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COMPRESSIVE STRENGTH CHARACTERISTICS OF CONCRETE PARTIALLY REPLACED BY FLY ASH & GGBS

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Abstract

Fly ash and Ground Granulated Burnt Slag (GGBS) are chosen mainly based on the criteria of cost and their durable qualities. Not only this, Environmental pollution can also be decreased to some extent because the emission of harmful gases like carbon monoxide & carbon dioxide are very limited. This paper presents a laboratory investigation on optimum level of Fly ash and Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement of cement to study the strength characteristics of concrete as compare to conventional concrete (CC) of M25 grade. Portland cement was partially replaced by 10%, 20% & 30% of GGBS i.e. (GC1, GC2, and GC3) and Fly ash by 10%, 20% & 30% as FC1, FC2 & FC3. It is observed that replacement of cement in any proportion lowers the compressive strength of concrete as well as delays its hardening. This provides an environmentally friendly method of fly ash and GGBS disposal.

Keywords: Fly ash, GGBS, Conventional Concrete, Compressive strength

I. INTRODUCTION

Now-a-days the most suitable and widely used construction material is concrete. This building material, until these days, went through lots of developments. One of the main constituents of concrete is Portland cement. With the increase in use of concrete, the manufacturing and consumption of cement has increased drastically. A various number of research have been conducted to examine the effects of use of Fly Ash as additive in cement, admixture in concrete and as replacement of cement in concrete. There are many factors involved in these failures, some of which are due to environmental conditions and others, which have arisen from human errors or lack of knowledge. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant. Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state.

Slag is a co-product of the iron making process. Iron cannot be prepared in the blast furnace without the production of its co-product i.e. blast furnace slag. In the country like India, where the development of the infrastructures projects such as large irrigation, road and building projects are either being constructed or in completion of their planning and design stage, such uses of waste material in cement concrete will not only reduce the emission of greenhouse gases but also will be the sustainable way of management of waste. In this paper a detailed review of literature is carried out in order to study the feasibility of GGBS with the cement in concrete. This is a review paper where the aspects of strength and durability of GGBS concrete & fly ash concrete is studied.

II. LITERATURE REVIEW

P. R. Wankhede [2014] :- In this paper investigation Effect of Fly Ash and Properties of Concrete the effect of fly ash. Ultimate compressive strength of concrete goes on decreasing with increase in w/c ratio of concrete. Slump loss of concrete goes on increasing with increase of quantity of fly ash. Concrete with 20% and 30% replacement of cement with fly ash shows good compressive strength for 28 days than normal concrete for 0.35 w/c ratio.

Swamy. et.al. (1983*)*: Extensive investigations have been carried out by Swamy et. al. (1983) on the properties in the fresh and hardened state of Fly ash concrete containing normal weight and light weight aggregate suitable for structural application. Fly ash up to 30 percent by weight of cement and that Fly ash concrete characteristic were in no way different from these of comparable normal concrete.

Venu Malagavelli et al. [1] studied on high performance concrete with GGBS and robo sand nd concluded that the percentage increase of compressive strength of concrete is 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBS and 25% of sand with ROBO sand.

Ganesh Babu and Sree Rama Kumar [6] **Wainwright** [7] studied on efficiency of GGBS in Concrete conducted Bleed tests in accordance withASTM C232-92 on concretes in which up to 85% of the cement was replaced with ground granulated blast furnace slag (GGBS) obtained from different sources. They observed that delaying the start of the bleed test from 30 to 120 min reduced the bleed capacity of the OPC mix by more than 55% compared with 32% for the slag mixes. The reduction in bleed rate was similar for all mixes at about 45%.

Tamilarasan et al. [7] studied on Chloride diffusion of concrete on using GGBS as a partial replacement material for cement and without and with Superplasticiser. The study results showed that, with the increase in percentage of GGBS, the Chloride diffusion of concrete decreases. Also it is found that the Chloride diffusion in the M25 concrete is less than M20 concrete.

Alvin Harrison [2014][2] work on effect of Fly Ash on Compressive Strength of Portland Pozzolona Cement Concrete. Compressive strength of of concrete 30% replacement by cement give the stimulated result as on the days of 28 days and 56 days concrete strength.

Prince Arul raj [2011][3] :-In this paper the workability and compressive strength of concrete with Nano fly Ash were determined and the results were compared with that of Normal Cement Concrete Specimen with Nano fly ash was found stronger than normal cement concrete and the average rate of increase of strength is 30% within range of 15-46 N/mm².

Pavia andCondren [9] studied the durability of OPC versus GGBS Concrete on Exposure to Silage Effluent. This research concluded that PC composites incorporating GGBS are more durable than those made with PC alone in aggressive environments under the action of acids and salts such as those produced by silage.

Rama Mohan Rao [2010][4] investigate the inclusion of fly ash in glass fiber reinforced concrete reduces the environmental pollution and improves the workability and durability properties of concrete. In the experimental investigation glass fibers in different volume fractions with 25% and 40% replacement of cement by fly ash has been used to study the effect on compressive strength, split tensile strength, flexural strength of concrete. The addition of fibers in the plain concrete will control the cracking due shrinkage and also reduce the bleeding of water.

III. MATERIALS & METHODS

Cement

Cement in general can be defined as a material which possesses very good adhesive and cohesive properties which make it possible to bond with other materials to form compact mass. Locally available Ordinary Portland cement of 53 grade of the ACC cement Branch conforming to ISI standard was used having specific gravity: 3.10 ,31.5% Consistency and compressive strength 53 MPa.

Fine & Coarse Aggregates

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand and crushed sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screened, to eliminate deleterious materials and over size particles. Locally available river sand, basalt stone chips were used for preparation of concrete. Machines crushed locally available hard basalt, well graded 20 mm and down size were used.

Fly ash

It is most commonly used as a pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous material, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. Particle size of fly ash varies from 1µm to 100µm in diameter with more than 50% under 20µm.

Granulated Blast Furnace Slag (GGBS)

If the molten slag is cooled and solidified by rapid water quenching to a glassy state, little or no crystallization occurs. This process results in the formation of sand size (or frit-like) fragments, usually with some friable clinker like material. When crushed or milled to very fine cement-sized particles, ground granulated blast furnace slag (GGBS) has cementitious properties, which make a suitable partial replacement for or additive to Portland cement.

Water

Drinking water was used for the preparation of concrete. The quality was uniform and the water samples were potable.

Fig. 1 Materials used in the study

Mix Proportion – After testing of material their specific gravity are 2.85 (for cement) , 2.71 (for coarse aggregate) & 2.62 (for fine aggregate) .The target strength for mix proportioning of M25 concrete calculated as (25 + 1.65 x 4) = 31.6 *N/mm2. The* maximum water-cement ratio adopted as per code 0.55. For 20 mm aggregate, 186 kg/m^3 of water content is used. The cement content is determined by ratio of W/c =0.45 which is 413 kg/m^3. The total volume of all aggregate is difference of absolute volume minus Volume of cement, water content i.e.

$$V_{ta} = [V_{abs}] - \left[\frac{C}{S_c} + \frac{W}{S_w}\right] = \left[1 - \frac{413}{2.85} - \frac{186}{1}\right] X \frac{1}{1000} = 0.669 \text{ Kg/m}^3$$

where, V_{ta} = Volume of all in aggregate

S_w & S_c = Specific Gravity of Water & cement

C & W = Masses of Cement & water in Kg/m^3

The quantity of ingredients in M25 mix-design are Cement = 413 Kg/m^3 , Water = 186 Kg/m^3 ,Fine aggregate = 666 Kg/m^3 , Coar se aggregate = 1124 Kg/m^3 . IS 10262:2009[1] Code is used for Mix Design. The final Mix proportion obtained for M25 grade concrete is 1: 1.61: 2.72 (W/c is 0.45).

Experimental Programme

This experimental program consists of the following steps:

- Collection of Materials
- Casting
- Curing
- Testing

Collection of materials - The constituent materials used in this investigation were procured from local sources. These materials are used after conducting different tests. The materials used are Cement, Fly ash, GGBS, Fine aggregate, Coarse aggregate, Water.

Casting

Initially the constituent materials were weighed and dry mixing was carried out for cement, sand and coarse aggregate and admixtures. This was thoroughly mixed manually to get uniform colour of mix. The mixing duration was 2-5 minutes and then the water was added as per the mix proportion. The mixing was carried out for 3-5 minutes duration. Then the mix poured in to the cube moulds of size 150 x 150x 150 mm and then compacted manually using tamping rods.

Curing

The cubes are demolded after 1 day of casting and then kept in respective solutions for curing at room temperature with a relative humidity of 85% the cubes are taken out from curing after 7days, 28 days for testing. Curing is a procedure that is adopted to promote the hardening of concrete under conditions of humidity and temperature which are conducive to the progressive and proper setting of the constituent cement. Curing has a major influence on the properties of hardened concrete such as durability, strength, water-tightness, wear resistance, volume stability, and resistance to freezing and thawing. Concrete that has been specified, batched, mixed, placed, and finished can still be a failure if improperly or inadequately cured. Curing is usually the last step in a concrete project and, unfortunately, is often neglected even by professionals.

Testing

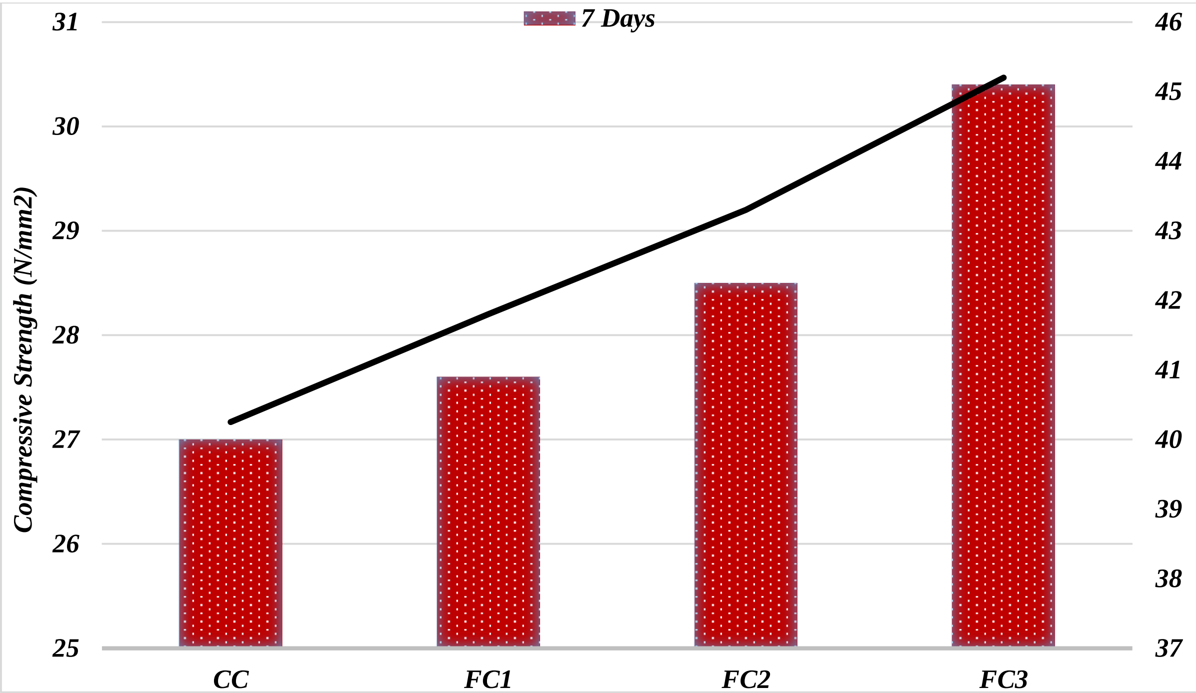
Cubes are tested after completion of curing and for 7days these are tested by UTM with rate of loading 14mpa/min and for 7days, 28 days and 60 days these are tested by CTM with a rate of loading of 14mpa/min

IV. RESULTS & DISCUSSIONS

The following assumption and requirement of ingredients of concrete calculated by trial were further tested for compressive test for each partial replacement cases as given below-

Table No-1 Comparison between Fly Ash Concrete and Conventional Concrete

Trials Cases	% of Fly Ash	Compressive Strength (N/mm²)	
		7 Days	28 Days
CC	0%	27	40.25
FC1	10%	27.6	41.8
FC2	20%	28.5	43.3
FC3	30%	30.4	45.2

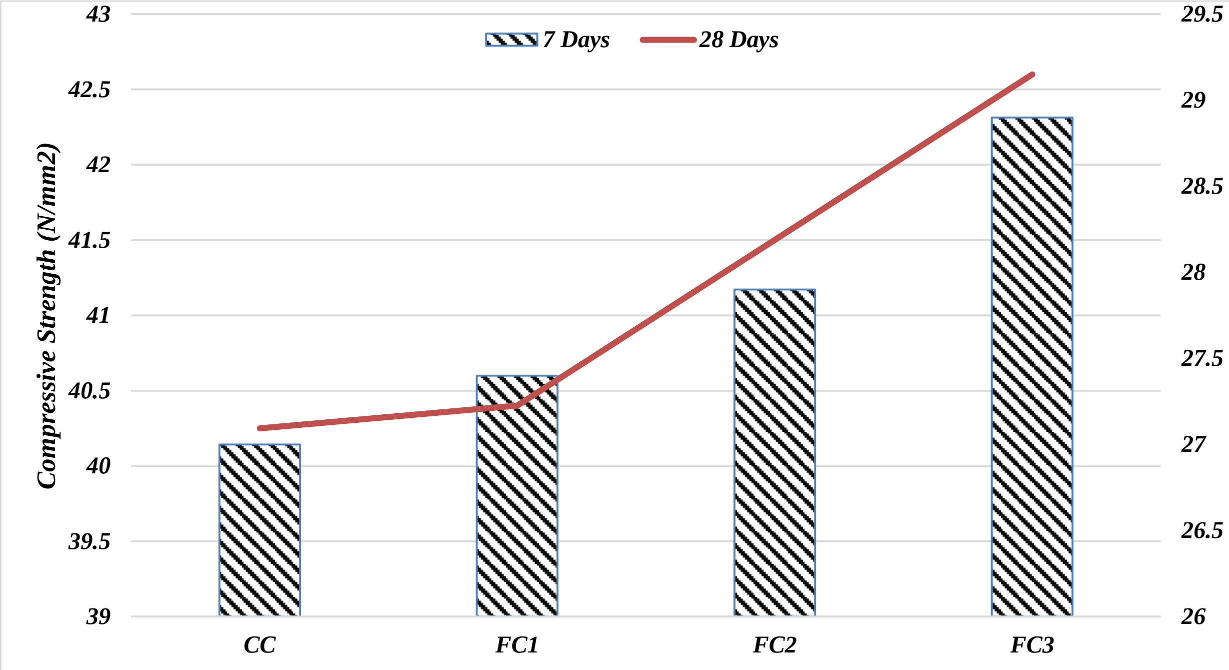


Graph 1 Comparison between Fly Ash Concrete and Conventional Concrete

The following table below exhibit values of compressive strength for 7 & 28 days of GGBS concrete

Table No-2 Comparison between GGBS Concrete and Conventional Concrete

Trial Cases	% Of GGBS	Compressive Strength (N/mm²)	
		7 Days	28 Days
CC	0%	27	40.25
GC1	10%	27.4	40.4
GC2	20%	27.9	41.5
GC3	30%	28.9	42.6



Graph 1 Comparison between GGBS Concrete and Conventional concrete

V. CONCLUSION

From the experimental work carried out and the analysis of the results following conclusions seem to be valid with respect to the utilization of Fly Ash and GGBS are as -

- The compressive strength of fly ash concrete is more than ggbs concrete and conventional concrete in both 7 & 28 days.
- Partial replacement of cement by GGBS and fly ash increases, the compressive strength also increases in both durations.
- FC1, FC2 & FC3 shows better compressive strength than conventional concrete (CC) in 28 days. In other case, GC1, GC2, GC3 exhibit more strength (compression) than CC in both 7 and 28 days.
- Flyash based concrete (FC3) shows strength of 45.2 MPa which is 6% greater than GC3 & 12 % more than conventional concrete.

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