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Parametric Strategy for Composite Cement Concrete Blended with Fly Ash & Glass Fiber

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Coping with population growth, houses are built to meet the hike. The prerequisites for concrete and steel reinforcements have surged up globally since last 3 to 4decades. Shortage of natural building materials, increased wastes from coal based industries to augment carbon foot print has worried the engineers to reuse their wastes (such as fibres, powders, granules, etc.) as building materials ingredient. Glass fibre has improved flexural capabilities with fly ash dosages in cement concrete and alternately helps in restricting environmental degradation. Present research aims at investigating the impact of glass fiber (at 1%, 2% and 3% addition) and fly ash (dosages of 10% and 20% over the existing fly ash in PPC). The ingredients and microstructure of composites are found by either X-ray fluorescent spectroscopy or scanning electron microscope. Experimental evaluation results of the blended composite concrete parameters of RCC are experimentally evaluated and compared have shown that concrete with 10% cement substitution with fly ash and 3% fibre showed optimum compressive strength performance than the concrete without fibre and fly ash and also chemically resistant against commonly used M-20 grade of Concrete.

Keywords: Cement concrete; aggregates; fly ash; electron microscope; glass fiber; strength of concrete; XRF spectrometer.

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ABBREVIATIONS

CC	*: Cement Concrete*
RCC	*: Reinforced cement concrete*
FRC	*: Fiber reinforced concrete*
CSC	*: Compressive strength of concrete*
GGBS	*: Ground Granulated blast furnace slag*
TSC	*: Tensile strength of concrete*
STS	*: Split tensile strength of concrete*
FA	*: Fine aggregates*
CA	*: coarse Aggregate*
FM	*: Fineness Modulus*
GFRC	*: Glass-fibre reinforced concrete*
TPP	*: Thermal Power plant*
BHEL	*: Bharat Heavy Electrical Limited*
OPC	*: Ordinary Portland cement*
GGBS	*: Ground granulated Blast furnace slag*
GGF	*: Ground Glass Fiber*
XRF	*: X-ray fluorescent spectrometer*

1. INTRODUCTION

Cement Concrete is the protuberant building material since mid of 19th century comprising of coarse aggregates, hydraulic cement, water, and fine aggregates. The CC work was introduced by I. K. Brunel in Thames Tunnel between Rotherhithe and Wapping south of London (1828) and the first exhibition on RCC works was portrayed by W B Wilkinson in 1851 in great exhibition at London (Radic et al. [1]). The concrete is a brittle material and is solid in compression but very weak in tension. To upsurge the TS and resistant to develop cracks, fibres are injected into concrete [2]. These fibres are distributed randomly or symmetrically as per bending moment developed at point. In post-cracking process the CC develop potential to become ductile for energy absorption, and develop crack resistance which helps in ensuring structural stability and coherence in CC/RCC [3-4].

Studies carried out so far have shown that thin, short and discrete fibres will enhance the flexural load carrying capacities for non-ferrous fibres (other than steel rods) and damage resistance against rusting, Sulphur and chlorine attack [5-7]. FRC also strengthens the structural integrity and CC or cement mortar develop hybrid substance, when the fibres are well distributed. Fibres are discrete substances with strength developing properties like productive and economical. Steel, glass, silica fumes, natural fibres (Cocanut coir or Syali fiber) that are most widely used, Lokuge et al., [8], Bilba et al. [9], Hemasi et al. [10], Behera and Mishra et al. [11].

Alkali-activated fly ash concrete is environment degrading waste from Blast furnaces and TPP’s can be used by substituting cement in manufacture of OPC. High percentage (%) of ash may make the concrete brittle and have negative impact on physical and mechanical properties of concrete so it must be optimized. Introducing fibers like natural or plastic or and glass fiber (GF); as steel is corrosive, there is development in the engineering properties of ambient-cured Glass-fibre reinforced concrete (GFRC) blended with fly ash which is hard to crack but easy to cut.

In the FRC domain, glass fibre is a novice fibre which is yet to be researched [12-14]. Glass fiber has a very high tensile strength (1020 to 4080 MPa). Glass fibre concrete is commonly used as decorative precast concrete and as external residential facade frames for glazing and reflections to avoid dust accretion on exterior walls. The use of red mud, GGBS, fly ash may be as a replacement for a section of the cement to reduce cost of concrete. Fly ash is an abundant waste product from coal-burning power plants and cement factories.

2. REVIEW OF LITERATURE

Solid Waste management stress upon using unused materials like polythene products, cement, Red mud, GGBS, SCBA, Pumecrete, Ferrochrome slag, building wastes, Cocoanut or Syali fiber and many unused environment polluting solids that is pushed in to widely used cement concrete as ingredients. For individual waste materials used either replacement or partial substitute of RCC has been studied by different authors like Rao et al. [15], Reddy KVR et al. [16], Teja et al. [17] (for Glass fiber waste), Frias M. et al. [18], Behera & Mishra S P [19], (for SCBA waste) Barbuta et al. [20], De et al. [21] (For glass fiber and fly ash waste), Ojha & Mishra S. P. [22] (Bauxite waste),. GRFC is a fabric manufactured product of cementitious matrix processed from cement, FA, CA, water and admixtures used in facet walls, precast panels, pipes and channels for use in building materials. The fibre glass is durable, weather resistant, very hard but easy to cut and one of best use for surface building materials. For fly ash concrete glass fiber possesses high tensile and flexural strength with 20% FA + 1% to 0.25% GF can crop better domino effect upon OPC built PC/GFRC. Koyali O, [23], Chandramouli et al. [24], Barbuta et al. [25], Gupta et al., [26], Baber Ali, [27], Ahamad et al., [28].

Workability of concrete is hindered by insertion of fibers because flow properties is affected which can be moderated by blending concrete with good quality fly ash. Addition up to 30% fly ash can improve durability of RCC. The fibre and fly ash also reduce drying shrinkage, Rout et al., 2017 [29], Shen Y et al. [30], Pratusha et al. [31].

From the above studies it is observed that the replacement of glass fiber as reinforcement and fly ash in addition to the fly ash added with available PPC has given different types of results. Present study emphasizes on the replacement of glass fiber and fly ash with varied proportion for the most commonly used M-20grade concrete and the results are compared with normal reinforced cement concrete results.

3. MATERIALS AND METHODS

The methodology employed in the present search comprises of steps like, material collection, Mix design, Material casting, curing and testing, determination of strengths by using concrete testing machine, Universal testing machine, and scanning by electron microscope of the laboratory. Various materials used in the composite concrete are Portland Pozzolana Cement (PPC) Cement, fine aggregate (FA), Coarse aggregate (CA), water, Plasticizer, fly ash and glass fiber whose specification, properties adhering to Indian Standard (IS) code are narrated below.

Cement- In this analysis, the cement that was available on the local market was used. The cement has been physically tested for properties as per IS: code 8112 [32]. The basic gravity cement rating OPC 53 was 3.14.

Fine aggregate- River sand was available from nearby vendors and cleaned to extract both organic and inorganic material. Locally available river sand (Kuakhai River) was screened to remove large and unnecessary organic materials from sand passing though IS sieve >4.75 mm. The Fineness Modulus (FM) and specific gravity are 2.93 and 2.55 respectively (**IS 373 2016**) [33].

Coarse aggregate- Locally available black hard granite chips without any weathered coating and deleterious material of CA was taken of 20 mm size available from local crusher yard. The samples are sieved by 10mm sieve to remove the lower grade chips. The Fineness module of the collected coarse aggregate is of specific gravity 2.80 (**IS 373-2016**).

Water: As per Table 2 of IS 456- 2000 [34], IS:10262-2009 [35], and the plasticizer specification, the quantity of potable water must be decided for a healthy concrete and the water should not be highly alkaline or acidic, and should not chloride or sulphate ion.

Fig. 1. Ingredients for fibre glass concrete blended by fly ash

Fly ash- It is naturally occurring materials available in market in 50kg bags from coal based plants. The gravity of particular fly ash is 2.13. Fly-ash blended and ecofriendly PPC manufactured by inter-grinding granulated PC with quality fly ash. Fly ash has hydraulic cementous properties exceptional to ordinary cements. It is available in specially designed 50-kg bags. Methods adopted are as per IS: 1727 (1967) [36] and IS: 3812 (1981) [37] for chemical analysis.

Fly ash may be low (F type) or high calcium (C-type), depending on the <10% or <02% carbon content within the ash (Khoso et al.,2019 [38]). Fly ash reduces the water constraint for a given slump, workability is improved by making the concrete expansive along with pozzolana action between fly ash and CaO in cement concrete Jayshree et al., [39]. The fly ash cannot be used directly. It should be prior activated by using CaO and Na_2SiO_3 Calcium by proportion 1:8 respectively.

Glass fiber- Glass fibre can be available in the Glass Fibre Cloth manufacturing industry as waste residue which is an inert solid that can solve waste disposal issues. They are obtained from the insulation of the electrical gadgets from Indian industries like Bharat Heavy Electrical Limited (BHEL) and Glass Fibre Textiles, Govindpura, Bhopal The glass fibres have silica compositions.

They are hard, durable, transparent, glossy, resistant to chemical attack, stable, and inert. GF impart better concrete properties like strength, flexible, and stiff. With these properties the material is selected to be used as facial textures like exterior walls, hard floors, coloured surfaces where weather impact need avoidance.

3.1 The Glass Fibres

Four types of glass fibres available in market are A (window glasses), C, (chemical resistant glasses), E-glass (chemically resistant and electrically insulators) and AE (S-2glass), chemically or alkali resistant are available (Karan Singh et al., 2017 [40]). Properties of E type-FG is given in Table 1.

Table 1. The properties of Fiber glass type E-glass: Source: Babar Ali et al. [27]

#	Designation	Phy. Prop.	I specification max^m.	Details of use IS12269-2015[42]
A	**Physical (IS 4031-1988{41})**	Alkali resistant,		Weather proof
	Fiber length	5-15mm		easy and flexibility in use
	Fiber dia.	14-16mm		Lump use by volume %
	Moisture	0.5%		water resistant & surfice use
	Loss on ignition	1.16%	4 max^m	CC is solar heat resistant
	Insoluble residue	1.73	4 max^m	Ash is free from impurities
	Workability CC	better		Make hard, durable, workable
	Specific gravity	2.6gm/ cm^3		Matchsp.gr of CC ingredients
	Softening Point	750^{0}C		Highly fire proof
	Initial setting Time	150mnt	30mnt min^m	delay in casting permissible
	Final setting time	300mnt	600mnt min^m	Early final setting time
B	**Chemical (IS 4032-1985[43])**	chemically inert	less weather action	For floor & exposed surfaces
C	**Electrical**	Resistant	Insulating	Good building material
D	**Mechanical Prop.**			
	Modulus of elasticity	72GPa		Highly brittle equal to epoxy
	Tensile strength	1700MPa		about that of brick

Table 2. Comparison of chemical composition from XRF results of E and S-2 glass

Composition	E-glass	S-2 glass
Boron oxide	7-12%	Nil
Silicon dioxide	50-54%	62-65%
Aluminum oxide	13-15%	23-25%
Calcium oxide	14-24%	Nil
Magnesium oxide	0-5%	10-11%
Sodium and potassium oxide	0-2%	Nil

In the present work: the E-glass is used for preparation GFRC

Table 3. The sources, type of materials and specification of the composite concrete

#	Type and material	Specification of materials used	Source of material
1	Coarse aggregate (CA)	Machine crushed, angular	Tapang quarry, Khurdha
2	Fine aggregate (FA)	Sand Zone III (IS-383-1970) [41]	River Sand (Kuakhai R.)
3	Cement type/ grade	(IS 12269-1999) [42]	Ambuja Cement/ PPC 53
4	Super Plasticizer Chemical Admixture	Confirming IS 9103-1999 [44] @225 gm/50 kg cement	Hind Plast supper-SCA Cebex-100
5	Potable Water	Confirming IS 3025-19984 [44]	Laboratory Tap water
6	Water cement ratio	Confirming IS 456-2000	0.375 < 0.4

The glass fibers used in the present study has been the byproduct collected from Govindapura, Cem-FII anti crack HD (High Dispersion) GF glass fibres. The Commonly used glass fibre are E-glass and S-2 glass type. Both the samples were procured and tested for their chemical composition. The E-glass samples were selected as it contains more calcium Oxide. E-glass is preferred instead of S-2 glass fiber as low cost, inflammable, low density, high strength and stability, chemically and electrically insulated (https://www.azom.com/article.aspx?ArticleID=764). The composition of both F-glass and S-2 glass is compared in Table 2.

The length and mean diameter as per factory specification is 16mm and 15μ of the sample, Modulus of elasticity as 30.0GPa, TS as 1510 MPa, and Elongation break as 5.4% (Shen Y et al. 2019).

Super plasticizer: They are high degree water reducers used to create the composite mix workable at low water-to-binder ratio. Initially at the green stage (before final setting) GF reduces the workability of RCC composite. In the present study uses powered Cebex 100 (@225 gm /50kg cement) is used as an admixture that reduces w/c ratio and imparts high fluidity requiring +expansions without affecting setting time of composite concrete. It is used in bed or duct grouting, non-shrink fills and in joints BS: 8110 Part 1-1985 [45], Section 8.9.4.6.

3.2 The making of conventional M-20grade Concrete

The details of collection of various ingredients of traditional M-20grade concrete prepared as per the manual of Civil Engineering laboratory of Centurion University of Technology and management is given in Table 3.

To enhance the durability, the glass fibres are dispersed in the Glass-fibre reinforced concrete (GFRC) which is mixed with fly ash, cement, CA, FA, water, fibre glass and admixtures. Glass fibres are mixed by volume fraction. Glass fibre are mixed by volume fraction as 10% and 20% fly ash and glass fibre in 1%, 2% and 3% and the tests like tensile strength test and split tensile strength tests were conducted and results compared.

Literatures reveal that use of fiber reinforced concrete is to moderate bleeding of slurry from concrete and reduces honeycombing. The FGRC also improves ductility, ceases post-crack formation due to dry shrinkage and more resistance to impact loading, and develop extra abrasion reduction and weather resistance in the concrete. Fly ash is replaced to cement to save cost and enhance flow ability of concrete. The stress/strain curve for normal concrete and FRC is given in Fig. 2.

3.3 Concrete/ Composite Mix Design

The calculation used f 'ck= fck+1.65 * S = 20 + 1.65 * 5 = 27N / mm2, where S=5N / mm2 (the normal deviation), f'ck = Comp guided. Concrete cube strength (average) after 7, 14 and 28 days of curing, fck = compact cube strength after 28 days of curing, and water cement ratio =0.55. (Page 2 of IS 10262 [35]). Proportion by weight of the final product combination was determined to be 1:1.5:2.3. Cubes, cylinders and beams were cast and healed for 7, and 28 days with portable water for various proportions and replacements. The target strength is 26.6N/mm2.

3.4 Laboratory Works

Conventional M20 blend concrete is popular as normal residential building's use this grade of concrete. The following works are undertaken in the laboratory of Centurion University of technology and management.

The experiments to be conducted are : Visualization of the fly ash and glass fiber under scanning electron microscope (SEM), Physical properties like Sp. gravity test, Testing of materials (FA, CA, FG, Fly ash, concrete), Chemical composition of material by X-ray fluorescent spectrometry, concrete mix/ composite mix as per mix design in cubes/ beams/ cylinders , CS, TS, & STS tests of (Cubes, beams and cylinder), CS of glass fiber, Post curing crack evaluation and etc. and the results are to be discussed.

3.4 Scanning Electron Microscope (SEM)

A scanning electron microscope (SEM) is a type of electron microscope that, by scanning the surface with a directed electron beam, produces images of a sample. The electrons communicate with atoms in the sample, creating different signals providing information about the topography of the surface and the sample composition. The electron beam and the location of the detector are scanned in a raster scan pattern. Among other factors, the amount of 2ndry electrons that can be detected, and thus the signal amplitude, based on the topography of the specimen (Fig. 3(a) and Fig. 3(b) (https://www.jeol.co.jp/en/applications/pdf/sm/sem_atoz_all.pdf).

3.5 Physical Properties of Ingredients of Composite Concrete

Physical tests required to find for suitability of the ingredients of concrete were conducted in the laboratory and the results are given in Table 4.

Table 4. The results and physical properties of various ingredients conducted in Laboratory

#		Test items	Unit	Values obtained
1	a	Specific gravity of cement	gm/cc	3.150
	b	Specific gravity of chemical Admixure	gm/cc	1.100
	c	Fine aggregate (river sand)	gm/cc	2.633
	d	Coarse aggregate 20mm (hard granite chips)	gm/cc	2.787
	e	Coarse aggregate 12.5mm (hard granite chips)	gm/cc	2.779
2		Percentage of water absorption		
	a	Fine aggregate (river sand)	%	0.86
	b	Coarse aggregate 20mm (hard granite chips)	%	0.42
	c	Coarse aggregate 12.5mm (hard granite chips)	%	0.48
3		Free surface moisture/ absorbed moisture		
	a	Fine aggregate (river sand)	%	Nil
	b	Coarse aggregate 20mm (hard granite chips)	%	Nil
	c	Coarse aggregate 12.5mm (hard granite chips)	%	Nil

Table 5. Mixing gradation of fly ash

MIX	FLY ASH %	AV.COMP.STRENGTH AT 7 DAYS, N/MM	AV.COMP.STRENGTH AT 28 DAYS, N/MM
FY10GF1	10	11.65	15.26
FY10GF2	10	11.87	16.87
FY10GF3	10	14.54	20.18
FY20GF1	20	12.43	17.25
FY20GF2	20	12.62	19.29
FY20GF3	20	13.27	20.48

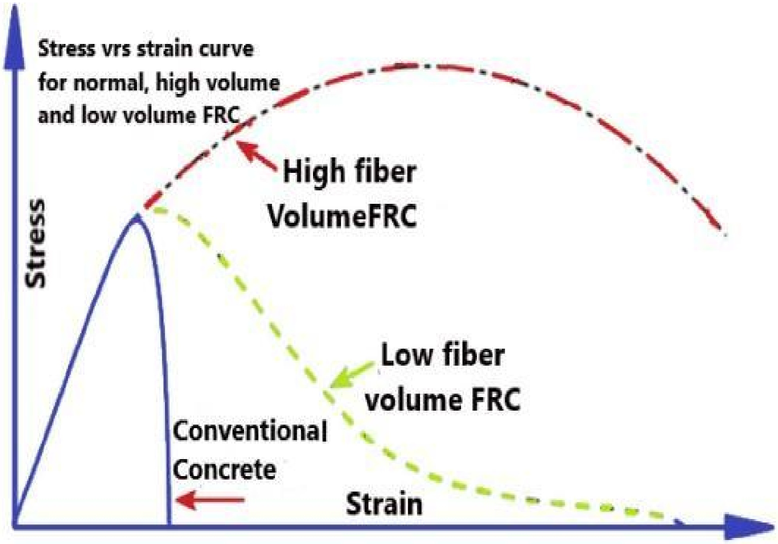

Fig. 2. The Stress/ strain curve for H/L Vol FRC with CC

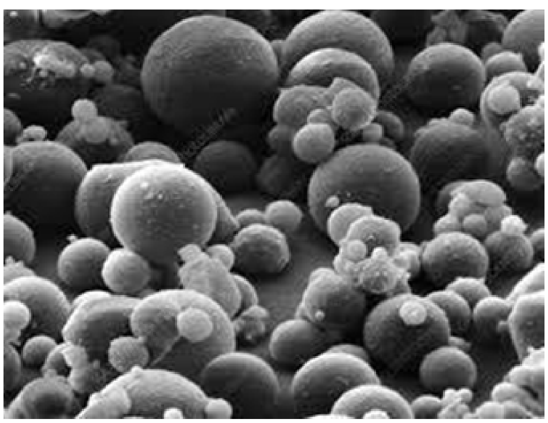

Fig. 3(a). SEM results of fly ash

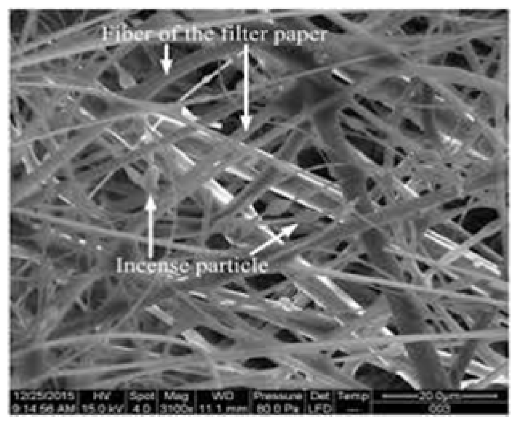

Fig. 3(b). SEM results of glass fiber

3.6 Percentage of Fly Ash Substituting PPC Cement Bag

The ratio of PPC cement to fly ash varies 25% during cement production in the Ambuja brand available in market (www.ambujacement. com›product-and-services › products › ambuja) in a commercial 50 kg bag of the company. According to the mineralogy of Ambuja cement; fly ash has 15- 45% Quartz, 15 -30% Mullite, 1-5% Hematite, 1-5% Magnetite, and about 25 - 35% of amorphous glassy alumino - silicate phase is present. And the maximum fly ash can be added for fiber concrete is 35%. The research started with adding 10% and 20%, fly ash was added to the M-20grade concrete mix to increase workability (www.ambujacement.com›product-and-services › products › ambuja).

3.7 Normal M-20 Concrete

Since M-20 is standard and commonly used concrete, it is felt less necessity to make a design mix for the M-20grade. Well accepted volumetric ratio for M-20 grade is 1:1.5:4 i.e. 1 part cement is mixed with 1.5 part of sand and 4parts of chips as per the IS-456 of 2000 [34], the water cement ratio (W/C) is 0.4 to 0.45 depending upon wet or dry sand.

Table 6. The conventional CC mix without fly ash and Fiber glass (CS results)

#	Conventional mix	7days cured compressive strength	28days cured compressive strength
	Unit	N/mm2	N/mm2
1	Mix -1	12.22	21.2
2	Mix - 2	12.80	20,8
3	Mix -3	13.32	21.4
4	Average	12.77	21.11

3.8 Compressive Strength (M-20 Cement Concrete)

In the present experiment only 20% and 10% by weight the fly ash is added and the specimens are casted as per the standard specification The CS is found by compressive testing machine (CTM) and the results are given below.

The 7 and 28 days cured plain cement concrete has compressive strength found to be 12.77N/mm2 and 21.11N/mm2 respectively.

3.9 Compressive Strength at Various Mix Proportions

Similarly considering the available literature the insertion of 1%, 2% and 3% were made for normal M-20 concrete and average composite strength of the concrete cubes were verified as given in Table 7.

The cubes of size 150x150x150mm were casted by the different compositions of fly ash (at 10% and 20%) is added in weight to the cement Ambuja (PPC) type grated 53. Precaution is to be maintained that the glass fiber are to be added during casting of specimen only. It is done because, the Fibers may project out on the surface of the specimen and may be pulled out during finishing. After casting, removal from the frame and curing for 7 and 28days is done from the date of casting. The tensile stress is carried out over dried specimen under UTM machine as per the laboratory manual. The cubes were tested for CS as per IS 1199 to 1959 and IS 516-1959. The results are shown in Table 7 and Fig. 4.

Table 7. Comparison for normal concrete for various mixes of fly ash and glass fibre

mix	fly ash % by volume of cement	glass fiber % by volume of cement	av. comp. strength at 7 days, N/mm^2	av. comp. strength at 28 days, N/mm^2
FY10GF1	10	0.1	13.65	16.26
FY10GF2	10	0.2	15.87	17.87
FY10GF3	10	0.3	18.54	22.18
FY20GF1	20	0.1	12.43	17.25
FY20GF2	20	0.2	14.62	19.29
FY20GF3	20	0.3	13.27	18.48

Table 8. The crack results of different mix FYGF beams tested by UTM

Mix	Fly ash %	Glass fiber	Av. split tensile strength at 7 days, N/mm^2	Av. split tensile strength at 28 days, N/mm^2
FY10GF1	10	0.1	0.704	4.29
FY10GF2	10	0.2	1.132	3.14
FY10GF3	10	0.3	1.46	4.98
FY20GF1	20	0.1	0.73	4.34
FY20GF2	20	0.2	0.92	5.12
FY20GF3	20	0.3	1.205	5.38

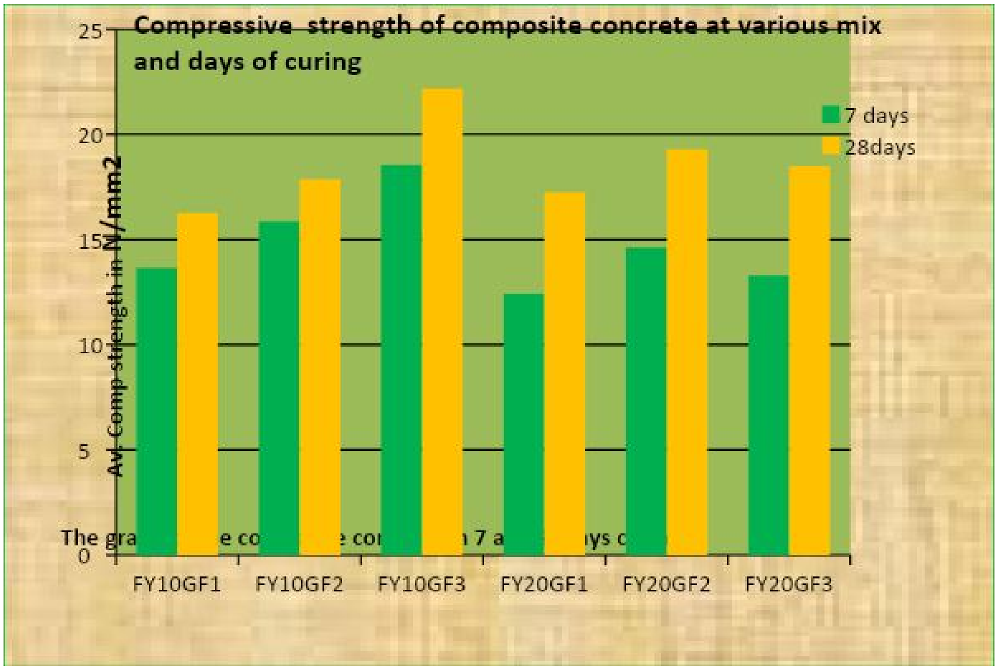

Fig. 4. Compressive strength of composite concrete at various mix and days of curing

From the result observed in the table and the graphical presentation it is seen that after seven days of curing of the composite concrete cubes and also after 28 days of curing the optimum compressive strength achieved by the composite mix when fly ash is 10% add to the PPC and when the glass fiber blending is 3% is 21.1N/mm2

3.10 Testing SPS (Split Tensile Strength)

The concrete is sturdy towards compression and puny towards tension. Such property of composite concrete can be tested by the Cylinder specimen. The FGFA composite concrete was casted 150mm dia cylinder being frames prepared by measurement (IS. 5816(1970) [46].

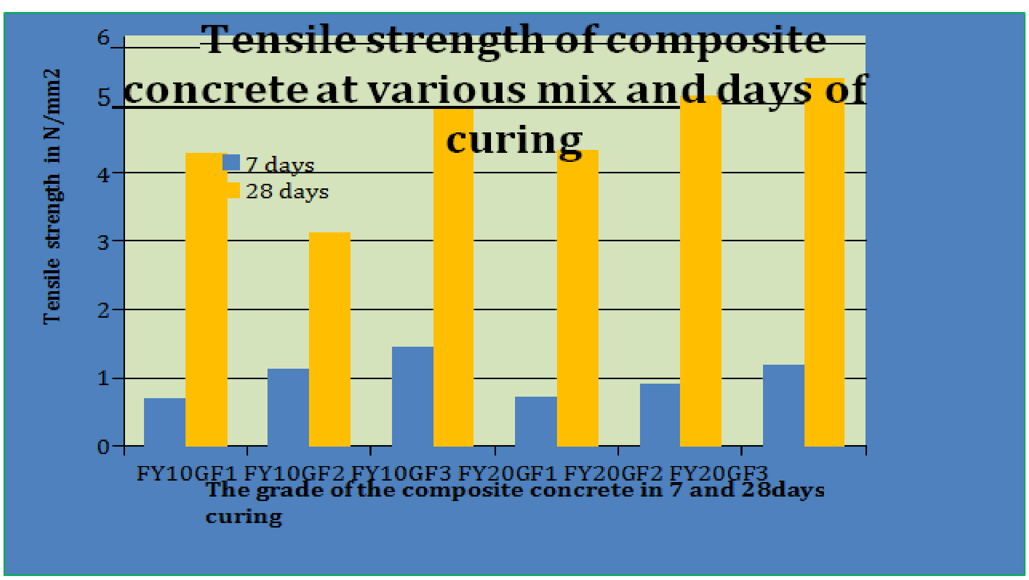

Fig. 5. Tensile strength results of composite FYGF concrete at various mix

The cylinder was casted for different mixes of the FG and fly ash proportion with normal M- 20 concrete. After casting the beams are wrapped in polythene and cured for 7days and 28days, Then the beams are unrevealed and dried for 2 to three days. The split tensile stress is tested under the UTM till it cracks. The results are tabled in Table 8 and Fig. 5.

Results exhibit that the reference concrete without fly ash and glass fibres CS value is 5.38N/mm2 at 28 days but in the case of M20 that is 10% of fly ash in PPC cement and 3% glass fibres, the strength was found to be 4.98 after 28days curing is a very good result as compared to the results obtained by various investigators like Kayali et al., [23], Chandra Priya et al., [24], Dong et al, 2019 [47].

3.11 Flexural Strength

The two point flexural load test has been conducted taking the beam 100mmx 100mmx 500mm as specimen. The composite concrete including 10% fly ash added Ambuja PPC cement and 3% of weight of cement and the FS test results are shown in Table 9.

It inferred from the result that optimum flexural strength up at 10% fly ash added with Ambuja 53 grade PPC cement and glass fibres 0.3% of weight had shown improved in flexural strength properties than the normal concrete Fig. 6. This substantial increase in FS with addition of 3% glass fibres may be attributed to the unsystematic orientation of fibres within the specimen Kayali et al. [23], Chandra Priya et al. [24], Dong et al. [47].

Table 9. Flexural strength of composite concrete at various mix and 7, 28days of curing

Design mix	fly ash in % wt of cement	glass fiber mixin % of cement	Flexural strength at 7 days, N/mm^2	Flexural strength at 28 days, N/mm^2
FY10GF1	10	0.1	2.704	4.29
FY10GF2	10	0.2	2.98	3.14
FY10GF3	10	0.3	3.46	5.98
FY20GF1	20	0.1	2.73	4.34
FY20GF2	20	0.2	2.92	5.12
FY20GF3	20	0.3	3.98	5.68

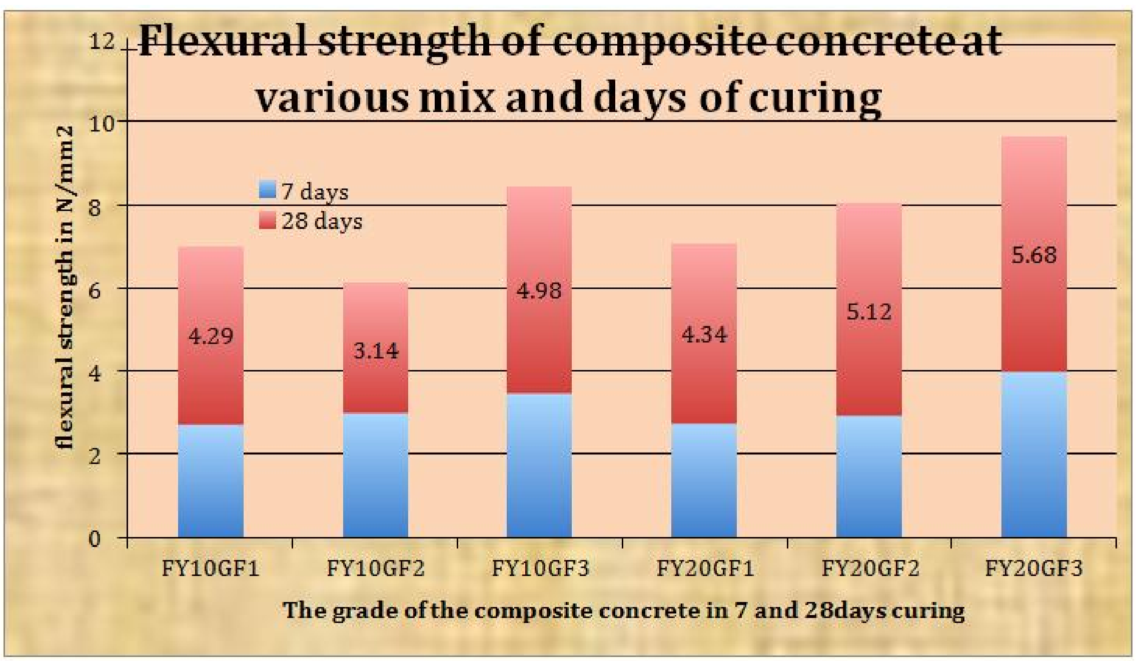

Fig. 6. Flexural strength of various FYGF composite conc. after and, 28 days of curing

3.12 Test for Acid Attack

For weathering action acid resistant tests are conducted as per IS: 2386 (Part III) - 1963. Two extra cubes were casted for this test. After 28days curing in water tank by water is removed kept for one day for drying and weighed (W1 gms). The dried specimen cubes are emerged in very diluted HCl solution (20 ml conc HCl + 1lit water) and kept in a glass tub. After 28 days the cubes were removed dried and final weight (W2) was taken. Also the compressive strength is taken for the cubes in HCl. It was found that the loss of weight was within 1% of previous cube and the CS was decreased by less than 1% which proves that the FYGF concrete cubes are acid resistant. Anand ku et al. 2017 [48].

3.13 Test for Sulfur Attack

The resistance of CC to SO4 – attack is very common if the surface exposed to sulphrous/ic nonmetals which can be dissolved in water. The Sulphur attack to CC can be estimated by loss/variation of weight when the specimen is emerged in 5% by weight of either Na_2SO_4 or $MgSO_4$ in water. Like Acid resistant test the cube was dipped in sulphurated water. Present search we found there is insignificant loss (<1%) in the cube both in weight and compressive strength indicating the FYGF conc. is safe against Sulphur attack (Anand ku. et al. 2017).

Table 10. Past results and present work in comparison for FGRC for concrete

#	Type of blended concrete	Optm vol. fly ash	Optm vol. GF	Work ability	Studied by
1	OPC + Fly ash + FG	6%	1.25%	good	Singh et al. 2020 [40] (Acessed) NBM & CW
2	OPC + Fly ash + FG	20%	0.25 % to 0.5%	good	B. Ali and L. A. Qureshi 2019 [21]
3	OPC + Fly ash +polymer fiber	10%	2.5%	not bad	Barbuta et al. 2017 [17]
4	OPC + Glass fibre	0%	0-1.6%	good	Zai et al., 2020 [49]
5	OPC + FG (M-20)	0%	3%	not bad	Ahirwar et al. 2020 [50]
6	OPC +Fly ash + FG (M-25)	10%	1%	good	Rana S et al. 2020 [51]
7	OPC +(GF+ Quarry dust) +Fly Ash (M-20)	20% GF+QD	2%	good	Meyyappan et al. 2018 [52]
8	OPC(30-35%), Gypsum (5%), Fly Ash (25%), GF (0.5%) & GGBFS (25%) (M-35)	50% (GF+ GGBS)	0.5%	good	Teja V et al., 2019 [20]
9	OPC + GF (M-35)	0%	1.2%	good	Manoj et al.,2019 [53]
10	OPC +Fly ash + FG (M-20)	20%	1.5%	good	Rahul et al., 2015 [54]
11	OPC +Fly ash + FG (M-20)	25%	1.0%	good	Sahana et al., 2013 [55]
12	OPC +Fly ash + FG (M-20)	30%	15% ?	very low	Tucan et al., 2001 [56]
13	OPC +Fly ash + FG (M-20)	40%	5%	Low	Khoso et al., 2019 [38]
14	OPC +Fly ash + FG (M-40)	0-3% (wt)	2%	Good	Alomayri T., 2017 [57]
15	OPC +Fly ash + FG (M-25)	22% (av)	3%	good	Reshma T V. 2018 [58] (rising no maxima)
16	OPC +Fly ash + FG (M-20)	30%	1%	good	Jayshree et al. 2018 [39]
17	OPC +Fly ash + FG (M-20)	25%	0.5%	good	Chari et al., 2020 [59]
18	OPC +Fly ash + FG (M-20)	25%+10 %	03%	very food	PRESENT STUDY Das and Mishra S. P.

4. DISCUSSION

RCC with steel reinforcement has the disadvantage of rusting. The optimum value of steel content by volume for constant aspect ratio is better in FGRCC when with substitution cement by fly ash to improve workability and also restrict the post cracking in RCC. The composite concrete is suitable to extreme weathering surfaces, polished and glossy surface to with stand alkaline or acidic situations, tunnels and drainages and syphon works. However considering the usefulness of the FGRC concrete and it's versatility; the previous works in the same blending has been collected and compared with the present work and is shown in Table 10.

5. CONCLUSION

Attempt is made in this laboratory investigation to find the properties of reinforced glass fibre concrete with partial substitution of in cement, fly ash for a composite economical and eco-friendly concrete compared to conventional prototype.

a. When 10 percent flyash is substituted with cement, the optimum compressive strength value for 7 days is obtained. Fly ash along with glass fibre of 0.3 percent.
b. If the glass fibre increases, the compressive power increases but higher increase of fly ash the compressive strength decreases
c. By 10% substitution of cement with fly ash, along with growing the proportion of fibre 1%, 2% & 3%, it is observed that 3% glass fibre blend demonstrate an improvement in compressive power.
d. Adding glass fibre, the split tensile strength increases and is ideal when substituted with 20% fly ash against cement and glass fiber by 3%.
e. It is also observed that the chloride, sulphate attack is reduced by adding flyash and the glass fiber.

Further investigation in the line is essential for practical use in the field.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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