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Study on Partial Replacement of Cement by Ground Granulated Blast Furnace Slag (GGBS) and Sand by Garbage ASH

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Abstract:
The utilization of supplementary cementitious materials is well accepted because of the several improvements possible in the concrete composites and due to the overall economy. The waste material from the industries has been continuously emphasized in the project work. The present work is to use GGBS (Ground granulated Blast furnace slag) and garbage ash as combined replacement for ordinary Portland cement and river sand respectively An experimental study has been performed to evaluate compressive strength, split tensile strength and flexural strength of hardened concrete by partially replacing the cement by 40% of GGBS and various percentages of garbage ash (0%,10%, 20% & 30%) for M_{30} concrete. Compressive strength, tensile strength and flexural strength are compared with those of concrete prepared with OPC. The test results indicate that it is possible to produce concrete replacing cement partially with GGBS and GARBAGE ASH

Keywords: Cement, concrete, GGBS, GARBAGE ASH, Compressive Strength, Split tensile strength. Flexural strength.

I. INTRODUCTION:

Concrete is an artificial material in which the aggregates i.e. both fine and coarse are bonded together by cement, when mixed with water. Concrete can also be considered as a material which consists of a binding material within which there are embedded fragments of aggregates. The demand on concrete is likely to increase in future to match the requirement resulting from growing population, housing, transportation and other amenities. At present, there is scarcity of conventional fine and coarse aggregates required for concrete making due to continuous demand on concrete for construction. For reducing the cost of concrete and also to meet the demand, locally available waste materials, such as, ground granulated blast furnance slag, fly ash, silica fume, rice husk, saw dust, rock flour and ceramic scrap replacing cement or aggregate can be used [1].

Among many alternatives, Ground granulated blast furnace slag is the industrial by-product which provide excellent binding properties to concrete and serve as a replacement of cement[2]. In India, the production is about 7.8 million tonnes of GGBS as a by-product obtained in the manufacture of pig iron in the blast furnace.

Blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. The recycling of these slags will become an important measure for the environmental protection. Iron and steel are basic materials that underpin mo3dern civilization, and due to many years of research the slag that is generated as a by-product in iron and steel production is now used as a material in its own right in various sectors [3].

Ground granulated blast furnace slag from modern thermal power plants generally does not require processing prior to being incorporated into concrete and is therefore considered to be an environmentally free input material.

When used in concrete, ground granulated blast furnace slag is a cementations ‘material that can act as a partial substitution for Portland cement without significantly compromising the compressive strength [4].

It was found that compressive strength of concrete increased as amount of GGBS increased and after an optimum percentage of 55% of GGBS, there was a decrease in compressive strength upon further addition of the slag.

The shrinkage of GGBS and that of normal concrete was found to be similar (Cervantes & Roesler, 2007) [5]. In this investigation halfway substitution of OPC (53-review) by GGBS by 40% by add up to weight of OPC and Fine aggregates up to 30% by Garbage fiery debris.

This examination explores the execution of solid blend as far as compressive quality of cube, flexural strength of beam and split tensile strength of cylinder for 7 days,14 days and 28 days individually

Scope of this project:
There is wide Scope of investigation of w9ork to be carried out for study incorporation of GGBS and Garbage ash cement (multiblended) concrete in plain concrete and reinforced concrete and their performance in normal as well as aggressive environment. It seems GGBS concrete improves the workability and strength and it improves the level of micro cracking in the transition zone and thus improves durability of concrete. The has to be studied by measuring flexure strength, tensile strength and flexural strength.

Materials and testing report:

Table.1. Properties Test

S.No	Properties	Result
1.	Consistency of cement	30%
2.	Initial setting time	138 minutes
3.	final setting time	417 minutes
4.	Sieve analysis for M sand	Zone 1 type of aggregate
5.	Sieve analysis for coarse aggregate	2.9201%
6.	Specific gravity of M Sand	2.71
7.	Specific gravity of Garbage ash	2.37
8.	Specific gravity of coarse aggregate	2.74
9.	Specific gravity of GGBS	2.85
10.	Aggregate crushing strength	7.63

GROUND GRANULATED BLAST FURANCE SLAG:

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in India, Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years.

Figure.1. GGBS

GARBAGE ASH:

Garbage Ash is a form of ash produced in incineration facilities. This material is discharged from the moving grate of municipal solid waste incinerators. Following combustion the ash typically has a small amount of ferrous metals contained within it. This ash can be processed to standardize the material and remove. contaminants in order for it to end as an aggregate.

Figure.2. Garbage Ash

MIX PROPORTIONING:

Table.2. conventional mix proportion

Cementitious material(cement+GGBS)	Fine aggregate (M.sand)	Coarse aggregate (20 mm down)	water	Super Plasticizer
385 kg/m^3	886kg/m^3	1114 kg/m^3	140 kg/m^3	7.7 kg/m^3
1	2.24	2.89	0.36	1.8%

Mix D: - 0% ASH + 40% GGBS

Mix D1: - 10% ASH + 40% GGBS
Mix D2: - 20% ASH + 40% GGBS
Mix D3: - 30% ASH + 40% GGBS

II. RESULTS AND DISCUSSION:

COMPRESSIVE STRENGTH OF CUBE:

The strength of concrete increases with age. Table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting..

Table.3. Compressive Strength of Cube

S.NO	Replacement details	COMPRESSIVE STRENGTH OF CUBE (N/mm^2)		
		7 DAYS	14 DAYS	28 DAYS
1	Mix D: - 0% ASH + 40% GGBS	20.4	26.5	31.9
2	Mix D1: -10% ASH+ 40% GGBS	21.3	28.4	33.3
3	Mix D2:-20% ASH + 40% GGBS	22.5	29.3	34.5
4	Mix D3: - 30% ASH + 40% GGBS	18.9	25.1	29.0

The Mix D1 clearly shows concrete attain strength by 7, 14 and 28 days strength with respect to the consecutive concrete. The remaining concrete D2 and D3 are also attain the required strength of concrete but D3 fails to acquire a very small amount of strength in 28 days

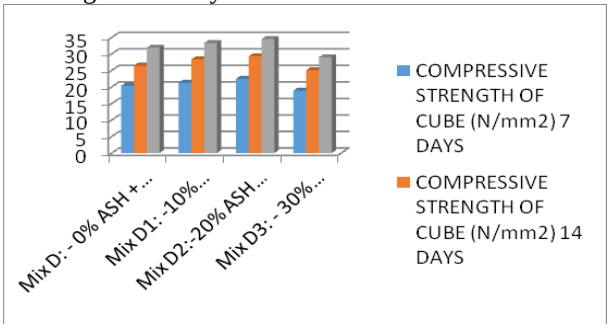

Figure.4. Compressive strength of Cube

The above graph show that compressive strength of cube of 7, 14 and 28 days of strength with respect to the0% 10 %, 20% and 30%of garbage mix proportion

SPLIT TENSILE STRENGTH OF CYLINDER:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

$$ft = \frac{2P}{\pi LD}$$

where P=compressive load at failures
L=Length of cylinder

D=Diameter of cylinder

Table.4. Split tensile test

S.NO	Replacement details	SPLIT TENSILE STRENGTH OF CYLINDER(N/mm^2)		
		7 DAYS	14 DAYS	28 DAYS
1	MixD:- 0% ASH + 40% GGBS	2.13	2.61	2.99
2	MixD1:-10%ASH+40%GGBS	2.26	2.82	3.23
3	MixD2:-20%ASH+40%GGBS	2.42	3.13	3.37333
4	MixD3:-30%ASH+40%GGBS	2.08	2.45	2.83

The table 8 represent the split tensile strength of the cylinder of standard size and acquire required strength of cylinder in 0%,10%, 20 %and 30% of mix garbage ash with 40% GGBS

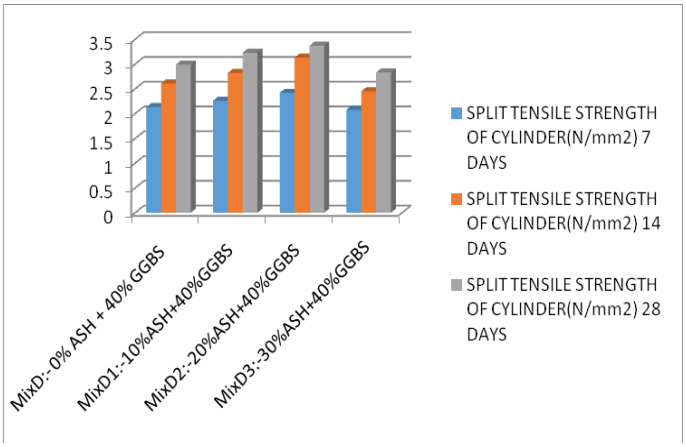

Figure. 5. Split Tensile Strength of Cylinder

The above graph show that compressive strength of cube of 7, 14 and 28 days of strength with respect to the0%, 10 %, 20% and 30% of garbage mix proportion.

FLEXURAL STRENGTH

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield.

$$\sigma = \frac{FL}{bd2}$$

Where *F* is the load (force) at the fracture point
L is the length of the support (outer) span
b is width
d is thickness

Table.5. Flexural Strength of beam

S.NO	Replacement details	Flexural strength of beam(N/mm^2)		
		7 DAYS	14 DAYS	28 DAYS
1	MixD:- 0% ASH + 40% GGBS	3.24	3.68	3.97
2	MixD1:-10% ASH+ 40% GGBS	3.51	3.76	4.23
3	MixD2:-20%ASH + 40% GGBS	3.63	3.91	4.37
4	Mix D3:-30%ASH+ 40% GGBS	3.15	3.59	3.85

The table 5 represent the flexural strength of the beam of standard size and acquire required strength of beam in 0%,10%, 20 %and 30% of mix garbage ash with 40% GGBS

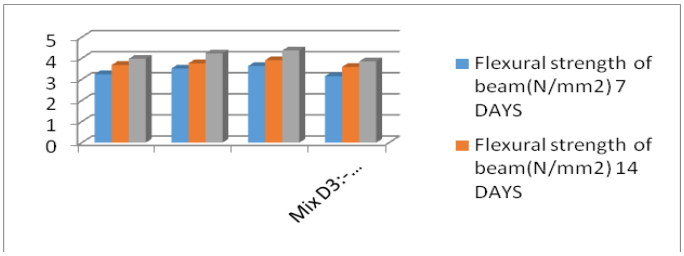

Figure.6. Flexural Strength of beam

The above graph show that compressive strength of cube of 7, 14 and 28 days of strength with respect to the 0%,10 %, 20% and 30% of garbage mix proportion

III. CONCLUSION

Based on the experimental investigation the following conclusions are, It is observed that GGBS 40% + garbage ash based concrete have achieved an increase in strength for 10% & 20% replacement of cement at the age of 7 , 14 and 28 days. 2) The replacement of cement by GGBS not only increases the compressive strength but also reduces the cement content which decrease in emission of CO2. The most optimized mix of GGBS 40% +garbage ash based concrete is found to be 10% & 20% from both compressive and split tensile strength of concrete. However, beyond 40% of replacement, the strength decreases. As far as cost is concerned, the cost of GGBS in the market including packaging and transporting is three times less than that of OPC. Therefore, the partial replacement of OPC in concrete by GGBS & garbage ash, is not only economical but also facilitates environmental friendly disposal of the waste slag into a useful product, which is generated in huge quantities from the iron and steel industries.

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