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Experimental Study on Glass Fibre Reinforced Steel Slag Concrete with Fly Ash

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ABSTRACT:- The scope of this project is to establish the use of steel slag , fly ash and glass fibre in many effective ways to achieve high strength than conventional concrete. This project shows the experimental studies on the enhancement of strength in concrete blocks by the application of using waste steel slag, glass fibre for increasing the strength and fly ash for replacing cement for good workability and also to achieve high strength than a conventional concrete. The proposed experiment was done and all the tests were done by us at our college campus laboratory. Grade of concrete is taken as M30.Fly ash was added in three different percentages (i.e. 5%, 10%,and 15%) by replacing of cement. And also fine aggregate in the concrete is replaced by steel slag in a constant percentage (30%), throughout the experimental studies. To find the optimum value of steel slag, steel slag concrete test analysis is also being done. The percentage of steel slag added was (20%, 30% and 40%). Glass fiber is an additive used with the concrete in order to achieve good properties. For that 1% of glass fibre is added to the volume of concrete. By using this replaced concrete - cubes, cylinders and prisms were casted and tested for their strength and then the result was compared with conventional concrete.

I. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Globally concrete is the backbone for the large development of infrastructure viz., buildings , industrial structures, bridges and highways etc.. leading to the utilization of large quantity of concrete**.** Glass fiber reinforced concrete (GFRC), in simplest terms, is the replacement of conventional large aggregate and steel rebar with a homogenously dispersed network of tiny strands of glass in a slurry of cement and sand. Fly ash is finely divided residue resulting from the combination of ground or powered coal. They are generally finer then cement and consist mainly of glassy spherical particles as well as residue of hematite and magnetite, char and some crystalline phases formed during cooling.

Steel slag is a by-product obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). The steel slag is obtained as a waste product after undergoing several industrial processes for the production of steels. Steel slag is having similar particle size characteristics likely to that of coarse aggregate. Likewise, many of this property match best with that of coarse aggregate. Hence, it is a better approach in using the slag as the replacement for coarse aggregate

II. MATERIALS USED AND ITS PROPERTIES

1. CEMENT

Cement is the most important binding material of concrete. The cement used for this experimental study is Ordinary Portland Cement conforming to IS 269-1976 and IS 4031-1968 of 53 grade.

Table 1: chemical properties of cement:

Chemical properties	Percentage
SiO_2	21.8
Al_2O_3	5.1
Fe_2O_3	3.9
CaO	64.8
MgO	<1.7
Cl	<0.03
SO_3	<2.0
L.O.I	<1.3
LnR	<0.65

Table 2: Properties of cement

Sr. No	Properties	Values
1	Consistency test	34
2	Specific gravity	3.15
3	Initial setting time	30 minutes
4	Fineness test	4.33%

2. COARSE AGGREGATE

Machine crushed granite obtained from a local quarry was used as coarse aggregate. The maximum size of the coarse aggregate used is 20mm.The density of coarse aggregate is 2.55 g/cm^3 and that of bulk density is 1597 kg/m^3.

Table 3: Properties of coarse aggregate

Sr. No	Properties	Values
1	Specific gravity	2.74
2	Fineness modulus	1.4
3	Impact value	8%
4	Water absorption test	0.5%

3. FINE AGGREGATE

The fine aggregate used for the concrete is natural river sand. Fine aggregates are used to make a greater building strength between cement and coarse aggregate. It has cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture it give good workability and also it have good texture.

Table 4: Properties of fine aggregate

Sl.no	Properties	Values
1	Specific gravity	2.74
2	Fineness modulus	4.923
3	Water absorption test	1%

4. STEEL SLAG

Steel slag is an industrial by-product obtained from the steel manufacturing industry. It is produced in large quantities during the steelmaking operations which utilise Electric Arc Furnace (EAF). Steel slag can also be produced by smelting iron ore in Basic Oxygen Furnace (BOF). This steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates. Steel slag is obtained from Ratna Private Ltd. Kanjikode, Kerala in fine form and its specific gravity is 2. Steel slag with fraction passing through 2.36mm sieve was used for cement mortar. The chemical composition of steel slag is usually expressed in terms of simple oxides.

Table 5: Properties of steel slag

Sr.No	Properties	Values
1	Specific gravity	2
3	Water absorption test	0.39%
4	Fines modulus	3.14
5	Density	1058kg/cum
6	Colour	Black

5. GLASS FIBRE

On a specific strength basis, glass fibre is one of the strongest and most commonly used structural materials. a composite of Portland cement, fine aggregate, water, acrylic copolymer, glass fiber reinforcement and additives. The glass fibers reinforce the concrete, much as steel reinforcing does in conventional concrete. The glass fiber reinforcement results in a product with much higher flexural and tensile strengths than normal concrete.

Table 6: Physical properties of glass fibre

Sr.no	Property	Value
1	Specific gravity	2.49
2	Tensile strength (MPa)	4.59
3	Tensile modulus (GPa)	86
4	Diameter range (microns)	8 – 13
5	CTE (per million per C)	2.9

6. FLY ASH

Fly ash used in this experimental study is from Malabar cements, palakkad. Fly ash is finely divided residue resulting from the combination of ground or powered coal. They are generally finer then cement and consist mainly of glassy spherical particles as well as residue of hematite and magnetite, char and some crystalline phases formed during cooling.

Table 7: Chemical properties of fly ash

PROPERTIES	VALUES
Specific gravity	2.69
Fineness modulus	3.43
Water absorption test	0.5%
Bulk Density test	1600 Kg/m^3

7. SUPER PLASTICIZER

Master Glenium-51 is Polycarboxylic ether based high range water reducing new second generation super plasticizer concrete admixture. This product has been primarily developed for the applications in high performance concrete where the highest durability and performance is required.

Table 8: Properties of super plasticizer

Properties	Values
Aspect	Light brown liquid
Relative density	1.064
pH	6
Density	1.062-1.065kg/litre
Specific gravity	1.064

8. WATER

Water is an important ingredient to form a plastic mix in a concrete. The observed pH value of the water used is 7.Portable drinking water is only suitable for mixing. The workability of concrete is depending upon the water added to the concrete.

III. TEST RESULTS AND DESCRIPTION

A. Comparison between Conventional Concrete and Replaced Steel Slag Concrete

M30 grade of concrete is used in this work. In three different percentages (20%, 30% and 40%) steel slag is replaced by weight of fine aggregate. This comparison is made to find out the optimum range of steel slag.

1. COMPRESSIVE STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF STEEL SLAG

Table 9: Compressive strength test analysis for 7 and 28 days curing

Sr. no	% replacement of Steel Slag	Compressive strength N/mm^2	
		7 days	**28 days**
1	0	23.17	33.11
2	20	24.25	35.37
3	30	28.88	39.12
4	40	26.8	36.16

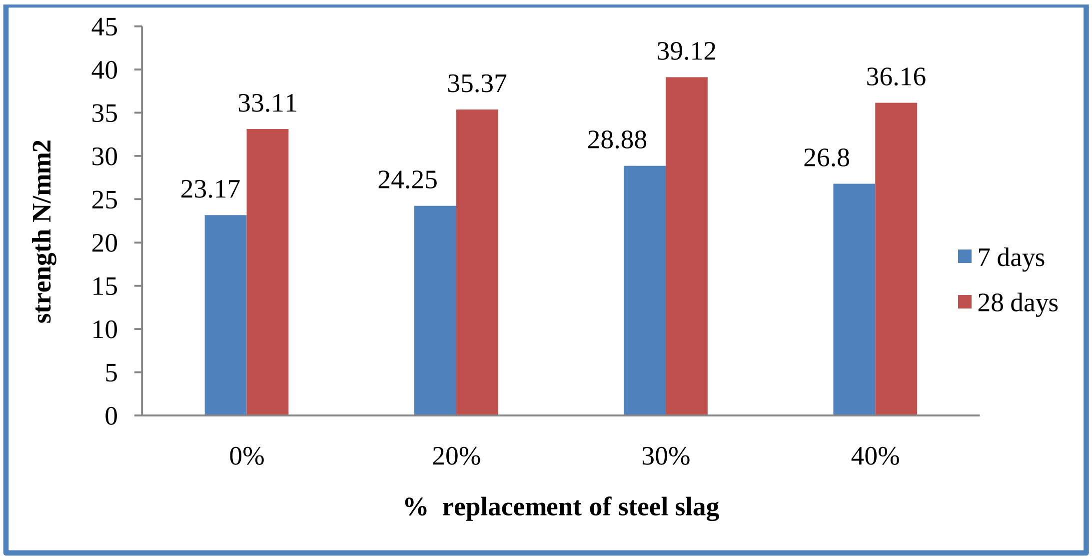

Figure 1 Compressive strength test result for steel slag

Above figure shows the increment in the strength and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum compressive strength is obtained at the optimum range of 30% replacement.

2. SPLIT TENSILE STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF STEEL SLAG

Table 10: Tensile strength test analysis for 7 and 28 days curing

	% replacement of Steel Slag	Tensile strength N/mm^2	
		7 days	28 days
1	**0**	**2.73**	**3.9**
2	**20**	**3.12**	**4.45**
3	**30**	**3.34**	**4.8**
4	**40**	**3.09**	**4.57**

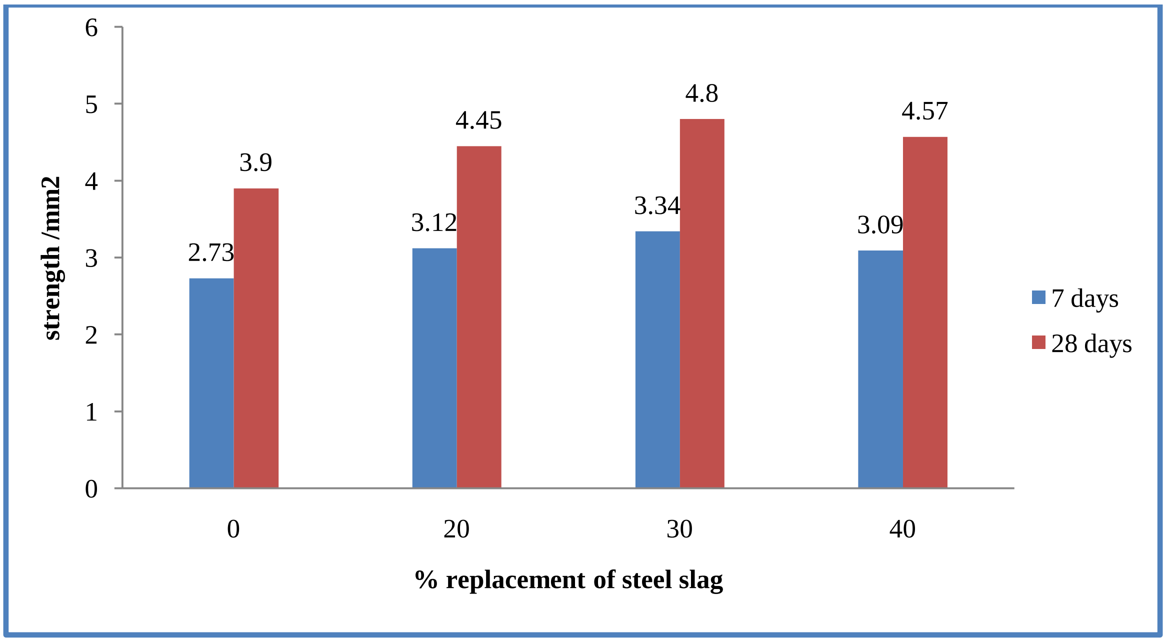

Figure 2 Split tensile strength test result for steel slag

Above figure shows the increment in the strength and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum tensile strength is obtained at the optimum range of 30% replacement.

3. FLEXURAL STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF STEEL SLAG

Table 11: Flexural strength test analysis for 28 days curing

Sr. no	**% replacement of Steel Slag**	**Flexural strength N/mm^2**
		28 days
1	**0**	**4.1**
2	**20**	**5.2**
3	**30**	**5.82**
4	**40**	**5.64**

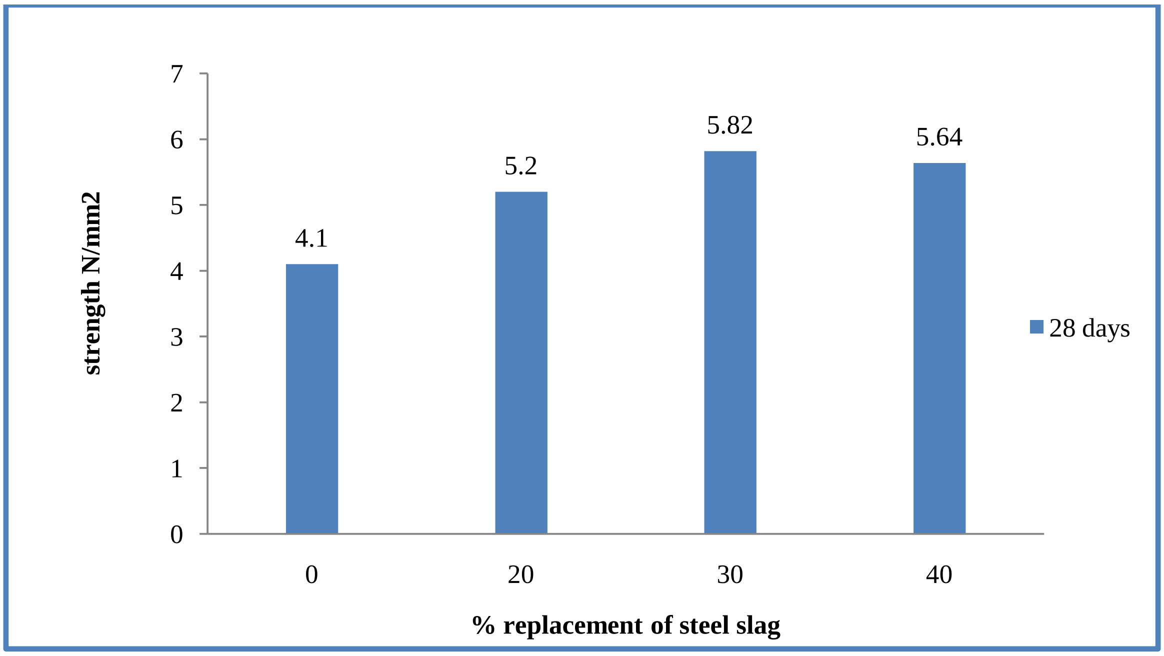

Figure 3 Flexural strength test result for steel slag

Above figure shows the increment in the strength and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum Flexural strength is obtained at the optimum range of 30% replacement.

B. COMPARISON BETWEEN CONVENTIONAL CONCRETE AND REPLACED CONCRETE

M30 grade of concrete is used. Steel slag, fly ash and glass fibre is used to replace the quantities in the concrete. steel slag is added to the concrete in a constant percentage (30%) that is obtained at the steel slag concrete test analysis. Cement is replaced by different percentages (5%, 10% and 15%)by fly ash. 1% of Glass fibre is added by weight of cement throughout this experimental analysis.

1. COMPRESSIVE STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF 30% STEEL SLAG

Table 12: Compressive strength test analysis for 7 and 28 days curing

Sr. no	Name of Specimen	% of replacement (SS+FA+GF)	Compressive strength N/mm^2			
			7 days	Mean value	28 days	Mean value
1	C0C1	0+0+0	22.64	23.17	32.35	33.11
	C0C2		23.42		33.46	
	C0C3		23.5		33.53	
2	C30C1	30+5+1	24.57	24.60	35.11	35.15
	C30C2		24.42		34.89	
	C30C3		24.82		35.45	
3	C30C1	30+10+1	27.6	27.19	39.51	38.86
	C30C2		26.5		37.86	
	C30C3		27.46		39.23	
4	C30C1	30+15+1	24.8	25.1	35.54	35.9
	C30C2		25.2		36.01	
	C30C3		25.3		36.23	

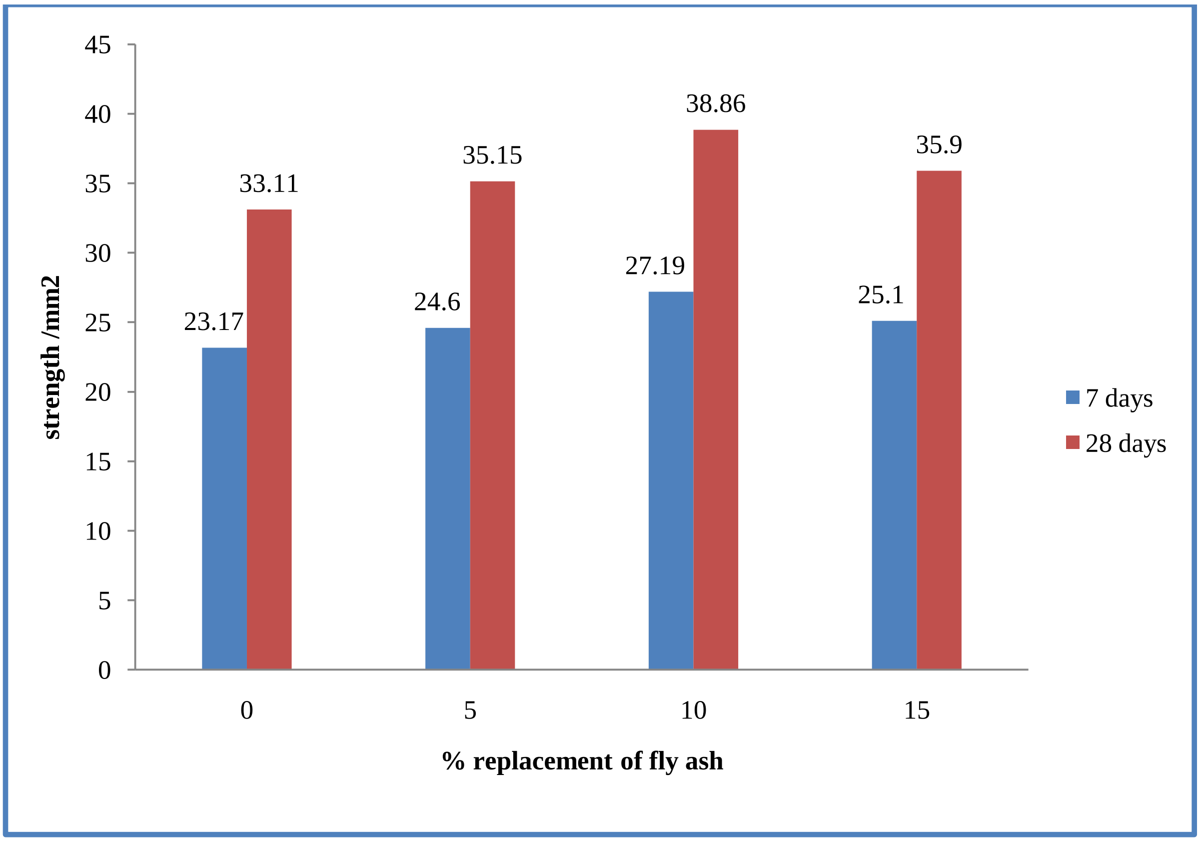

Figure 4 Compressive strength test result for fly ash

When compared with the conventional concrete this figure shows the increment in the strength at 10% and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum compressive strength is obtained at the optimum range of 10% replacement.

2. SPLIT TENSILE STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF 30% STEEL SLAG

Table 13: Tensile strength test analysis for 7 and 28 days curing

Sr. no	Name of Specimen	% of replacement (SS+FA+GF)	Tensile strength N/mm^2			
			7 days	**Mean value**	**28 days**	**Mean value**
1	S0C1	0+0+0	2.29	2.73	4.12	3.9
	S0C2		2.32		3.98	
	S0C3		2.73		3.99	
2	S30C1	30+5+1	3.3	3.2	4.4	4.45
	S30C2		3.15		4.56	
	S30C3		3.3		4.35	
3	S30C1	30+10+1	3.6	3.57	5.1	5.1
	S30C2		3.55		4.9	
	S30C3		3.57		4.97	
4	S30C1	30+15+1	3.28	3.21	5.1	4.59
	S30C2		3.19		4.85	
	S30C3		3.23		4.84	

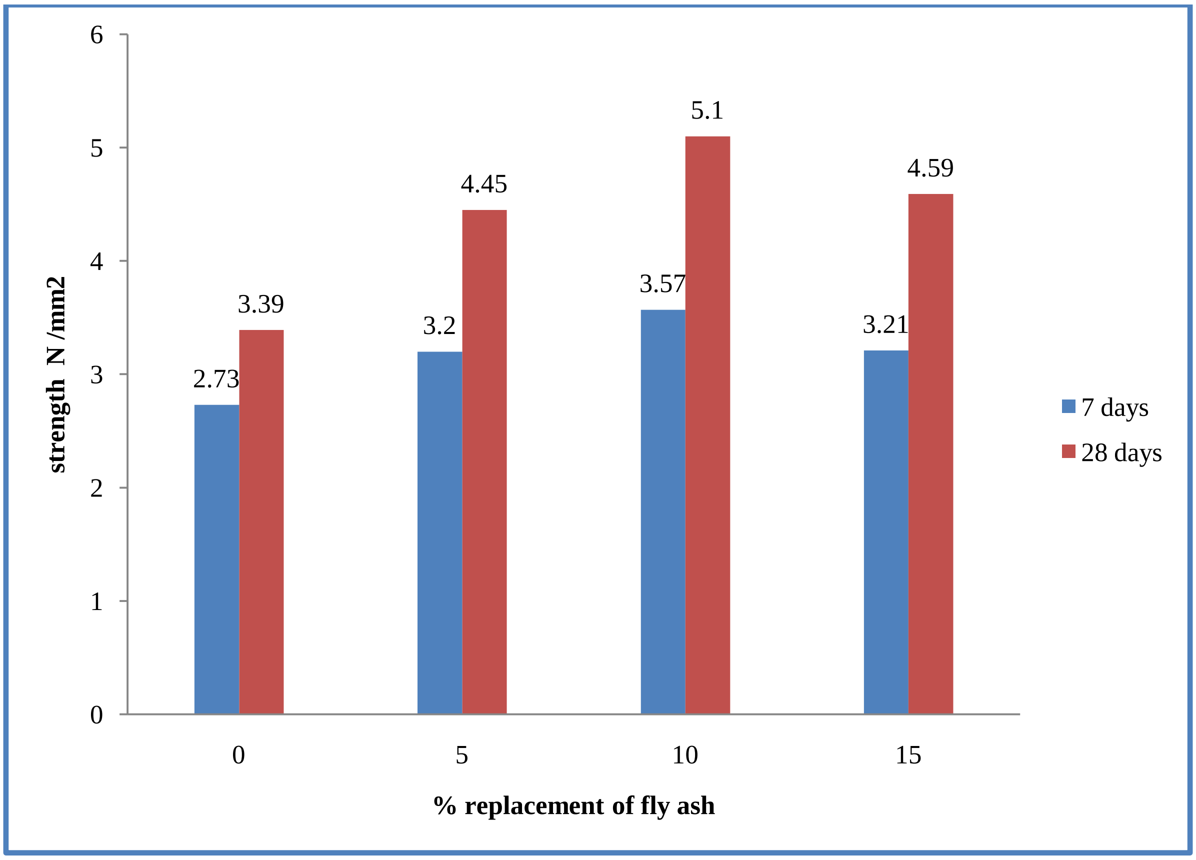

Figure 5 Tensile strength test result for fly ash

When compared with the conventional concrete this figure shows the increment in the strength at 10% and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum Tensile strength is obtained at the optimum range of 10% replacement.

3. FLEXURAL STRENGTH TEST ANALYSIS FOR THE REPLACEMENT OF 30% STEEL SLAG

Table 14: Flexural strength test analysis for 28 days curing

Sr. no	Name of Specimen	% of replacement (SS+FA+GF)	Flexural strength N/mm^2	
			28 days	**Mean value**
1	F0P1	0+0+0	4.85	4.1
	F0P2		4.9	
	F0P3		4.62	
2	F30P1	30+5+1	5.33	5.33
	F30P2		5.32	
	F30P3		5.31	
3	F30P1	30+10+1	6.08	6.04
	F30P2		6.09	
	F30P3		6.11	
4	F30P1	30+15+1	5.6	5.61
	F30P2		5.58	
	F30P3		5.62	

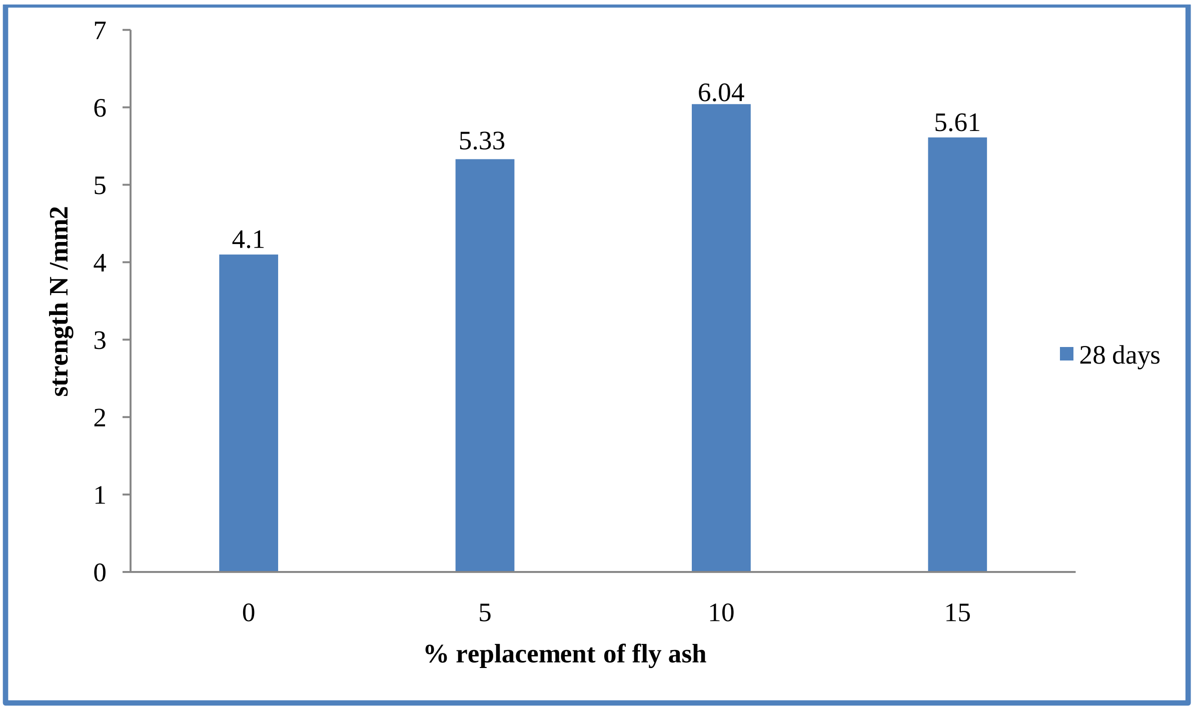

Figure 6 Flexural strength test result for fly ash at 28 days

When compared with the conventional concrete this figure shows the increment in the strength at 10% and when it reaches to an optimum rage it shows slight decrement so hence concluded that the maximum Flexural strength is obtained at the optimum range of 10% replacement.

IV. CONCLUSION

The following conclusion could be drawn from the present work:

- At the optimum percentage (30%) of steel slag the mechanical properties of the concrete increased at 10%.
- At 20% of concrete proportion there is a considerable reduction in the mechanical strength.
- The result showed that addition of steel slag, fly ash and glass fibre in to OPC mixture enhanced its compressive strength as well as the tensile and flexural strength.

- Also it increased the workability of the fresh concrete due to the addition of super plasticizer and fly ash to the concrete.
- In general from the above study it was incurred that, the performance of glass fibre reinforced steel slag fly ash concrete proves to be better than the normal concrete and very much comparable with other fiber reinforced concrete regarding its mechanical properties.
- Based on the finding of this study, the following conclusions were drawn: addition of glass fibre increases flexural and compressive strength of concrete . Addition of glass fibres in the concrete mix significantly influenced the cracking behavior and ultimate strength of beams.

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