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Compressive Strength Studies on Concrete by Partial Replacement of Cement by Fly ash and Ground Granulated Blast Furnace Slag using Various Methods of Curing

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***Abstract*— Concrete is the most abundant material used in different fields of construction. Concrete is a composite mixture of cement, fine aggregates, coarse aggregates and water which is strong in compression. Cement is the binding material in concrete which bears lot of compressive load while combining with aggregates. But due to high expensive and considering pollution measures, the content of cement will going to be reduced by using an alternative materials called Fly Ash, Ground Granulated Blast Furnace Slag in various percentages of 0, 10, 20 and 30 by using various curing methods like Normal Water Curing, Warm Water Curing and Boiling Water Curing for M20 grade of concrete as per relevant codes. The tests were conducted and the results are satisfied according to limits specified in the codes.**

Keywords*— Fly ash, ground granulated blast furnace slag, normal water curing, warm water curing, boiling water curing and M20 grade of concrete.

I. INTRODUCTION

Concrete is the well utilized material in building industries and become as a daily need in entire society. It is a composite material consists of cement, fine aggregate, coarse aggregate and water. In concrete, cement acts as a binding material which is prepared by using lime stone, clay, gypsum etc. The materials used in the manufacturing process of cement are obtained from non-renewable sources. So many researches were going on to reduce the usage of cement due to its environmental effects and cost, found out the various alternative cementeceous materials, mineral admixtures like fly ash, silica fume, coal burnt brick ash, rice husk ash, ground granulated blast furnace slag etc., are helpful in later age concrete strength development. While replacing such type of materials in concrete they give some benefits like reduces cement usage, cost reduction, reduce solid waste management, increases physical properties, increases durability etc.

To regulate the usage of cement in concrete the supplementary cementeceous materials viz., Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBS) were used as partial replacement materials in various percentages of 0, 10, 20 and 30 in two different mixes.

II. LITERATURE SURVEY

Fly ash is a principle by-product evolved into the world during coal burning from thermal power plants is well accepted as a pozzolanic material used in blended Portland cements [1] and its disposal was becomes as a major environmental challenge [2]. Fly Ash (FA) has been adopted widely in the construction industry as a binder replacement due to its pozzolanic activity, low water demand, reduced bleeding, and less heat evolution [3].

Due to the rapid economic development and the growth in the world iron production, slag has significantly increased. Ground Granulated Blast Furnace Slag (GGBS) a waste product of steel industry, having cementitious properties was formed by rapid cooling of the liquid slag, produced during smelting of iron ore in the blast furnace. After grinding the hardened slag forms fine powder, increasing the specific area of the material, is of favor for its hydraulic activity [4-6]. Majority of this slag is still disposed in landfills. Therefore, slag should not only be disposed of to prevent environmental pollution, but should be treated as a valuable resource [7].

A proper use of admixtures offers certain beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and sulphate resistance, control of strength development, improved workability, and enhanced finish ability [8-10].

III. MATERIALS AND METHODOLOGY

The materials used for this study are Zuari cement of 43grade having fineness, specific gravity, consistency, initial and final setting time of 4.5%, 3.15, 33%, 30minutes and 8$\frac{1}{2}$hours respectively was used. Fine aggregates are collected

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from river having fineness modulus, specific gravity of 3.5 and 2.7 respectively were used. Coarse aggregates of size 20mm having fineness modulus, specific gravity of 7 and 2.9 respectively and bore water having pH of 6.9 was used. The results are found satisfactory and conforming to all relevant codes [11-20].

In the present study, to reduce water cement ratio in concrete super plasticizer of specific gravity of 1.1 was used [21]. The mix proportion value of M20 grade concrete was calculated by using IS code of 10262:2009 [22]. After that the weigh batching was used in measuring the materials, mixing was done by machine and the concrete was casted in the steel moulds of size 150mm x 150mm x 150mm and allow settling for 24hours and demoulded placed in a curing tank containing water conducting normal water curing (NWC) [23].

Again another curing technique called accelerated curing method of accelerated curing methods of warm water curing (WWC) for a period of not less than 19 hours 50 minutes at the temperature of 55± 1^0C and boiling water curing (BWC) for a period of $3\frac{1}{2}$ hours ± 5 minutes at the temperature of 100^0C were adopted were used was as per standard Indian code of IS 9013-1978 [24-27]. Then after the concrete specimens are tested and the compressive strength results are calculated by using the following formulae:

$$R_{28}= 12.65+R_a \text{ (for warm water curing)} \quad (1)$$

$$R_{28}= 6.09+1.64R_a \text{ (for boiling water curing)} \quad (2)$$

Where,

R_{28} is the accelerated curing compressive strength of concrete at 28days.

R_a is the accelerated curing compressive strength of concrete at 1day.

TABLE I. COMPRESSIVE STRENGTH RESULTS OF FA REPLACED HARDENED CONCRETE

S.No.	Method of Curing	Average Compressive Strength (N/mm^2)			
		0% Fly ash	*10% Fly ash*	*20%Fly ash*	*30% Fly ash*
1	NWC	28.44	31.33	30.96	25.11
2	WWC (R_a)	14.07	15.19	15.04	11.93
3	WWC	26.72	27.84	27.69	24.58
4	BWC (R_a)	15.56	16.30	15.85	13.04
5	BWC	31.60	32.82	32.08	27.47

TABLE II. COMPRESSIVE STRENGTH RESULTS OF GGBS REPLACED HARDENED CONCRETE

S.No.	Method of Curing	Average Compressive Strength (N/mm^2)			
		0% GGBS	*10% GGBS*	*20% GGBS*	*30% GGBS*
1	NWC	37.78	31.56	30.59	25.63
2	WWC (R_a)	18.22	17.11	12.44	8.81
3	WWC	30.87	29.76	25.09	21.46
4	BWC (R_a)	16.89	19.63	15.70	10.67
5	BWC	33.78	38.28	31.83	23.58

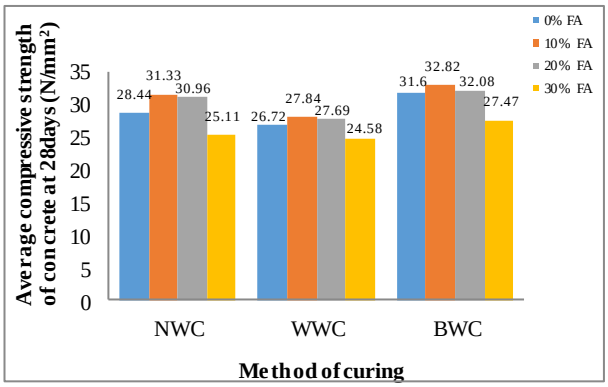

Fig. 1. Comparison of average compressive strength of concrete and Method of curing for FA replaced concrete

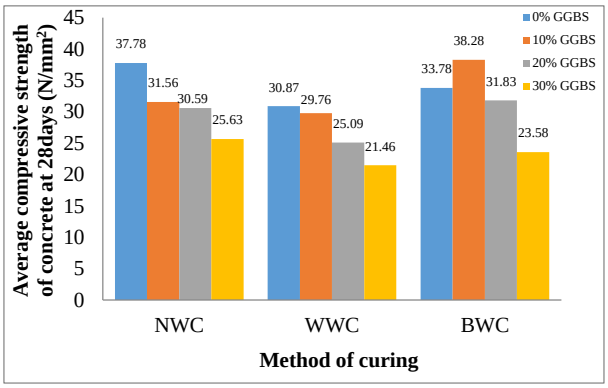

Fig. 2. Comparison of average compressive strength of concrete and Method of curing for FA replaced concrete

IV. RESULTS AND DISCUSSIONS

Strength values obtained from various methods of curing are presented in table 1 and 2. The compressive strength of FA concrete and GGBS concrete were optimum at 10% replacement and the remaining percentages was also given better values are more than the target mean strength of concrete. The values obtained by using BWC are more than the NWC and WWC which are presented in fig 1 and 2. This was due to the fact that in NWC and WWC, the rate of hydration process was very slow hence the rate of gaining strength was low but in the BWC, due to high temperature i.e.

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at 100^0C the hydration process in concrete was very high and hence strength of concrete was increases. The strength values of GGBS concrete are more than the FA concrete, this is because FA is pulverized fuel having porous structure.

V. CONCLUSIONS

Based upon the above mentioned results, the compressive strength GGBS concrete almost more than the FA concrete. This may be due to the fact that GGBS is having high strength when compared with FA. The cost of concrete was reduced by using partial replacement low cost mineral admixtures like FA and GGBS in cement.

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