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Use of Waste Glass Powder as Partial Replacement of Cement in Concrete

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Abstract- Concrete has occupied an important place in construction industry in the past few decades and it is used widely in all types of construction ranging from small buildings to large infrastructural dams or reservoirs. Cement is major ingredient of concrete. The cost of cement is increasing day by day due to its limited availability and large demand. At the same time the global warming is increasing day by day. In the present study an attempt been made on concrete and also an experimental investigation on the concrete using by replacing cement with FLYASH and GROUND GRANULATED BLASTFURNACE SLAG(GGFBS) to decrease the usage of cement as well as emission of concrete. Experimental studies were performed on plain cement concrete and replacement of cement with Fly ash is done. The main properties of flyash are fineness, specific gravity, chemical composition, carbon content etc. the fineness of flyash is important because it effects the workability of the concrete. Specific gravity does not directly effect concrete quality, it has value in identifying changes in other flyash characteristics. The variability of the chemical composition is checked regularly as a quality control measure. GGBS is a byproduct of the manufacturing of iron in the blast furnace can partially replace cement in concrete. GGBS hardens very slowly so it is generally used along with OPC in concrete. A typical combination of GGBS(70,80,90%) and fly ash is used in 10, 20 and 30%.

Keywords: Concrete, Cement, Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), Supplementary Cementitious Materials (SCMs), Sustainable Construction.

I. INTRODUCTION

General

The versatility and the application of concrete in the construction industry need not be emphasized.
Research on normal and high strength concrete has been on the agenda for more than two decades. As per IS: 456–2000[Code of Practice for Plain and Reinforced Concrete], concretes ranging 25 – 55 MPa are called standard concretes while those above 55 MPa can be termed as high strength concrete. Concretes above 120/150 MPa are called ultra high strength concrete.

High strength concrete has numerous applications worldwide in tall buildings, bridges with long span and buildings in aggressive environments. Building elements made of high strength concrete are usually densely reinforced. This congestion of reinforcement leads to serious problems while concreting. Densely reinforced concrete problems can be solved by using concrete that can be easily placed and spread in between the congested reinforced concrete elements. A highly homogeneous, well spread and dense concrete can be ensured using such a type of concrete.

SCOPE AND OBJECTIVES

Scope Ofwork:

In this project our main aim is to determine the,

1. Compressive Strength of self-compacting concrete.
2. Split Tensile Strength of self-compacting concrete.

By varying the curing duration and Molarities of Alkaline liquid changed the strength. This present work consists of fly ash, alkaline liquids. Alkaline liquid to the fly ash ratio is 0.45 and also replacing cement by 100% of fly ash. The present work aims of determining the Compressive Strength, Split Tensile Strength, and flexural strength of geopolymer concrete at 24hrs, 48hrs and 96hrs by hot air oven curing at temperature 60 º c.

II. EXPERIMENTAL PROGRAM

General:

The experimental program was designedto investigate the strength of slef compacting concrete containing fly ash with ggbfs and complete replacement of water with sodiumsilicate(water glass).In this program trials were ma・de at varying replacement value levels(10%,20%,30%) of fly ash and ggbfs of (70%,80%,90%). The fresh properties of SCC such as filling ability passing ability and segregation resistance are evaluated using workability tests such as slump flow (flow table),V-funnel , and L-Box tests. For M20 grade concrete ,the mechanical properties of SSC such as compressive strength and split tensile strength at 24hrs,48hrs, 96hrs of curing at an ambient room temperature.

Materials used:

GGBS(Ground granulated blast furnace slag) and fly ash Fine aggregate
Coarse aggregate
Sodium silicate (water glass)

Mix Design

Example A:

For 1 m3 of concrete. The ratio of solution /binder was taken as 0.65.
Binder was taken as 850 kg/m3
The ratio of solution /binder was taken as 0.65.
The activator solution was calculated by multiplying The solution/binder ratio by the binder content, i.e., 0.65 × 850 = 552.5 kg/m3. Unit weight of concrete is 25 kN/m3 or 2500 kg/m3.
Total aggregate = 2500 − 850–552.5=1097.5 kg.
The ratio of Fine aggregate/Coarse aggregate = 50:50. Coarse aggregate =1097.5 × 0.50 = 548.75 kg. Fine aggregate = 1097.5 × 0.50 = 548.75 kg. Binder content =850 kg/m3,
Fine aggregate = 548.75 kg, Coarse aggregate = 548.75kg, Solution = 340 kg/m3.
Therefore,
Binder: Fine Aggregate: Coarse Aggregate:Solution
=>850:548.75:548.75:340
=>1: 0.64: 0.64 : 0.4

For one mix, the total binder weight for 9 cubes =Density of concrete × cube size × No.of cubes × Factor of safety
Sum of the ratio of each material
Hence,
Total material for one mix, Binder = 10.07 kg/m3, Fine Aggregate = 6.4 kg, Coarse Aggregate =6.4 kg, Activator solution = 4.02 kg/m3.

Mixproportions:

Ggbs:Flyash	Coarse Aggregate	Fine Aggregate	Ggbs	Flyash	Activator Solution
40:60	6.4	6.4	4.028	6.042	4.02
30:70	6.4	6.4	3.021	7.049	4.02
20:80	6.4	6.4	2.014 38	8.056	4.02

Example B:

For 1 m3 of concrete. The ratio of solution /binder was taken as 0.6.

Binder was taken as 850 kg/m3
The ratio of solution /binder was taken as 0.6.
The activator solution was calculated by multiplying The solution/binder ratio by the binder content, i.e., 0.6 × 850 = 510kg/m3. Unit weight of concrete is 25 kN/m3 or 2500 kg/m3.
Total aggregate = 2500 − 850–510=1140 kg.
The ratio of Fine aggregate/Coarse aggregate = 50:50. Coarse aggregate =1140 × 0.50 = 570 kg.
Fine aggregate = 1140 × 0.50 = 570 kg. Binder content = 850 kg/m3,
Fine aggregate = 570 kg, Coarse aggregate = 570kg, Solution = 340 kg/m3.
Therefore,
Binder: Fine Aggregate: Coarse Aggregate:Solution
=>850:570:570:340
=>1: 0.67: 0.67 : 0.4

For one mix, the total binder weight for 9 cubes =Density of concrete × cube size × No.of cubes × Factor of safety
Sum of the ratio of each material
Hence,
Total material for one mix, Binder = 9.85 kg/m3,
Fine Aggregate = 6.59 kg, Coarse Aggregate =6.59 kg, Activator solution = 3.94 kg/m3.

Mixproportions:

Ggbs:Flyash	Coarse Aggregate	Fine Aggregate	Ggbs	Flyash	Activator Solution
40:60	6.59 Kg	6.59 Kg	3.941 Kg	5.91 Kg	3.94 Kg/M^3.
30:70	6.59 Kg	6.59 Kg	2.955 Kg	6.895 Kg	3.94 Kg/M^3.
20:80	6.59 Kg	6.59 Kg	1.952 Kg	7.88 Kg	3.94 Kg/M^3.

Example C:

For 1 m3 of concrete. The ratio of solution /binder was taken as 0.55.
Binder was taken as 850 kg/m3
The ratio of solution /binder was taken as 0.55.
The activator solution was calculated by multiplying The solution/binder ratio by the binder content, i.e., 0.55 × 850 = 467.5kg/m3. Unit weight of concrete is 25 kN/m3 or 2500 kg/m3.
Total aggregate = 2500 − 850–467.5 =1182.5 kg.
The ratio of Fine aggregate/Coarse aggregate = 50:50. Coarse aggregate =1182.5 × 0.50 = 591.25 kg. Fine aggregate = 1182.5 × 0.50 = 591.25 kg. Binder content = 850 kg/m3,
Fine aggregate = 591.25 kg, Coarse aggregate =591.25kg, Solution = 340 kg/m3.
Therefore,
Binder: Fine Aggregate: Coarse Aggregate:Solution
=>850:591.25:591.25:340
=>1: 0.69: 0.69 : 0.4

For one mix, the total binder weight for 9 cubes =Density of concrete × cube size × No.of cubes × Factor of safety
Sum of the ratio of each material
Hence,
Total material for one mix, Binder = 9.71 kg/m3, Fine Aggregate = 6.701 kg Coarse Aggregate =6.701 kg, Activator solution = 3.884 kg/m3.

MIXPROPORTIONS:

GGBS:FLYASH	COARSE AGGREGATE	FINE AGGREGATE	GGBS	FLYASH	ACTIVATOR SOLUTION
40:60	6.701 kg	6.701 kg	3.884 kg	5.826 kg	3.884 kg/m^3
30:70	6.701 kg	6.701 kg	2.913 kg	6.797 kg	3.884 kg/m^3
20:80	6.701 kg	6.701 kg	1.942 kg	7.768 kg	3.884 kg/m^3

III. CASTING AND CURING PROCEDURE

General:

In this chapter, we discuss about, how the casting and curing of the specimens is done.

- Batching
- Mixing
- Casting
- Curing

Batching:

Batching means measuring the quantities of constituents of concrete required for the preparation of concrete mix. Weight batch method is adopted to measure the quantities. The quantities of fine aggregate, coarse aggregate, fly ash, GGBFS,sodium silicate (geo activator) for each batch were measured by a weighing balance according to the mix proportions.

Mixing:
The objective of aggregate particles with paste is to blend all the ingredients to have uniform mass. Though mixing of the materials is essential for the production of uniform mortar. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. In this study the process of hand mixing and mechanical mix as shown in figure as

Fig.7 Dry and Wet Mixing of Concrete

Casting:

Fig.8 Casting of specimen

The moulds were kept ready before preparing the mix. Moulds were cleaned and oiled on all corners and sides and placed on a uniform surface. Concrete mix was placed in moulds and compacted. When compacting by hand, the standard tamping rod was used and the strokes of the rod were distributed in a uniform manner over the cross section of the mould.

Curing:
The testing specimens after casting leave them in dry place for 7days and28days from the time of addition of chemical to the dry ingredients. After this period, the specimens were de-moulded from the moulds, cut of the extra surfaces and it is cured in the ambient room temperature.

5 Size of test specimen used
The Self Compacting Concrete mixes, after having checked for the satisfaction of the fresh properties of self compacting specifications as per EFNARC [2002] was cast into cube moulds of size 150 mm x 150 mm x 150 mm, and cylindrical moulds of 300 mm height x 150mm diameter. The moulds were fabricated with steel sheets. It is easy for assembling and removing the mould specimen without damage. Moulds were provided with base plates, having smooth surface to support. The mould is filled without leakage. Care was taken to ensure that there were no leakages.

Table: DETAILS OF SPECIMENS TO BE CASTED FOR 7 DAYS

S.NO	GGBS:FLYASH	CUBES				CYLINDERS			
		0.5	0.55	0.6	0.65	0.5	0.55	0.6	0.65
1	40:60	3	3	3	3	3	3	3	3
2	30:70	3	3	3	3	3	3	3	3
3	20:80	3	3	3	3	3	3	3	3
TOTAL		9	9	9	9	9	9	9	9

Total number of cubes = 36
Total number of cylinders =36

Table : DETAILS OF SPECIMENS TO BE CASTED FOR 28 DAYS

S.NO	GGBS:FLYASH	CUBES				CYLINDERS			
		0.5	0.55	0.6	0.65	0.5	0.55	0.6	0.65
1	40:60	3	3	3	3	3	3	3	3
2	30:70	3	3	3	3	3	3	3	3
3	20:80	3	3	3	3	3	3	3	3
TOTAL		9	9	9	9	9	9	9	9

Total number of cubes = 36
Total number of cylinders = 36

IV. TESTS CONDUCTED

Compressive Strength Test:
Compression test is the most common test conducted on hardened concrete, because it is an easy test to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. Sometimes prism is also used.

Compressive strength = Load in N / Area in mm2

Compression Testing Machine

The cube specimens of size 150mmx150mmx150mm were tested on compression testing machine of 2000kN. The bearing surfaces of the machine were cleaned and any loose sand or other material removed from the surfaces of the specimen. The axisof the specimen was carefully aligned at the center of the loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increase the load breaks down and no longer can be sustained. The maximum load applied on the specimen was recorded. The cube specimen under compressive test is shown in figure.

Split Tensile Strength
A concrete cylinder of size 150mm dia×300mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.
Horizontal tensile stress=2P/πDL
Where P=the compressive load on the cylinder.

L=length of the cylinder D=dia of cylinder

Compression Testing Machine

V. RESULTS AND DISCUSSIONS

In chapter – 4, a detailed experimental investigation covering the various fresh properties such as Mechanical properties such as compressive strength and split tensile strength have been studied. The present chapter highlights the results obtained from the above experimental investigation.

In this study, fresh and hardened properties of self-compacting concrete were investigated by using waste materials (class F fly ash) at seven replacement rates for cement. The investigations were carried out according to appropriate criteria given by European standards. In the present study, such properties of self-compacting concrete produced with fly ash were investigated based on fresh concrete tests, specifically workability and strength tests.

HARDENED PROPERTIES:

The hardened properties of self-compacting concrete for M20grade of concrete is evaluated by

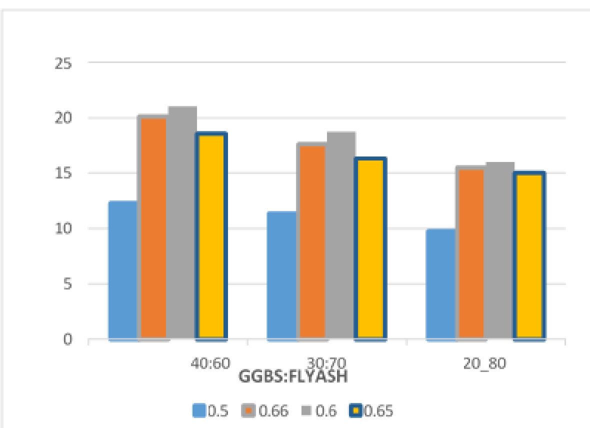
1. Compressive strength
2. Split tensile strength

1. Compressive Strength

The compressive strength of SCC has been measured by compression test as per IS: 5161959. The following shows the compressive strength for plain concrete and concrete mixed with flyash from 0 to 30%. The compressive strength increases as Dcrease in flyash percentage i.e., up to 30%. The fig shows the graphical representation of compressive strength of selfcompacting concrete for 48 hrs and 96 hrsof curing period. The test results gives better strength at 10% replacement of flyash, when compared to other ratios.

Table :COMPRESSIVESTRENGTH OBSERVED IN THE CUBES FOR 7 DAYS IN MPa

S.NO	GGBS:FLYASH	CUBES			
		0.5	0.55	0.6	0.65
1	40:60	12.31	20.11	21.02	18.55
2	30:70	11.34	17.61	18.73	16.34
3	20:80	9.73	14.33	15.71	15.25



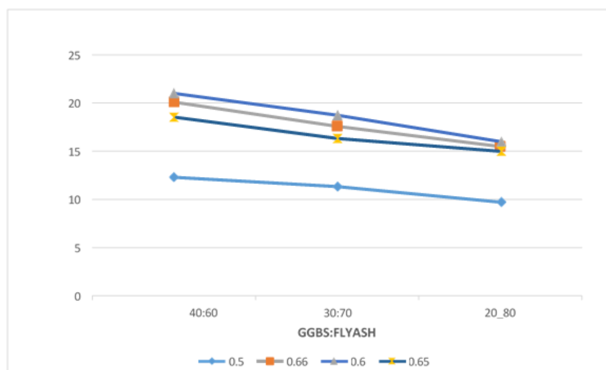
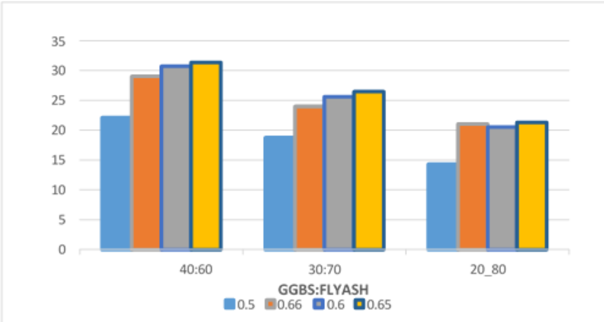
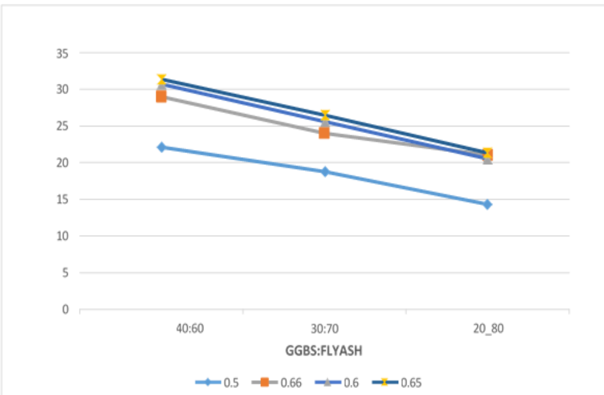


Table: COMPRESSIVESTRENGTH OBSERVED IN THE CUBES FOR 28 DAYS IN MPa

S.NO	GGBS:FLYASH	CUBES			
		0.5	0.55	0.6	0.65
1	40:60	22.12	30.73	29.37	31.37
2	30:70	18.78	25.14	25.61	26.12
3	20:80	14.31	21.04	20.53	21.33

COMPRESSIVESTRENGTH OBSERVED IN THE CUBES FOR 28 DAYS IN MPa





Split Tensile Strength:

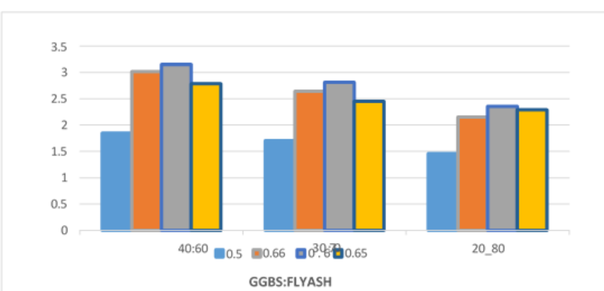
The split tensile strength of SCC has been measured by compression test as per IS: 5161959. The following shows the split tensile strength for concrete mixed with flyash from 10% to 30%. The split tensile strength decreases as increase in flyash percentage i.e., up to 10%.

The fig shows the graphical representation of compressive strength of self compacting concrete for 48 hrs and 96 hrs curing period of ambient room temperature. The test results gives better strength at 10% replacement of flyash, when compared to other ratios.

Table :SPLIT TENSILE STRENGTH OBSERVED IN CYLINDER FOR 7 DAYS IN MPa

S.NO	GGBS:FLYASH	CYLINDERS			
		0.5	0.55	0.6	0.65
1	40:60	1.8465	3.0165	3.153	2.7825
2	30:70	1.701	2.6415	2.8095	2.451
3	20:80	1.4595	2.1495	2.3565	2.2875

SPLIT TENSILE STRENGTH OBSERVED IN CYLINDER FOR 7 DAYS IN MPa



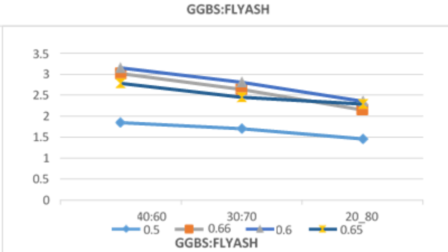
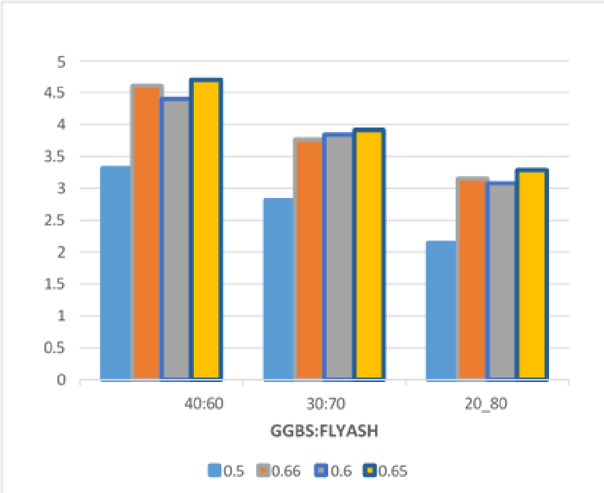


Table: SPLIT TENSILE STRENGTH OBSERVED IN CYLINDER FOR 28 DAYS IN MPa

S.NO	GGBS:FLYASH	CYLINDERS			
		0.5	0.55	0.6	0.65
1	40:60	3.318	4.6095	4.4055	4.7055
2	30:70	2.817	3.771	3.8415	3.918
3	20:80	2.1465	3.156	3.0795	3.1995

SPLIT TENSILE STRENGTH OBSERVED IN CYLINDER FOR 28 DAYS IN MPa



OBSERVATION:

- It is observed that with increase in content of GGBS there is increase in strength
- It is clearly noted that increasing the liquid to binder ratio increases the strength; but the liquid should be minimal in order to get less cracks and be economical
- VMA is more useful for lesser liquid to binder ratio samples so as to increase the flow ability
- Due to addition of water flowability increases but strength decrease so in order to replace the water superplasticizer has been used to increase the strength of concrete

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