Nylon fibre, being a textile waste, can be utilized in concrete as a replacement for the fine aggregate. 10% Metakaolin can be used as a replacement of cement. Metakaolin mixed with concrete reduced the setting time of concrete. Addition of 1% nylon fibre in concrete enhanced the compressive, tensile and flexural strengths; replacement of cement with 10% of Metakaolin improved the workability and reduced the setting time of concrete.

MATERIALS AND METHODS

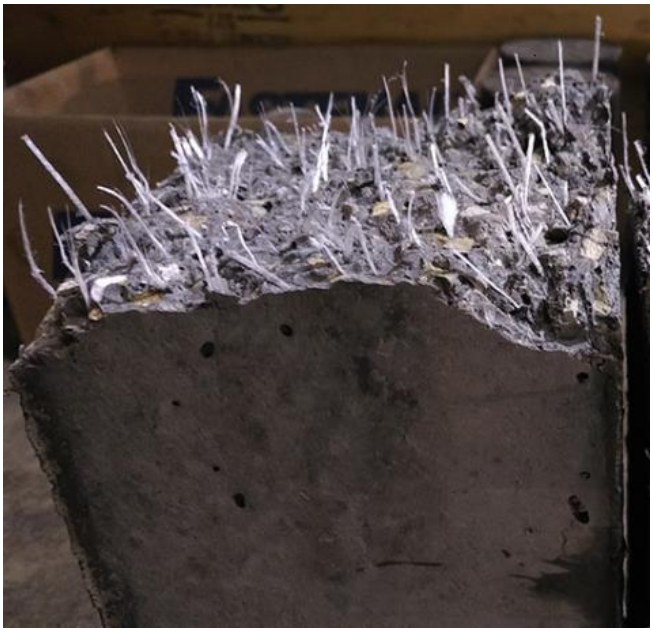
Glass fiber: Glass is defined as a hard, brittle, translucent and commonly transparent substance, white or colored, made by fusing together sand or silica with lime, potash, soda or lead oxide. Class E fiber was used. Fiberglass is an immensely versatile material due to its light, inherent strength, weather resistant finish, and variety of surface texture.

Plastic Fiber: Plastic fiber-reinforced concrete offers significant advantages in improving crack resistance, durability, and impact resistance, making it a valuable material in construction, especially in non-structural or lightly

loaded applications. While not a replacement for traditional reinforcement, plastic fibers serve as an excellent supplement to enhance the overall performance of concrete, particularly in environments exposed to harsh conditions, such as freeze-thaw cycles, chemicals, and water exposure.

Concrete mix & Casting

The objective of mixing the ingredients is to ensure that each particles of aggregate in fresh concrete will be coated with the cement paste. Mixing was done in standard drum—type mixer. GFC+PFC & CA were first mixed in dry state until the mixture become homogenous. For the test of compressive strength six cubes were casted each time of size 150mm xl50min x 150mm in cube mould. Tests were conducted after 7 days and 28 days respectively.



The body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material.

It is often important to refer back (or forward) to specific sections. Such references are made by indicating the section number, for example, “In Sec. 2 we showed…” or “Section 2.1 contained a description….” If the word Section, Reference, Equation, or Figure starts a sentence, it is spelled out. When occurring in the middle of a sentence, these words are abbreviated Sec., Ref., Eq., and Fig.

At the first occurrence of an acronym, spell it out followed by the acronym in parentheses, e.g., charge-coupled diode (CCD).

Table -1: (SLUMP CONE TEST)

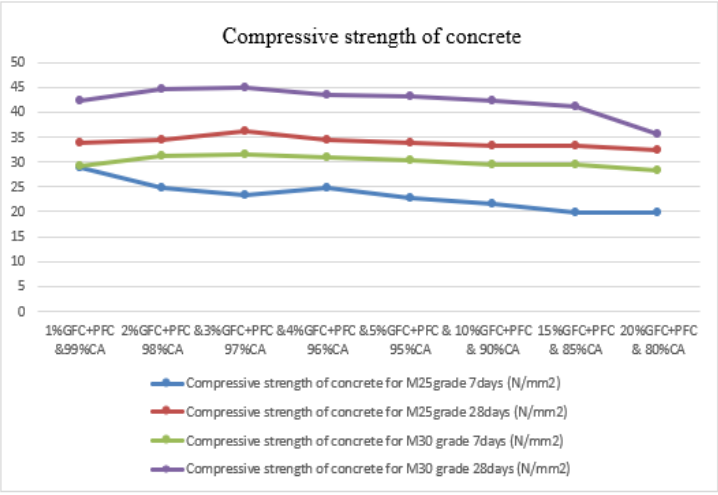
S.NO	% Replacements Glass fiber concrete & Coarse Aggregate	Slump for M25 GRADE in (mm)	Slump for M30 GRADE in (mm)
1	1%GFC+PFC &99%CA	100	90
2	2%GFC+PFC & 98%CA	90	86
3	3%GFC+PFC & 97%CA	85	72
4	4%GFC+PFC & 96%CA	76	70
5	5%GFC+PFC & 95%CA	72	68
6	10%GFC+PFC & 90%CA	69	60
7	15%GFC+PFC & 85%CA	80	72
8	20%GFC+PFC & 80%CA	82	80

Table-2. COMPRESSIVE STRENGTH TEST RESULT

S.NO	% Replacement (GFC+PFC & CA-COARSE AGGREGATE)	Compressive strength of concrete			
		for M25grade		for M30 grade	
		7days (N/mm 2)	28days (N/mm 2)	7days (N/mm 2)	28days (N/mm 2)
1	1%GFC+PFC &99%CA	28.78	33.76	29.25	42.25
2	2%GFC+PFC & 98%CA	24.68	34.45	31.34	44.55
3	3%GFC+PFC & 97%CA	23.32	36.25	32.50	44.85
4	4%GFC+PFC & 96%CA	24.87	34.45	30.89	43.45
5	5%GFC+PFC & 95%CA	22.74	33.95	30.45	43.25
6	10%GFC+PFC & 90%CA	21.64	33.35	29.60	42.25
7	15%GFC+PFC & 85%CA	19.73	33.20	29.45	41.25
8	20%GFC+PFC & 80%CA	19.82	32.25	28.25	35.55

The above results show that there is a marginal increase in 7- & 28-day’s compressive strength for 3% addition of GFRC & PFRC while compressive strength increases at all ages for up to 3 % addition of FRC content as compared to control specimen. However, the compressive strength start decreasing as the increment of FRC in concrete percentage.

Graph -1: Compressive Strength



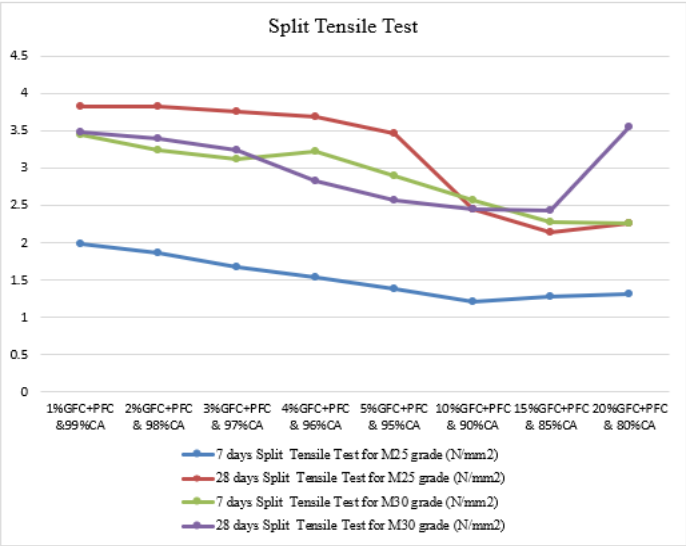
The above graph show that there is a marginal increase in 7- & 28-day's compressive strength for 3% addition of GFRC & PFRC in concrete, the compressive strength start decreasing as the increment of FRC in concrete percentage the strength get decrease.

Table.3 Split Tensile Strength Test Result

S.NO	% Replacement (GFC+PFC & CA-COARSE AGGREGATE)	7 days Split Tensile Test for M25 grade (N/mm2)	28 days Split Tensile Test for M25 grade (N/mm2)	7 days Split Tensile Test for M30 grade (N/mm2)	28 days Split Tensile Test for M30 grade (N/mm2)
1	1%GFC+PFC &99%CA	1.98	3.83	3.45	3.48
2	2%GFC+PFC & 98%CA	1.86	3.82	3.23	3.39
3	3%GFC+PFC & 97%CA	1.92	3.76	3.12	3.23
4	4%GFC+PFC & 96%CA	1.54	3.69	3.22	2.83
5	5%GFC+PFC & 95%CA	1.38	3.46	2.89	2.56
6	10%GFC+PFC & 90%CA	1.21	2.44	2.57	2.44
7	15%GFC+PFC & 85%CA	1.28	2.13	2.27	2.43
8	20%GFC+PFC & 80%CA	1.32	2.25	2.25	3.55

The split tensile strength of concrete increases with respect to control mix at 2% and 3% of fiber content. Other percentages of fiber show a reduction in the split tensile strength with reference to control mix. Again, for all ages, fiber reinforced concrete gave best results at a mix ratio of 1.5% by weight of cement.

Graph -2: Split Tensile Strength (in N/mm^2)



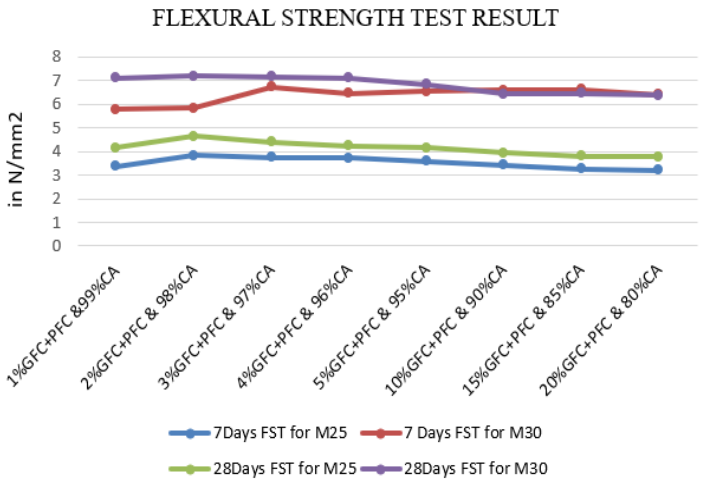
The above graph represents the split tensile strength of concrete increases with respect to control mix at 2% and 3% of fiber content. Other percentages of fiber show a reduction in the split tensile strength with reference to control mix. Again, for all ages, fiber reinforced concrete gave best results at a mix ratio of 1.5% by weight of cement.

Table.4 flexural Strength Test Result

S.NO	% Replacement	7 days Flexural strength Test for M25 grade	28 days Flexural Strength Test	7 days Flexural Strength Test for M25 grade	28 days Flexural Strength Test for M30 grade
1	1%GFC+PFC &99%CA	3.38	5.78	4.15	7.10
2	2%GFC+PFC & 98%CA	3.82	5.83	4.65	7.20
3	3%GFC+PFC & 97%CA	3.75	6.74	4.40	7.16
4	4%GFC+PFC & 96%CA	3.72	6.45	4.25	7.10
5	5%GFC+PFC & 95%CA	3.60	6.55	4.15	6.85
6	10%GFC+PFC & 90%CA	3.42	6.59	3.95	6.44
7	15%GFC+PFC & 85%CA	3.25	6.62	3.80	6.45
8	20%GFC+PFC & 80%CA	3.21	6.40	3.78	6.38

Results are shown in figure above that the flexural strength at between 2%-3% addition of FRC in concrete is best results but when increasing by percentage above 4% the strength get decreases, also the 28days maximum strength is 6.74 N/mm^2 for M25 mix similarly the maximum strength for M30 at 28 days was found to be 7.20 at 2% of addition of FRC in concrete.

Graph -1: Flexural Strength Test (in N/mm^2)



Results are shown in figure above that the flexural strength at between 2%-3% addition of FRC in concrete is best results but when increasing by percentage above 4% the strength get decreases.

3. CONCLUSIONS

1. This article summarized that fiber reinforced concrete is a very useful and strong material that can be used in construction. After using FRC around 2 to 3 percent enhancement in compressive strength. It helps to make the precast elements lightweight, so the cost of transportation decreases effectively in pre-cast construction. Tensile and Flexural strength also get improved by using FRC which makes structural element resistant against cracking and more durable
2. Flexural strength of glass fiber reinforced concrete increases more than 1.5 times at 1.5 & 2.0% mix ratios with respect to control mix.
3. The small amount of addition Glass Fiber (1 up to 3) % has reviewed gives a desirable improvement to the mechanical properties of concrete.
4. The review has been conducted utilization Glass powder from (1 up to 3) % also good as the replacement of fine aggregate in concrete, which gives a desirable improvement to mechanical properties of concrete.
5. Utilization of Glass Fibers and plastic Fibers in concrete give desirable improvement to compressive strength as compare to conventional concrete. Utilization of Glass Fiber and plastic Fibers in concrete give desirable improvement to Flexural Strength of concrete compare to conventional concrete.
6. Utilization of Glass Fiber and plastic Fibers gives desirable improvement to Split Tensile Strength of concrete compare to conventional concrete.
7. By utilization of Glass Fiber and plastic Fibers in concrete the modules elastic of concrete is increased as compared to the normal concrete from the above researches it also found that the addition of FRC decreases workability and addition of GFRC & PFRC either as cement replacement or aggregate replacement increases workability of FRC in concrete.
8. Increase in percentage replacement by FRC and after 3 percentage the strength reduces in compressive strength and split tensile strength of concrete.

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BIOGRAPHIES

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