A Comparative Study on Strength characteristics of Concrete using Fly ash aggregates and Glass Fibre

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ABSTRACT: *Various researches have been conducted in the area of fly ash utilization in the past. It is used as one of the most common type of cement replacement material in concrete production. But the production and utilization of manufactured aggregates with fly ash helps in achieving utilization of further more quantity of FA in the construction industries. Currently fly ash is being utilised in very large amount in construction industries as it can impart good strength and durability throughout its life time thus achieving environmental sustainability and limiting the demand for the natural resources in construction sectors also The concrete production needs aggregates as a static filler material for imparting expanded volume and stiffness to the concrete material. The crush aggregates are partially replaced with the pellets of Fly ash aggregates(FAA), This paper focuses mainly on the manufacturing process of light weight fly ash aggregates using pelletizer and also utilizing the glass fibre material as special reinforcing material in concrete to enhance the tensile properties of the concrete for the M40 grade replacing them partially. The strength characteristics of concrete such as compressive, flexural and split tensile strength determined were experimentally and conclusions were drawn.*

Keywords: **Compressive Strength, Fly ash aggregate Pellets, Light Weight Concrete, Glass fibres, Palettization, FAA, GF.**

I. INTRODUCTION

Concrete is a composed material of coarse & fine aggregate binded together with fluids of cement that gets hardened over time. There are many different concrete types which are available differentiated by their ingredients mix proportions. In this way, by the replacement of cementitious and aggregate stages, the product which is finished can be moulded to its application. Strength characteristics, the density, the chemical as well as the thermal resistance are variables. Concrete as very well known to everyone is stronger in compression, because of the efficiency of the aggregates to carry the compressive load. Having said that, its tensile strength is weaker as the cement, in place, holding the aggregates can produce cracks, making the structure to breakdown and collapse. Concrete which has been reinforced adds either reinforcing the steel bars, the steel fibres, plastic fibres, or glass fibres to carry tensile loads. GFRC is one of the most common category of fibre-reinforced concrete. Concretes reinforced with glass fibres are largely used in façade palisades construction of exterior building and as a precast concrete in architecture. The added fibres give reinforcement for the concrete matrix and play various effective roles in fibre reinforced compounded materials. Fibres of glass shall be integrated into the concrete mix either in continuous or chopped lengths. Another substance which can be used effectively in the construction sector is the fly ash, The fly ash utilization has grown considerably in recent years in India. Both the main ingredients of concrete coarse and fine aggregates have become scarcer and many other countries including India have halted the quarrying of stone and sand. These pelletized aggregates of fly ash , in addition to being lightweight, are not put through alkali-aggregate reaction. About 200 metric tonnes of fly ash is being produced in India yearly. As coal is going to remain the main substantial natural resource for energy production in India and other parts of the world**.** In construction industry, fly ash is basically used in the insulation of the roofs, Trench reinstatement of trenches, formation of Roads, Bridge abutments, reclamation of lands, void filling, Light weight pre casted blocks, Fire resistance, screed Insulation and stabilization of soil. The combination of FAA & glass fibre is going to be utilised and their strength parameters are going to be analysed.

II. OBJECTIVES:

- This experimental investigation has major objectives, which are as follows.
- To Manufacture the Fly Ash aggregates using 4 different proportions of Fly ash + cement and cure it for 28 days.
- To investigate the physical properties of machine prepared fly ash aggregates used as to replace the coarse aggregate and glass fibre utilised as an supplementary reinforcement.
- To assess the variations in workability for the light weight concrete as soon as CA is partly replaced with FAA & the enhance in additional reinforcement as glass fibre.
- To examine the different physical characteristics of FAA based concrete such as compressive, split tensile and flexural properties in this investigation.
- Utilisation of factory waste materials in such a manner so as to diminish the trouble of waste disposal presently and in future, as well as to also importantly mitigate the CO_2 release in the atmosphere and also reduce the dire impacts on the different environmental aspects, provide economy in the construction material being utilised in the construction sector.

III. LITERATURE REVIEW:

Budda Beeraiah, et al. (2021), In this experimental work Natural Coarse aggregates has been replaced with pelletized fly ash aggregate and their strength and durability properties were studied. The NCA were replaced in different variations 0%, 10%, 20%, 30%, 40% & 50%. Results indicated the increase in strength and durability of concrete at 40% and 20% replacement of Fly ash aggregate respectively. (1)

S. Hemalatha, et al. (2010), The glass fibre was added to the concrete in varying percentages 0.33%, 0.66%, 1%, 1.33%, 1.66%, 2%. Comparison was done to assess the effect of glass fibre over different strength parameters of concrete and the results shown the increase in strength at 1% addition of GF to the concrete. (2)

P. Jayabharath, et al. (2017), conducted an experiment on fly ash aggregate to study their impact strength. The OPC 53 cement and fly ash were added to the concrete in various different proportions 10:90, 12.5:87.5, 15:85, 17.5:82.5, 20:80, and 22.5:77.5 were added to fly ash aggregates. At ratio of 15:85, the Impact strength test were conducted of on FAA at 7 and 28 days and the impact strength was found to be developed by 10 % and 5 % in comparison with to that of other aggregates. (3)

K.L Ravishankar, et al. (2015), investigated the addition of Artificial fly ash aggregates, which were used as replacement material in concrete and its effect on strength parameters were studied, the fly ash was mixed with cement in the proportion of 37.5:62.5, 35:65, 32.5:67.5, 30:70, 27.5:72.5, 25:75 were adopted for the production of Artificial aggregates of fly ash. The particle size distribution, bulk density, specific gravity, and impact test on aggregate were conducted. The concrete cube and beam specimens were casted using both Natural aggregates and Artificial aggregates, The compressive and flexure tests were carried out. The compressive and flexural strength gave maximum strength values at 30:70 of cement and fly ash replacements after 28 days of curing. (4)

Md. Abid Alam, et al. (2016), Used the glass fibre as a material for Reinforcing the concrete. The different mixes for glass fibres with varying percentages were added for different grades of concrete, M20 and M30. And based on the observation of the results, The compressive and Tensile strength were improved up to 26.19% and 25.4%. The workability of the concrete doesn't seem to alter with the addition glass fibres. The massive increase in tensile strength for the concrete indicates glass fibre can be effectively utilised in the concrete to deal with the low tensile strength and without affecting the workability properties. (5)

IV. TESTS ON MATERIAL PROPERTIES

1. Cement

OPC 53 grade complying to IS 8112-1989 was employed. The table below shows results for the tests conducted in the laboratory.

Table 1. Characteristics of Cement

Characteristics	Cement
Specific gravity	3.15
Standard consistency	29%
Setting Time(Initial)	39 min
Setting Time(Final)	485 min
Fineness	5.4%

2. Fine Aggregate

Naturally available sand below 4.75mm size complying to zone 1 IS 383-1970 was used as fine aggregates. The table below indicates the basic characteristics of Fine aggregate.

Table 2. Characteristics of Fine Aggregates

Characteristics	Fine Aggregate
Specific Gravity	2.65
Water absorption	1.5%

3. Coarse Aggregate

The 20mm downsize crushed gravel stones are used as coarse aggregates. The table below shows the different characteristics of coarse aggregates.

Table 3: Basic Characteristics of Coarse Aggregates

Characteristics	Coarse Aggregate
Specific Gravity	2.65
Water absorption	1.5%

4. Fly Ash Aggregate

The pelletised aggregates of fly ash is utilised in the concrete partially replacing with coarse aggregates. The impact, Crushing & Specific gravity tests were conducted & the results were tabulated there after the best proportion was chosen for producing light weight concrete.

Figure 1. Sintered Fly Ash Aggregates

Table 4. Characteristics of Fly Ash Aggregates

Sl. No.	Mix (FA & Cement)	Impact Value	Crushing Value	Specific Gravity
1	10:90	33	51.25	2.42
2	20:80	26.22	37.65	2.27
3	30:70	23.55	30.65	2.05
4	40:60	20.37	28.70	1.92

5. Glass Fibre

The alkali resistant glass fibres are basically rounded and also straight having diameters of 0.014 mm. they could also be packed up together to manufacture glass fibre bundles with diameters up to 1.3mm.

Table 5. Basic Characteristics of Glass Fibre

Characteristics	Glass Fibre
Specific Gravity	2.68
Modulus of elasticity	72 GPA

6. Water

Ordinary portable water was used in this experimental work for blending and curing both.

7. Superplasticizer

SP430 conplast is the superplasticiser which was adopted to enhance the workability. It is a chemical admixture, which is chloride free. It is used to control the W/C ratio and improve the workability of the concrete mix.

8. Mix Design for Concrete

The proportional mix followed for this experimental works are 1:1.62:2.67 (M40) with W/C ratio of 0.45 & superplasticizer 0.80%.

9. Batching & Mixing of Materials

Weigh batching & machine mixing were implemented for this investigation.

IV. SCOPE OF THE WORK

A. Compressive Strength:

The cubic specimen were casted and kept cured for 7 & 28 days, and the compressive strength properties were studied using CTM having capacity 2000KN. The compressive strength for the prepared cubic specimen shall be determined by dividing the load applied on the cubic specimen with the cross sectional area measured from the dimensions will be expressed in N/mm^2. Of all the other properties of concrete, compressive strength is an important characteristics which is used to define the quality of the concrete specimen.

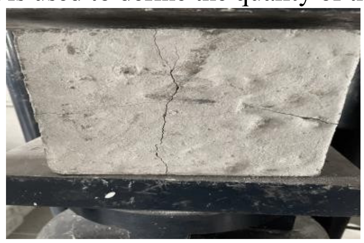

Figure 2. Compressive Strength test cubic Specimen FAA Concrete

B. Split Tensile Test:

Concrete known for its weaker tensile strength as much strong it is against compressive loads. Tensile strength still remains one of the important properties for concrete. The cylindrical specimens were casted and the strength results were found using the CTM after 28 days of curing, the results will be drawn and conclusions will be made.

Figure 3. Tensile Strength on Cylindrical Specimen

C. Flexural Strength Test:

Concrete beam specimens of size $100x100x500$ is utilised for determining the flexure strength, in accordance with BS 1881. The strength results for the flexure were calculated in UTM, after curing the concrete for 28 days. The results were calculated and conclusions were drawn.

Figure 4. Failed Beam Specimen from UTM

V. RESULTS

The concrete mixes were prepared in trials for cubes, cylinders and beams. Cubes of the 150X150X150 is casted for different proportion for glass fibre and fly ash aggregates, selecting W/C 0.40. Superplasticizer SP Conplast 430 is added for different mixes to enhance the workability. The sintered fly ash aggregate is added and presence of fly ash would increase the bonding between the cement and the aggregate. The Compressive, Split tensile & flexure strength for three sets are then found out.

i. Compressive Strength Results

The test results for the compressive strength test were calculated and tabulated after 7 and 28 days of curing.

Table 6: Compressive Strength Results(N/mm^2)

Sl. No.	% FAA replacement to CA	S-type Glass fibre	Compressive Strength(N/mm^2)		
			7 days	28 days	56 days
1	0%	0%	25.67	48.28	50.12
2	15%	0.5%	30.53	50.4	53.75
		1.0%	32.89	52.84	55.34
		1.5%	29.27	49.76	54.47
3	30%	0.5%	32.84	54.67	56.88
		1.0%	34.17	55.32	58.33
		1.5%	33.01	51.89	55.72
4	45%	0.5%	35.24	54.78	60.13
		1.0%	36.78	55.64	60.78
		1.5%	35.11	53.17	58.96
5	60%	0.5%	32.13	49.13	56.77
		1.0%	33.27	50.28	57.12
		1.5%	31.78	48.65	54.46

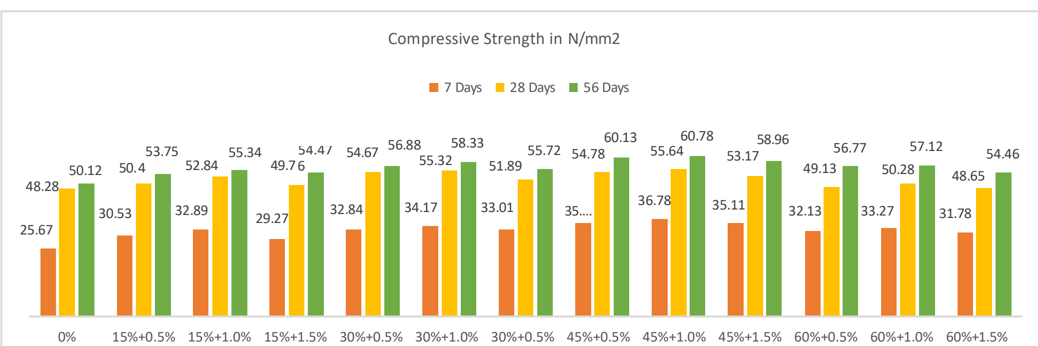

Figure 5. Compressive Strength in N/mm^2

From the above test results and graph it's been discovered that the compressive strength results for FAA+GF mix combinations keep on increasing upto an optimum value. The strength has found to be increased at 45% FAA+ 1.0% GF combination, thereafter the strength results deplete with further addition of FAA+GF.

ii. Tensile Strength Results

The tensile strength results were calculated and tabulated after 7 days, 28 days & 56 days of curing.

Table 7. Tensile Strength Results(N/mm^2)

Sl. No.	% FAA replacement to CA	S-type Glass fibre	Tensile Strength(N/mm^2)		
			7 days	28 days	56 days
1	0%	0%	2.82	3.89	4.48
2	15%	0.5%	3.05	4.36	5.28
		1.0%	3.23	4.68	5.45
		1.5%	3.11	4.47	5.16
3	30%	0.5%	3.18	4.86	5.47
		1.0%	3.34	5.02	5.65
		1.5%	3.27	4.72	5.32
4	45%	0.5%	3.47	5.13	5.94
		1.0%	3.64	5.37	6.20
		1.5%	3.27	5.23	5.77
5	60%	0.5%	3.03	4.57	5.34
		1.0%	3.19	4.75	5.46
		1.5%	3.13	4.46	5.22

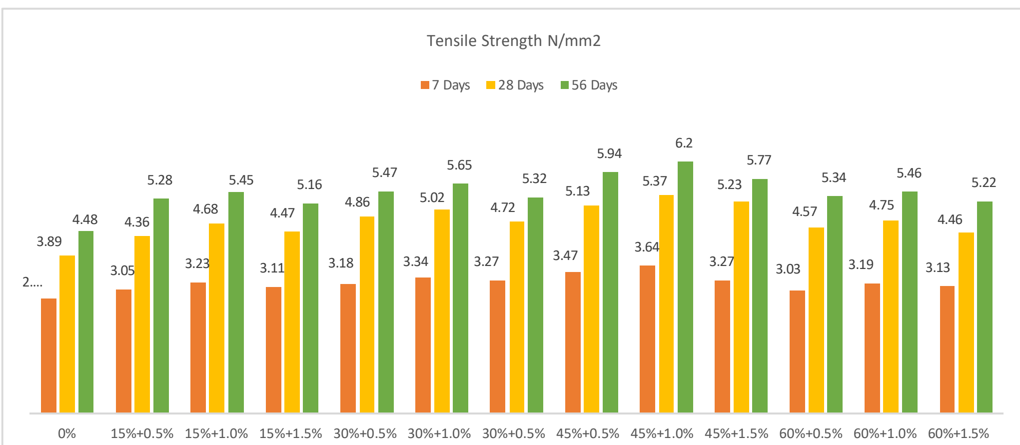

Figure 6. Tensile Strength in N/mm^2

The above fig.2 Represents the tensile strength for the mix combinations of FAA+GF, and it has been found that the Tensile strength seems to increase when made comparisons with the conventional concrete mix.

III. Flexural Strength Results

The Flexural strength results were calculated and tabulated after 7 and 28 days of curing.

Table 8: Flexure Strength Results(N/mm^2)

Sl. No.	% FAA replacement to CA	S-type Glass fibre	Flexural Strength(N/mm^2)		
			7 days	28 days	56 days
1	0%	0%	2.6	4.75	6.02
2	15%	0.5%	2.91	4.98	6.45
		1.0%	3.15	5.17	6.67
		1.5%	2.77	4.85	6.54
3	30%	0.5%	3.78	5.22	6.83
		1.0%	4.03	5.54	7.2
		1.5%	3.57	5.38	6.68
4	45%	0.5%	4.12	5.95	7.25
		1.0%	4.34	6.26	7.3
		1.5%	3.99	6.02	7.08
5	60%	0.5%	3.02	5.72	6.71
		1.0%	3.26	5.87	6.85
		1.5%	2.89	5.54	6.53

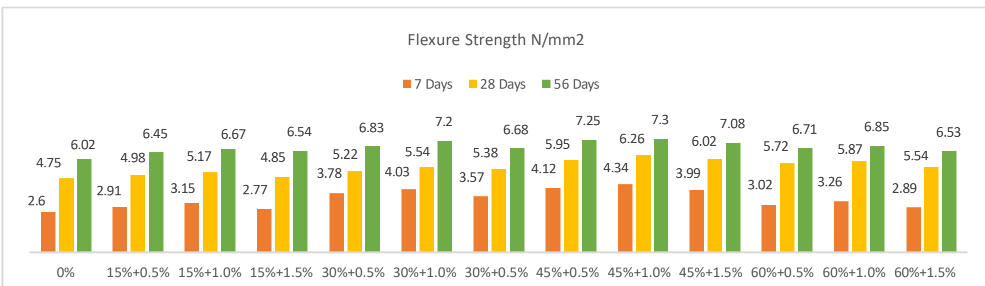

Fig. 3: Flexural Strength(FAA+GF) in N/mm^2

From the above figure it has been concluded that the FAA+GF combinations gives out better flexure strength results when made comparisons with the normal concrete, the optimum strength value is found to be increased at 45% FAA+1.0% GF.

VI. CONCLUSIONS

Below the conclusions have been drawn from the investigations done

1. The strength properties seem to increase gradually and shown better strength when comparisons were made to the normal concrete.

2. The concrete Compressive strength of FAA+GF based concrete enhances up to 45% replacement of FAA and 1% addition of glass fibre to concrete mix and then decreases as we further increase the amount of both the materials.

3. The flexural and Tensile strength also seem to increase the strength upto 45% FAA and 1% Glass Fibre Replacements.

4. The fly ash aggregates utilisation reduces the requirement for Natural coarse aggregates there by achieving the economy in construction and also achieving environmental sustainability.

5. The Fly ash light weight aggregates having lower specific gravities when made comparisons with the Natural coarse aggregates thus reducing the concrete self-weight of the structures.

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