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The Mechanical Properties on Partially Replacement of Cement by Ground Granulated Blast Furnace Slag and Fly-Ash in M40 Grade Concrete

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Abstract: In the present generation the construction activity is rapidly increasing as a result the usage of cement is growing more and leads to environmental hazards. This study deals with the mechanical properties of partial replacement of cement by GGBS and Fly-Ash in M40 grade concrete. Cement were replaced as partially in the form of 5%,10%,15% and 20%. As per IS 456:2000 [1] the tests were conducted on 3,7 and 28th days after curing condition. This study proves that the possible replacement to cement by GGBS is 10% and fly ash 15% used in the concrete, which helps in minimizing the consumption of cement and environmental problems also.

Keywords : Cement;fly-ash;Ground Granulated Blast Furnace slag (GGBS); Compressive strength.

I. INTRODUCTION

Cement is a binding material commonly used in the manufacturing of concrete. Such high consuming binding material emits high amount of carbon dioxide. As to reduce this environmental problem, the material has to replace in the manufacturing of concrete. The binding material were replaced with fly-ash, GGBS, these materials possess pozzolanic properties and can be used as an alternate material to the cement in the manufacturing of concrete [2,3,4]. From the thermal power plant, fly ash is obtained as coal based by product. The presence of pozzolanic substance in fly -ash which contain siliceous and aluminous material that makes concrete within sight of water to improves the quality of the concrete. GGBS is another alternate material for cement to rise the fresh and hardened properties of concrete. GGBS is frequently used in the production of low heat cement. It has good properties with less ecological impacts. It was discovered that the utilization of GGBS in concrete will be eco-friendly.

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II. EXPERIMENTAL WORK

A. Materials used

In this inspection the used substance for the manufacturing of concrete like OPC grade 53, river sand, stone aggregate, water, fly ash and GGBS.

B. Cement

The cement that is used for the concrete specimens are OPC grade 53 as per Indian Standard specifications 12269:2013 [5], which acts as a binding property in the concrete and has to be thoroughly in contact with water for the hydration process.

C. Fine aggregate

Fine aggregates are huge involve with most particles experiencing less than 4.75 mm size these are the structural fillers which will occupy the most part of the concrete and gives the mixture more stability and also influences the hardening properties of the mix. The code used for aggregate is Indian standard 383:2016 [6].

D. Coarse aggregate

The aggregate used for the concrete specimen which is obtained after the crushing of the stone, 20 mm size aggregate are used for this study. Coarse aggregate is useful for the properties of strength, hardness, durability. The code used for aggregate is Indian standard 383:2016 [6].

E. Fly ash

This ash material is a coal-based outcome get from the power plant. Which is helpful for the increasing of the strength and reducing the permeability it also gives more workability with less quantity of water which leads to more strength.

F. Ground granulated blast furnace slag

GGBS is a cementitious material which is good at structural and durable properties for the replacement to cement, it also helps for the protection of sulphate attack and chloride attacks in concrete.

III. RESULTS AND DISCUSSION

Different tests were conducted on the harden concrete spe cimen that are cubes, cylinders, flexural beams and RCC beams and are tested after the curing condition of 3, 7 and 28th days.

3.1 Compressive strength test

To find capacity of the harden concrete test was done on concrete specimens as shown in Figure 1, the cube size of 150 × 150 × 150 mm. The test was conduct on the compressive testing machine as per the Indian Standard 516:1959 [7]. The main usage of this test is to find the load that can withstand the load acting on it [8]. The compressive strength of each samples is obtained by the equation (3.1) and presented in the Table 1. The compressive strength graphical representation is shown in Figure 2.

$$f_{ck} = \frac{P}{A} \tag{3.1}$$

Where f_{ck} ~ compressive strength in N/mm^2,
P ~ ultimate crushing load in N, **A** ~ area of section in mm^2.

Figure 1 Test on concrete specimen

Table 1. Compression strength test results

Compressive strength in N/mm2				
Different mixes	**Cement replacement (in %)**	**Day 3**	**Day 7**	**Day 28**
Standard concrete	0%	22.1	35.6	48.77
Fly-ash concrete	5%	20.3	32.18	41.4
	10%	18.6	30.7	40.85
	15%	16.3	28.5	39.6
	20%	14.08	25.4	37.13
GGBS concrete	5%	19.5	33.6	41.7
	10%	17.3	31.8	40.2
	15%	16.50	28.2	38.4
	20%	14.8	25.1	36.7

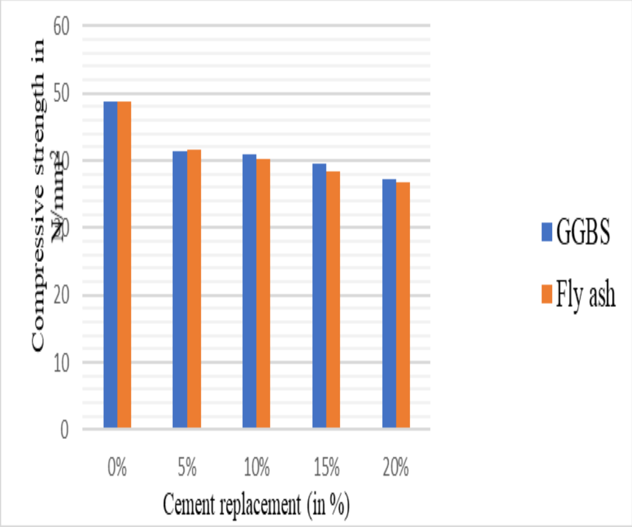

Figure 2 Graphical representation on compressive strength

3.2 Split tensile strength

Test was carried to find out the split tensile strength on cylindrical specimen as shown in Figure 3 of 150×300 mm in size. This experimental work was conducted in the universal testing machine as per the ASTM C496 / C496M [9]. From this test, finding the split tensile strength by applying the load diametrically on it. Equation was used to calculate (3.2) and the splitting tensile strength results are presented in the Table 2 and graphical representations are shown in Figure 4.

$$f_t = \frac{2P}{\pi DL} \tag{3.2}$$

Where f_t ~ splitting tensile strength in (N/mm2),
P ~ ultimate load in Newton, D ~ diameter in mm,
L ~ length in mm.

Figure 3 Test on cylindrical specimen

Table 2. Split tensile strength result

Split tensile strength in N/mm2				
Different mixes	**Cement replacement (in %)**	**Day 3**	**Day 7**	**Day 28**
Standard concrete	0%	4.18	6.20	8.14
Fly-ash concrete	5%	4.02	5.13	7.60
	10%	4.16	5.08	7.14
	15%	3.64	4.18	6.30
	20%	2.90	3.82	5.74
GGBS concrete	5%	4.06	5.14	7.42
	10%	4.36	4.92	7.04
	15%	3.76	4.16	6.08
	20%	3.18	3.94	5.36

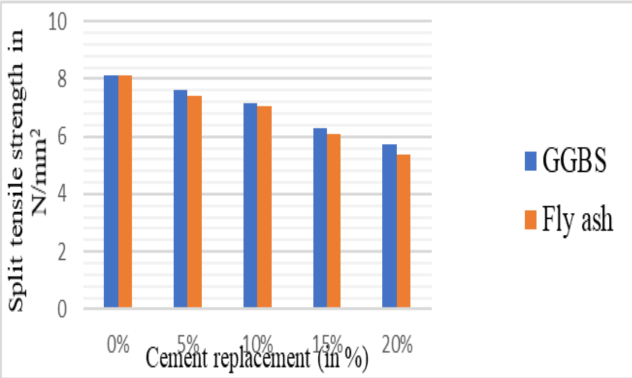

Figure 4 Graphical representation of split tensile strength

3.3 Flexural strength

This experimental was done on prism specimen as shown in Figure 5 of 100×100×500 mm in size. The test was done on the compressive testing machine as per the ASTM C78-84 [10]. From this test, the ability of the beam to resist without bending when load is applied was noted. For all specimens tested, the fracture took place within the middle one-third, and pure bending is applicable. The equation was used for finding (3.3) the flexural strength from ultimate load [11] are presented in Table.3 and the graphical representation on flexural strength tests are shown in Figure 6.

$$f_b = \frac{PL}{bd^2} \qquad (3.3)$$

Where f_b ~ flexural strength in N/mm2, P ~ ultimate load in N, L ~ supported length in mm, B ~ width in mm, D ~ depth in mm.

Figure 5 Test on prism specimen

Table 3. Flexural strength result

Flexural strength in N/mm^2				
Different mixes	**Cement replacement (in %)**	**Day 3**	**Day 7**	**Day 28**
Standard concrete	0%	2.19	3.30	5.48
Fly-ash concrete	5%	2.02	3.13	5.06
	10%	1.9	2.96	4.82
	15%	1.84	2.7	4.40
	20%	1.31	2.01	3.35
GGBS concrete	5%	2.3	3.4	5.71
	10%	2.2	3.3	5.43
	15%	2.1	3.1	4.63
	20%	1.8	2.6	3.40

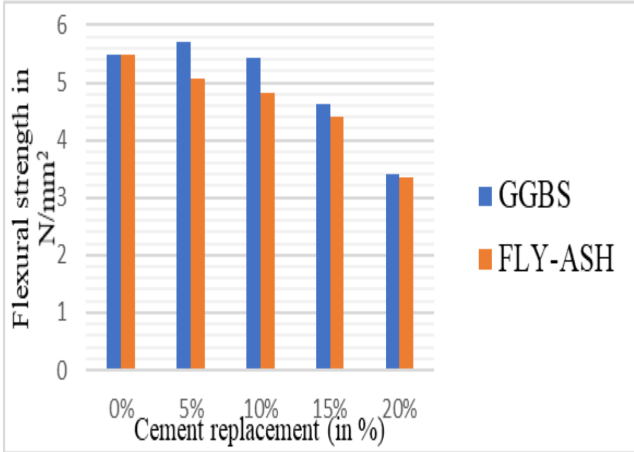

Figure 6 Graphical representation of Flexural strength test

3.4 Failure analysis of RCC beam

Failure analysis of RCC beam is done to find the behavior of the beam as shown in Figure 7. It shows the deflection on the beam failure after a maximum load applied by using the two-point load and the deflectometer was placed at bottom of the specimen to find the deflection [12]. The RCC beam size is 150×230×1500 mm, the results presented in Table 4 and its graphical representations are shown in Figure 8 and Figure 9.

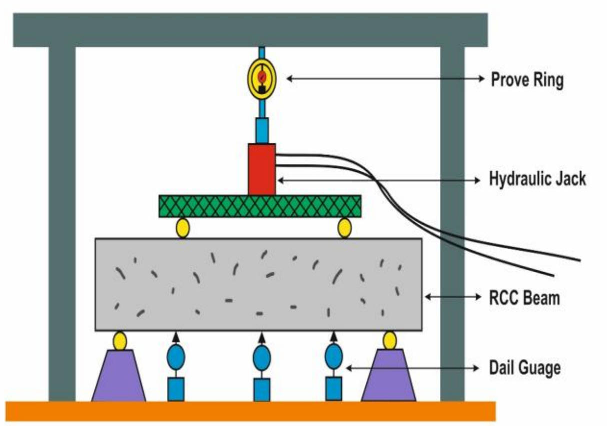

Figure 7 Loading schematic diagram of RCC beam

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Table 4 Deflection values on RCC beam

S.No	Mix type	Break Load (T)	Maximum deflection @ center in mm
1	Standard concrete	18.6	9.3
2	Fly ash 5%	17.82	8.46
	Fly ash 10%	16.50	7.60
	Fly ash 15%	16.85	7.42
	Fly ash 20%	16.43	7.3
3	GGBS 5%	17.68	8.38
	GGBS 10%	17.04	7.86
	GGBS 15%	16.52	6.7
	GGBS 20%	15.8	6.21

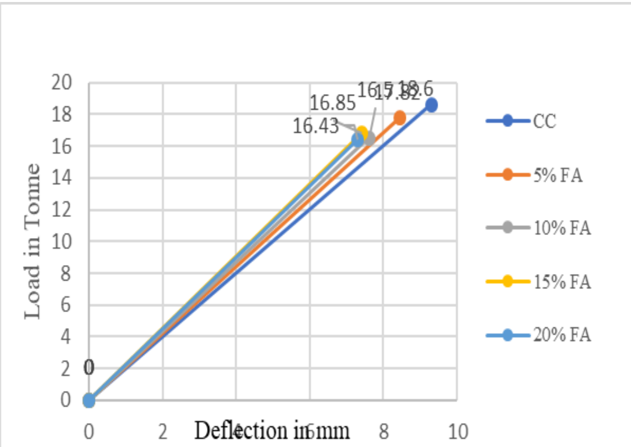

Figure 8 Graphical representation on Fly ash concrete

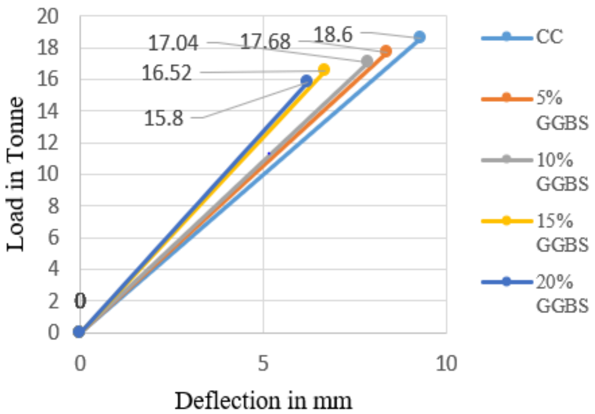

Figure 9 Graphical representation on GGBS concrete

IV. CONCLUSION

From this research work the following conclusions are given below.

1) This study proves the possible replacement for cement by Fly-ash is 15% and GGBS is 10%.
2) Cement were replaced as partially in the form of 5%,10%,15% and 20%.
3) It helps to reduce the consumption of cement and also to solve the environmental problems.
4) When replacing cement with these materials are the way to save the natural resources.

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