Experimental Study on Partial Replacement of Cement by Flyash with Glass Fibers

G Ramya[1], M Shivani[2], K mahesh[3], G Sandyarani[4], G Ajay[5]

[1]*Assistant Professor, Department of Civil Engineering, Jyothishmathi Institute of Technology and Science, Karimnagar, Telangana, India,505001*

[2,3,4,5] *B.Tech students, Department of Civil Engineering, Jyothishmathi Institute of Technology and Science, Karimnagar, Telangana, India,505001*

Abstract: Concrete is one of the mostly widely used construction material in today's world. Cement being one of the essential constituent of the concrete. Concrete mainly suffers from limited ductility, low tensile strength, and slightly resistant from cracking. With increase in coal based thermal power projects there is increase in production of fly ash which is a waste material and the disposal of this fly ash is hazardous to environmental if it is not disposed well. The addition of glass fibres to concrete considerably increase structural characteristics such as flexural strength, impact strength, tensile strength and ductility.

In this study addition of glass fibre and fly ash of class -f as cement replacement in production of concrete with percentage ranging from 0%, 0.5%, 1% and 2% of glass fibre and 20% replacement of fly ash. The main objective of this project with M30 ratio of 1:1.75:2.03. Due to addition of glass fibre and fly ash the compressive strength, split-tensile strength and flexural strength was increased due to pozzolonic action of fly ash with glass fibres. The strength attained maximum at 20%, 2% of fly ash and glass fibre respectively.

INTRODUCTION

One of the oldest and most widely used building materials in the world is concrete. It is the second most involved substance on the planet after water. Concrete is a combination of coarse total, fine total, concrete and water. This blend frames a liquid slurry that is effectively emptied and formed into shape. Substantial assumes a fundamental part in many designs, for example, structures, spans, channels etc.n the past, lime based concrete folios, for example, lime clay, were frequently utilized however once in a while with other pressure driven concretes, (water safe, for example, a calcium aluminate concrete or with Portland concrete to shape Portland concrete cement (named for its visual similarity to portland stone). Asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concrete, which uses polymers as a binder, are two examples of many other non-cementitious types of concrete. Mortar is not the same as concrete. Mortar is a bonding agent that typically holds bricks, tiles, and other masonry units together, whereas concrete is a building material in and of itself.

Concrete turning into an inside piece of a development works, the use of cement is turning out to be more because of improvement of the development business. The presentation of cement relies on the properties of totals to diminish the utilization of substantial parts. Concrete is used twice as much as aluminum, plastic, wood, and so on. Concrete is a flexible material utilized in a wide range of underlying works. Since the beginning of human development on this planet, man has always been a part of some kind of development activity, which includes using cement concrete.

In this current day world, the particular changes have vexed the improvement business and advancement works out. Improvement industry, including vertical turn of events and level turn of events. Vertical advancement insinuates the structure improvement and level improvement implies significant turn of events. Building development encompasses both private and non-private building structures, as well as open and private structures. The substantial development includes a large number of the largest and most significant structures, including railroads, interstates, air terminals, harbors, dams, trenches, spans, and numerous other significant open works. Mechanical development, marine development, and so on are examples of incidental specialization structures in the development industry. Appropriately being developed of these major and spectacular designs, broad and overpowering proportions of concrete cement is required. Concrete cement is one of the world's most versatile and by and large used advancement materials.

Concrete is a strong material in compression but very weak in tension. It is a hard material. So to expand the elasticity of cement a strategy of presentation of strands in concrete is being utilized. These fibers stop the cracks from spreading by acting as crack arrestors. These strands are consistently conveyed and haphazardly organized. This substantial is called fiber built up concrete. The primary objectives of adding fibers to concrete are to provide crack resistance and crack control, as well as to enhance the concrete's capacity for energy absorption and ductility after cracking. Additionally, it aids in maintaining the material's cohesiveness and structural integrity. Concentrates on directed up until this point demonstrated that the short and discrete, little strands can work on the flexural load conveying limits and effect opposition for non ferrous filaments. Fiber built up concrete will be concrete containing sinewy material which improves its underlying honesty. Therefore, fiber-reinforced concrete can be defined as a mixture of cement concrete or mortar and discrete, uniformly dispersed fiber.

Fiber is a discrete material having a few trademark properties. The fiber material can be anything. Yet, not all will be compelling and conservative. A few strands that are most usually utilized are steel, glass, carbon, and normal filaments. Fiber concrete is made with glass fiber, which was just recently introduced. It has exceptionally high rigidity of 1020 to 4080Mpa. Glass fiber concrete is broadly utilized in outside building veneer boards and as structural precast cement. Because it is denser than steel, this material is very good at shaping the front of any building. Fly debris can be utilized in pervious concrete as a substitute for a piece of the concrete. The use of fly ash has obvious advantages. Utilizing fly ash, a byproduct of coal combustion in power plants, saves energy needed to make cement.

OBJECTIVE

- To study the behavior of glass fiber reinforced concrete with fly ash as a replacement to cement.
- To study the mechanical properties of the cubes , cylinders, prisms and to arrive at optimum result.
- To study the compressive strength and split tensile
- To compare the results optioned.

LITERATURE REVIEW

Prameela N, Vivek Vardhan S (2022): In this investigation glass fiber added is of 2% as constant and replacement of fly ash varies from 5% and 10%.The test specimens were tested at the interval of 7 days and 28 days respectively. It was observed that conventional concrete of (10% of FA +2% of GF) shows that compressive strength is maximum at 7 and 28 days.

Dr.N. K. Patil, Padmaraj Anand Naik (2022): They have carried an experimental investigation on the M20 grade concrete with the mix design 1:1.5:3 and with W/C ratio 0.5. In their investigation they obtained the maximum strength at replacement of 25% of fly ash and 1.5% at 28 days for compression and split tensile strength.

Reshma T (2018): In this first part of investigation they carried out the experimental study on M15, M20, M25 grades of concrete and different percentage of glass fiber i.e., 0%, 3%, 5%, 7% by weight of aggregates it improves the homogeneity and reduces the probability of cracks.And second part of investigation proved that cement replaced by fly ash is of 0%, 18%, 20%, 22% addition of fly ash improved the workability by decreasing water-cement ratio.For different grades of concrete compressive strength of concrete is maximum when glass fiber content is 7% at 7 and 28 days. For M25 grade of concrete compressive strength has increased by replacement of fly ash of 20%.

Adarsh Dubey, Sanjay Saraswat (2016) : Studied with replacement of fly ash with 30%. And glass fiber is with different fractions of 0%, 1%,1.5%, 2%, 3%. Grade of concrete is M25. The compressive strength of conventional concrete is increased at 28 days by 28.46N/mm2 when 3%

glass fiber is used.The compressive strength of conventional concrete is increased with the increase in glass fiber content.

K. Venu Ramu Reddy(2016): In this experimental study observed fly ash content is taken as 10% and 20% and glass fiber is of 0.1, 0.2%, 0.3%.Compressive strength is increased with fly ash content of 10% and glass fiber is of 0.3% at 28 days of compressive strength is 17.25N/mm^2.Due to addition of glass fiber split tensile strength is increased and is optimum when 10% of cement is replaced with fly ash and with 0.3% glass fiber.

Chandrashekar A, Ajith B T (2015): They performed tests on M40 grade of concrete with varying fly ash content 10% and 15% with glass fiber of 0.17% as constant.The maximum compressive and tensile strength was achieved at 15% of replacement of fly ash. And for flexural the strength was achieved at 10% of replacement of fly ash.Use of fly ash reduces the amount of cement content as well as heat of hydration in a concrete mix.

Kartikey T, et al. (2013), He suggested that when the cement is partially replaced with fly ash, fly ash improves the properties of structural concrete. In this work characteristic strength and properties of various grades of concrete were studied, the various grades were M15, M20 and M25 for all these grades fly ash was used with cement at 20%, 40% and 60%. When the cement is partially replaced with fly ash, workability of concrete was increased with an increased percentage of fly ash. For each grade of concrete three cubes were tested for compressive strength. The optimum strength obtained for M15 grade was 14.48 N/mm2 for 20% replacement, 14 N/mm2 for M20 grade at 20% replacement level and 14.05 N/mm2 for M25 grade at 20% replacement. From this work finally concluded that fly ash replacement upto 20% shows greater strength than 40% and 60% for all three grades at 28 days of curing period.

Shamsuddin H, et al. (2012). In this experimental work glass fiber was added to the concrete at 0.03% by concrete volume. Comparison study was carried out to show the effectiveness of with and without glass fibers. It observed that workability decreases with increase in glass fiber.Flexural strength, Split tensile strength for M20, M30, and M40 grade of concrete at 3, 7 and 28 days are observed to be 20% to 30% and 25% to 30% respectively when compared with 28 days strength of plain concrete.

Kariappa et al. investigated that the concrete grade (M20) and observed that the addition of 0.4% (total mixture weight) ARGF filaments resulted in the highest resistance values for the flexural, compression and tensile strengths, and the increase rate improved to 33.21%, 54% and 58.24%, respectively after aging for 28 days.

MATERIALS AND PROPERTIES

A. *Cement*

Argillaceous (clayey) and calcareous (containing lime) materials are combined to form cement, a binding substance that becomes stronger when water is added. Mortar is made of cement and fine aggregate and is used for masonry work, plastering, and other applications. Concrete is created using cement, fine aggregate, and coarse aggregate. We used 53 grade regular portland cement in our project.

The properties of cement are listed in the below table

Table 1 Properties of Cement

Properties	Results
Fineness of cement	93%
Normal consistency or Standard consistency	32%
Initial setting time	30 min
Final setting time	10 hours
Specific gravity	3.1

B. *Fine Aggregate*

When the granular material's particles are so small that they can fit through a 4.75mm screen, it is referred to as fine aggregate. Aggregate is the granular material used to make concrete or mortar. The spaces between the coarse aggregate are filled with the fine aggregate.

The properties of fine aggregate are listed in the below table

Table 2 Properties of Fine aggregate

Properties	Results
Specific gravity	2.57
Water absorption	1.35%

C. *Coarse Aggregate*

Concrete is made with coarse aggregates, which are granular and uneven materials like sand, gravel, or crushed stone. Coarse is typically found in nature and can be obtained by blasting quarries or crushing them manually or with crushers.Coarse aggregate refers to materials that are large enough to be caught by a 4.7mm sieve.

The properties of coarse aggregate are listed in the below table

Table 3 Properties of Coarse aggregate

Properties	Results
Specific gravity	2.63
Water absorption	0.81%

D. *Flyash*

Fly ash, a finely split byproduct of pulverised coal combustion, can be used to improve the strength and workability of concrete while lowering permeability. We employed Class F fly ash in our project. By reducing bleeding, permeability, and cracking with fly ash in concrete, a solid, highly durable concrete that is impervious to sulphate and alkali-aggregate reactions is produced. Additionally, this concrete mix uses less water and tends to resist shrinkage.

The properties of flyash are listed in the below table

Table 4 Properties of Flyash

Properties	Results
Specific gravity	2.62
Fineness	96%

❖ Mix Design

In our experimental work, we used concrete of grade M30 with a mix ratio of 1:1.7:2.46 and a water-cement ratio of 0.45. The proportioning of the concrete mix is done in accordance with IS 10262 (2009): Guidelines for Concrete Mix Design.

METHODOLOGY

The primary goal of the current experiment is to investigate the consequences of using fly ash, a mineral byproduct, to partially substitute cement. Glass fibre is being used as an additional kind of reinforcement in the investigation.

Consequently, it is anticipated that glass fibre and fly ash will be used in concrete.

- Trial and error is used to select the mix design. Based on the improved slump data, the concrete mix or ratio is adjusted.
- Mixing of the concrete is done mechanically.
- There are a total of 12 cylinders, 12 cubes, and 12 beams or prisms that are casted. The specimens undergo 7, 14, and 28 days of curing. The specimens are tested when they have finished curing.
- Cubes, beams, and cylinders, respectively, were subjected to compression, flexure, and split-tensile testing.

TESTS ON FRESH CONCRETE

Fresh concrete's ability to fully compress without bleeding or segregation in the final product is measured by the quantity of practical internal work required. One of the physical characteristics of concrete that influences strength and durability as well as labour costs and final product appearance is workability. When concrete is simply poured and compacted uniformly, that is, without bleeding or segregation, it is considered to be workable. Unworkable concrete requires more work or effort to compact in place, and completed concrete may also have visible honeycombs.

The workability of concrete can be evaluated using one of the three methods below, depending on the water cement ratio in the mix.

1. Slump cone test
2. Compation factor test
3. Vee-bee test

TESTS ON HARDEND CONCRETE

As the name suggests, hardened concrete has acquired its shape and has served the intended purpose for the designated amount of time; it is no longer plastic. It won't be feasible, meaning that it won't be possible to modify the structure's shape. It is essentially at the "plasticity" stage, where its fluidity has completely disappeared. With time, hardened concrete becomes stronger, thus it's critical to assess the durability and quality of the material. The following tests are conducted on hardened concrete:

1. compressive strength test
2. Split-tensile test
3. Flexural test

Figure 1: Compressive Strenght Test

Figure 2: Split-Tensile Strength Test

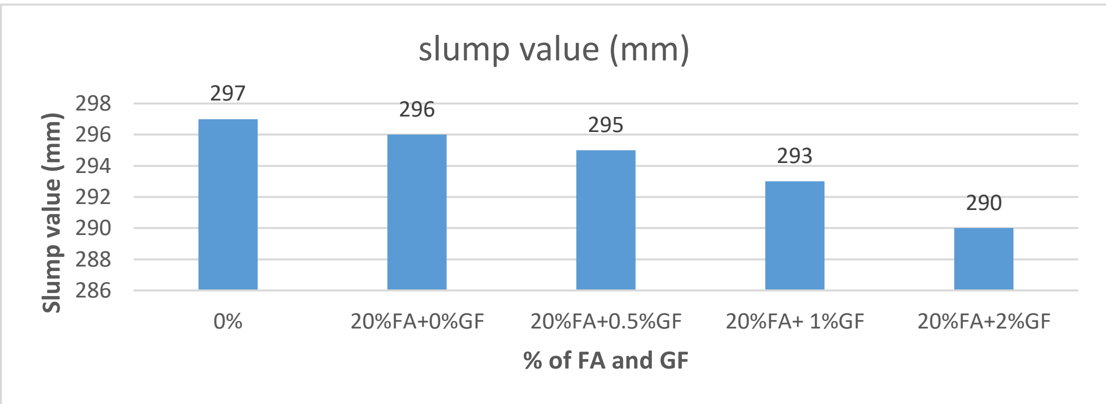
Figure 3: Flexural Strength Test

RESULTS AND DISCUSSIONS

A. *Slump cone test*

Table 1 Slump cone test

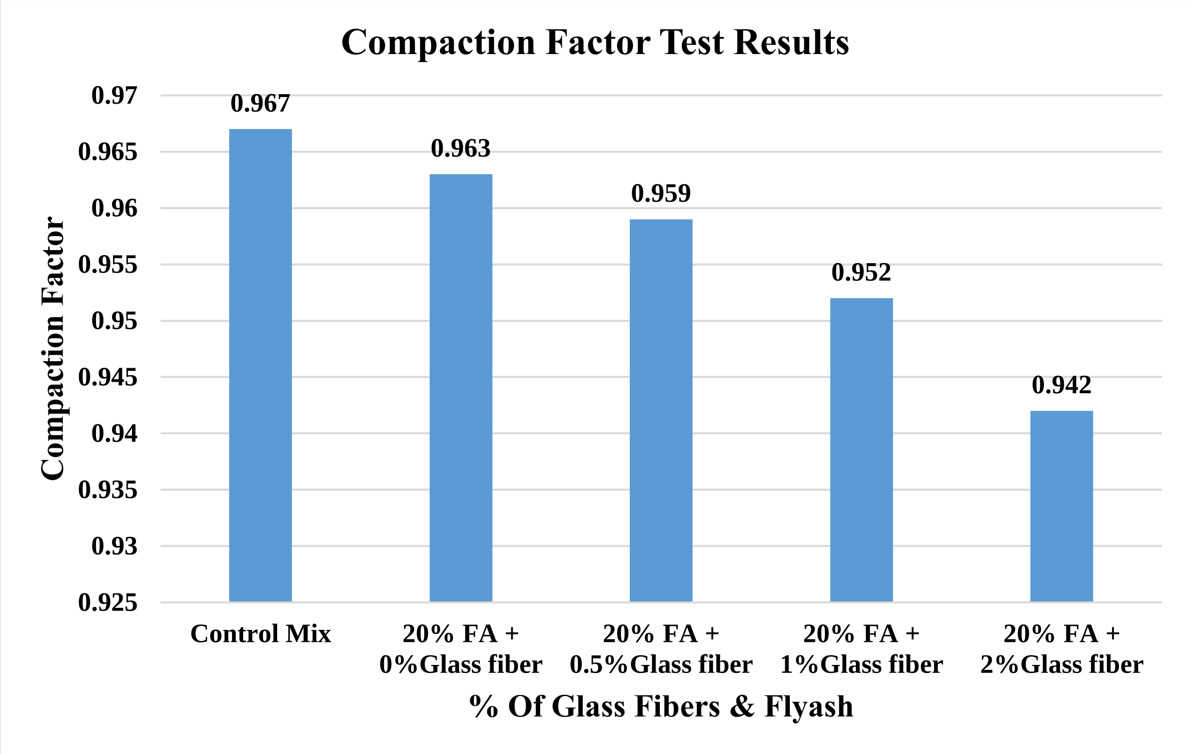
Sl.no	% of fly ash	% of glass fibre	Slump from top in mm
1	0%	0%	297
2	20%	0%	296
3	20%	0.5%	293
4	20%	1%	291
5	20%	2%	290



Compaction factor test:

Table 2 Compaction factor test

Sl.no	% of fly ash	% of glass fibre	Compaction factor
1	0%	0%	0.967
2	20%	0%	0.963
3	20%	0.5%	0.959
4	20%	1%	0.952
5	20%	2%	0.942



The above graph shows that the values of compaction factor for various replacements. The workability is slightly decreasing with the increase of the glass fibers percentage.

Compressive Strength Test:

Table 3: Compressive strength values after 7 days of curing

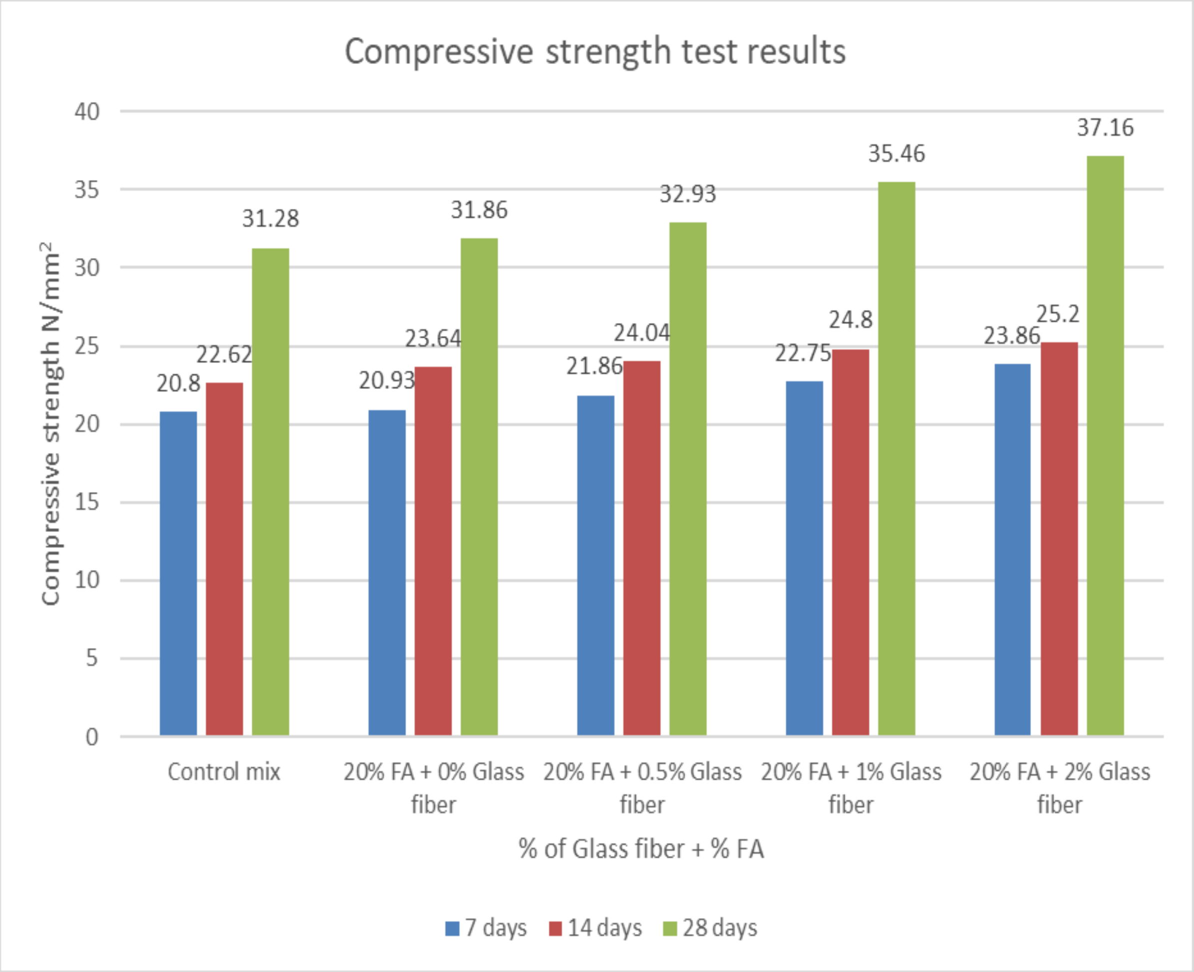
S.no	Grade of concrete	% of fly ash	% of glass fiber	Load (KN)	Area(mm)	Compressive strength (P/A)N/mm
1	M30(1:1.75:2.03)	0%	0%	468	22500	20.8
2		20%	0%	471	22500	20.93
3		20%	0.5%	492	22500	21.86
4		20%	1%	512	22500	22.75
5		20%	2%	537	22500	23.86

Table 4: Compressive strength values after 14 days of curing

S.no	Grade of concrete	% of fly ash	% of glass fiber	Load (KN)	Area(mm)	Compressive strength (P/A)N/mm
1	M30(1:1.75:2.03)	0%	0%	509	22500	22.62
2		20%	0%	532	22500	23.64
3		20%	0.5%	541	22500	24.04
4		20%	1%	558	22500	24.8
5		20%	2%	567	22500	25.2

Table 5: Compressive strength values after 28 days of curing

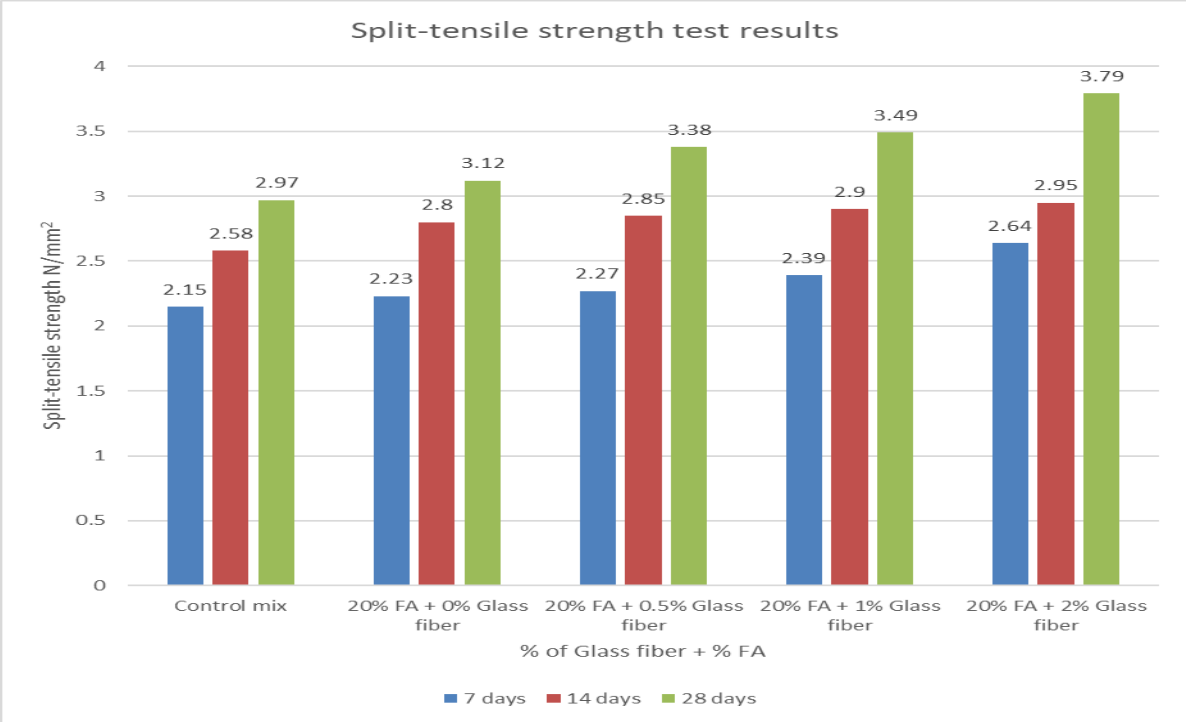
S.no	Grade of concrete	% of fly ash	% of glass fiber	Load (KN)	Area(mm)	Compressive strength (P/A)N/mm
1	M30(1:1.75:2.03)	0%	0%	704	22500	31.28
2		20%	0%	717	22500	31.86
3		20%	0.5%	741	22500	32.93
4		20%	1%	798	22500	35.46
5		20%	2%	846	22500	37.16



The above graph shows their gradual increase the compressive strength due to increase in glass fiber percentage. The maximum strength was achieved in 28 days at 20% flyash + 2% glass fiber. The strength was increased by 15.82% in conventional mix compared to control mix.

Table 6 Split-tensile test results

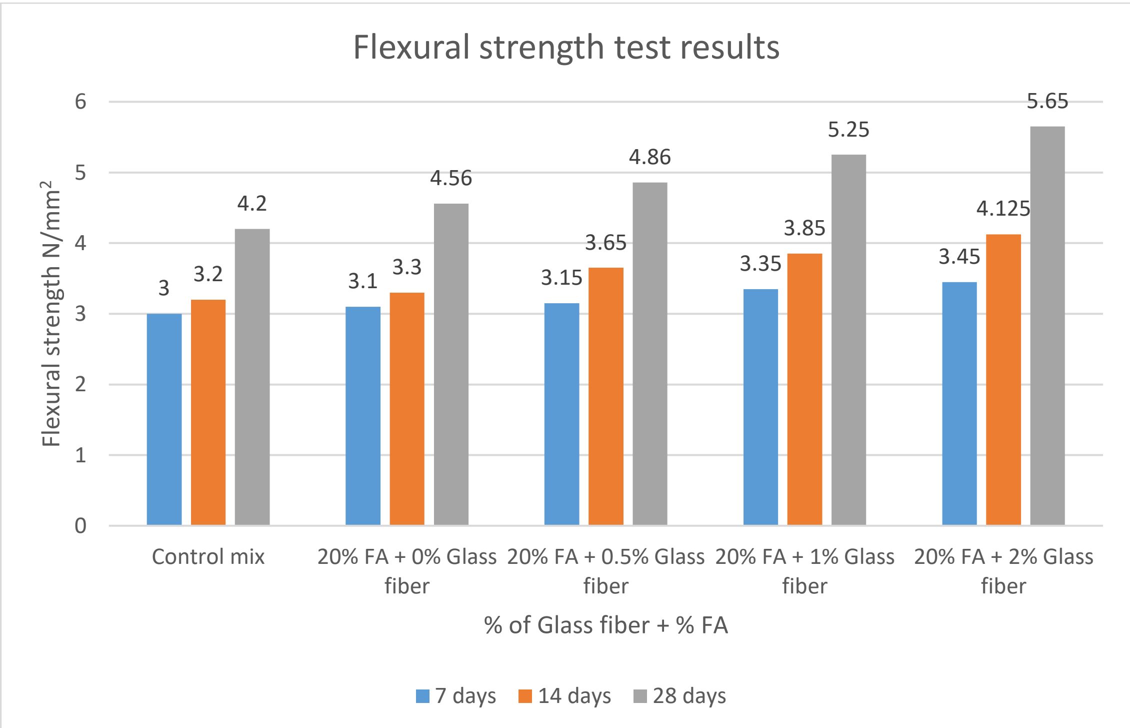
% of flyash	% of glass fiber	7 days		14 days		28 days	
		load	strength	load	strength	load	strength
0	0	152	2.15	183	2.58	210	2.97
20	0	158	2.23	198	2.80	221	3.12
20	0.5	161	2.27	202	2.85	239	3.38
20	1	169	2.39	205	2.9	247	3.49
20	2	187	2.64	209	2.95	268	3.79



The above graph shows their gradual increase the split-tensile strength due to increase in glass fiber percentage. The maximum strength was achieved in 28 days at 20% flyash + 2% glass fiber. The strength was increased by 21.63% in conventional mix compared to control mix.

Table 7 Flexural strength test results

% of flyash	% of glass fiber	7 days		14 days		28 days	
		load	strength	load	strength	load	strength
0	0	6	3	6.4	3.2	8.4	4.2
20	0	6.2	3.1	6.6	3.3	9.12	4.56
20	0.5	6.3	3.15	7.1	3.65	9.13	4.86
20	1	6.7	3.35	7.7	3.85	10.5	5.25
20	2	7.1	3.45	8.25	4.125	11.3	5.65



The above graph shows their gradual increase the flexural strength due to increase in glass fiber percentage. The maximum strength was achieved in 28 days at 20% flyash + 2% glass fiber. The strength was increased by 38.93% in conventional mix compared to control mix.

CONCLUSION

The experimental investigation is carried out on the development of green concrete with 20% flyash and glass fibers. The M30 grade of concrete is used for this study. Based on the test results the following conclusions are drawn:

- Flyash content increased the workability of the concrete but flyash + glass fibers combination mixes ranges the workability as medium.
- There is a better improvement in the compressive strength after addition of the glass fibers to the concrete. The maximum compressive strength was achieved at 28 days for 20% flyash @ 2% glass fibers with an increase of 15.82% strength as compared to normal mix.
- 20% flyash @ 2% glass fibers gives good tensile strength than other mixes and normal mix or normal concrete at 28 days with an increase of 21.63%.
- The maximum flexural strength was achieved at 20% flyash @ 2% glass fibers with an increase of 25.66%.
- Use of flyash reduces the amount of cement content as well as heat of hydration in a concrete mix. Thus, the construction work with flyash concrete becomes environmentally safe and also economical.
- Use of glass fiber improves the quality of work, improve the homogeneity and reduce the probability of cracks compare to coventional concrete.

REFERENCE

[1] IS: 456 (2000) “Plain and reinforced concrete code of practice”.

[2] IS: 10262 (2009) Guidelines for concrete mix design proportioning.

[3] IS 4031 (Part-1) 1996 Fineness of cement by dry sieving.

[4] IS 4031 (Part-4) 1988 Determination of consistency of standard cement paste.

[5] IS 4031 (part-5) Determination of initial and final setting times.

[6] IS 2720 part-3 Determination of specific gravity of cement.

[7] As per BS 6349 Determination of water absorption of fine aggregate.

[8] Dr.N.K.Patil (2022).Characteristics Study on Effect of Glass Fiber in Concrete with Replacement of Cement by Fly ash,International Journal of Innovative Research in Technology(IJIRT),Volume-9,Issue-5,ISSN:2349-6002.

[9] Mohd Zeeshan Khan (2022). Glass fibre reinforced concrete with partial replacement of cement with flyash , International Journal of Creative Research Thoughts (IJCRT), ISSN: 2320-2882.

[10] Zeeshan Khan (2017).Glass Fibre Reinforced with Partial Replacement of Cement with Fly ash of M30 grade, International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT), Volume 3, Issue 3, ISSN:2454-132X.

[11] Ms.Reshma T.V (2018). Experimental Study on Compressive Strength of Glass Fibre Reinforced Concrete and Partial Replacement of Cement with Flyash Research, IJNTR, ISSN:2454-4116, Volume-4, August 2018.

[12] Shwetha P, Praveen K (2015). Experimental Study on Partial Replacement of cement by Fly Ash with Glass Fiber Reinforcement, International Journal of Engineering Research &Technology, ISSN: 2278-0181.