Experimental Study on High Performance Concrete with Partial Replacement of Cement by using Silica Fume, Fly Ash and GGBs

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Abstract— The Now a days, we need to look at a way to reduce the cost of building materials, particularly cement is currently so high that only rich people and governments can afford meaningful construction. This study investigated the strength properties of Silica fume, fly ash, GGBS. This work primarily deals with the strength characteristics such as compressive, Split tensile and flexural strength. The High performance concrete M40 Mix design a set of 7 different concrete mixture were cast and tested with different cement replacement levels (0%, 2.5%, 5%, 7.5%, 10% 12.5% and15%) of Fly ash (FA) with silica fume (SF) as addition (0%,5%,10 % ,15%,25and 30%) by wt of Cement and/or each trial super plasticizer has been added at constant values to achieve a constant range of slump for desired work ability with a constant water-binder (w/b) ratio of 0.30.Specimens were produced and cured in a curing tank for 3, 7, 14 and 28 days. The cubes were subjected to compressive strength tests, split tensile test after density determination at 3,7,14 and 28 days respectively. The density of the concrete decreased with increased in percentage of micro silica and Fly ash replacement up to 15%. Increase in the level of micro silica fume and Fly ash replacement between 30% to 45% led to a reduction in the compressive strength of hardened concrete. This study has shown that between 15 to 22.5% replacement levels, concrete will develop strength sufficient for construction purposes.

Keywords: Durability, Fly Ash, High Performance Concrete, Silica Fume/Micro Silica, Density, Water Absorption

I. Introduction

It was observed and noted that since decade of years that the cost of building materials is currently so high that only corporate organizations, individual, and government can afford to do meaningful construction. Waste can be used as filler material in concrete, admixtures in cement and raw material in cement clinker, or as aggregates in concrete (Olutoge, 2009). Ordinary Portland cement (OPC) is acknowledged as the major construction material throughout the world. The production rate is approximately 2.1 billion tons per year and is expected to grow to about 3.5 billion tons per year by 2015 (Coulinho, 2003).

According to Adepegba (1989), the annual cement requirement is about 8.2 million tones and only 4.6 million tons of Portland cement are produced locally. The balance of 3.6 million tons or more is imported. If alternative cheap cement can be produced locally, the demand for Portland cement will reduce. The search for suitable local materials to manufacture pozzolana cement was therefore intensified (Adepegba, 1989). Most of the increase in cement demand could be met by the use of supplementary cementing materials, in order to reduce the green gas emission (Bentur, 2002). Industrial wastes, such as silica fume, blast furnace slag, fly ash are being used as supplementary cement replacement materials and recently, agricultural wastes are also being used as pozzolanic materials in concrete (Sensale, 2006). When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete (Igarashi et al, 2005).

Throughout the world and to produce them, it is necessary to reduce the water binder ratio and increase the binder content. High strength concrete means good abrasion, impact and cavitations resistance. Using high strength concrete in structures today would result in economical advantages. In future, high range water reducing admixtures (Super plasticizer) will open up new possibilities for use of these materials as a part of cementing materials in concrete to produce very high strengths, as some of them are make finer than cement. The brief literature on the study has been presented in following text. (Hooten RDC,1993) investigated on influence of silica fume replacement of cement on physical properties and resistance to sulphate attack, freezing and thawing, and alkali silica reactivity. He reported that the maximum 28 days compressive strength was obtained at 15% silica fume replacement level, at a W/C ratio of 0.35 with variable dosages of HRWRA. (Prasad et al, 2003), has undertaken an investigation to study the effect of cement replacement with micro silica in the production of high – strength concrete. (Yogendran et al, 1987) investigated on silica fume in high – strength concrete at a constant water binder ratio (w/b) of 0.34 and replacement percentages of 0 to 25, with varying dosages of HRWRA.The maximum 28 day compressive strength was obtained at 15% replacement level. (Lewis et al, 2001) presented a broad overview on the production of micro silica effect of standardization of micro silica concrete both in the fresh and hardened state. (Bhanja et al, 2 003) reported and directed towards developing a better understanding of the isolated contributions of silica fume concrete and determining its optimum content. Their study intended to determine the contribution of silica fume on concrete over a wide range of w/c ratio ranging from 0.26 to 0.42 and cement replacement percentages from 0 to 30. (Tiwari et al, 2000) presented a research study carried out to improve the early age compressive strength of Portland slag cement (PSC) with the help of silica.

High performance concrete has been used more widely in recent years due to the increasing demand for durable concrete in an attempt to extend in service life and reduce maintenance cost of concrete structures. The requirements may involve enhancements of characteristics such as placement and compaction without segregation, long-term mechanical properties, early age strength, toughness, volume stability, or service life in severe environments. High performance concrete incorporation silica and fly ash as pozzolanic mineral admixture is being increasingly used in the construction of structures for large projects. High performance concrete each commonly available in metropolitan areas. Because of superior mechanical properties and the significant economic savings offered by high performance concrete. Mix design of high performance concrete is complex, because it includes more ingredients like supplementary cementations materials such as a fly ash (FA), micro silica (MS) ground granulated blast furnace slag (GGBFs), and superplasticizers. The use of mineral admixture such as a fly ash, silica fume and GGBF slag add strength and durability to concrete. High performance concrete provides enhanced properties in structural precast- concrete, including elevated tensile and compressive strength, and a boosted stiffness. The high performance concrete usually contains both pozzolanic and chemical admixtures. Hence, the rate of hydration of cement and the rate of strength development in HPC is quite different form that of conventional cement concrete (CCC).

A. Fly Ash Concrete

The pulverized fly ash, generally referred to as fly ash is a byproduct resulting from the burning of powdered coal in thermal power stations.

The requirements for fly ash to be used in concrete mixture are stated in ASTM C. 618. A finely divided inorganic material used in concrete in order to improve certain properties or to achieve special properties.

Fly ash improves concretes workability, pump ability, cohesiveness, finish, ultimate strength, as well as solves many problems experienced with concrete today.

The observed slow set and low early strength obtained with fly ash has caused a reduction in the amount of this mineral admixture used in concrete.

Good quality fly ash generally improves workability or at least produces the same workability with less water. The reduction in water leads to improved strength. Because some fly ash contains larger or less reactive particles than Portland cement, significant hydration can continue for six months or longer, leading to much higher ultimate strength than concrete without fly ash.

II. LITERATURE REVIEW

A review of previous investigation was done by proper systematic procedure to accomplish the Gopalakrishnan et.all, [1] to produce high performance concrete" The cement content of conventional high strength concrete is generally high which often leads to higher shrinkage and greater evolution of heat of hydration besides increase in cost. Very few studies have been reported in India on the use of fly ash for development concrete (HPC) and durability characteristics of these mixes have not been reported. In order to make a quantitative assessment of different cement replacement levels (CRL) with fly ash on the strength and durability properties of HPC mixes and arrive at the optimum level of replacement of cement with fly ash, investigations were undertaken.This paper reports on the performance of HPC mixes having different replacement of cement with low calcium fly ash (class F). A compressive strength of 80 MPa at days was achieved by using 25 percent replacement of cement with fly ash. The results also show that the fly ash concretes have superior durability properties. Rajendra prasad,et al [2] The presence of mineral admixtures in concrete is known to impart significant improvements in workability and durability. The use of byproducts is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. This study focuses on utilization of waste Pozzuolana products such as fly ash and Rice Husk Ash (RHA) as an alternative to OPC to produce ternary blended cement with an objective to increase the optimum percentage of replacement of pozzuolana to OPC without affecting the concrete properties. CO_2 curing is carried out to reduce the curing duration without affecting the compressive strength and trying to achieving the 28 days compressive strength in a short period of 18 hours. The study of CO2 cured specimens kept in air and water for 3 days, 7 days is also carried out along with comparison of the compressive strength of normal concrete. Sivasundaram et.al [3] to study the development of engineering database on the mechanical properties and durability aspects of high-volume fly ash concretes incorporating Canadian fly ashes and cements. Six fly ashes and five ASTM Type I Portland cements were selected from sources across various regions of Canada cements were selected from sources across various regions of Canada. Mechanical properties such as compressive, flexural, and splitting- tensile strength, Young s modulus of elasticity and creep were determined. Durability aspects concerning chloride-ion penetration were also investigated. The concrete cover depths to the steel reinforcing bars ranged from 13 mm to 76 mm. Ashok Kumar [4] he had present a laboratory study using blended cements- both Portland pozzolana cement (PPC) and Portland slag cement (PSC)- for pavement quality concrete (PQC). It is shown that while the required strengths for PQC work are obtainable using blended cement, the latter would improve durability properties too.

Shariq et.al [5] Experimental study on, the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag is studied. Pazhani el. al [6] had experimental studied the Concrete has been the major instrument for providing stable and reliable Infrastructure.

Deterioration, long term poor performance, and inadequate resistance to hostile environment, coupled with greater demands for more sophisticated architectural form, led to the accelerated research into the microstructure of cements and concretes and more elaborate codes and standards. the results innovations of supplementary materials and composites have been developed. In other side, India has an enormous growth in the steel and copper industries. The following are major byproducts from these industries: copper slag-a by-product of copper refinery, and ground granulated blast furnace slag (GGBS)-a by-product in the manufacture of iron in steel industry. If they are not disposed of properly, they may cause environmental hazards to the surrounding area. Considering the long term performance and stability of structures. Bhanj et al. [7] has Extensive experimentation was carried out over water–binder ratios ranging from 0.26 to 0.42 and silicafume–binder ratios from 0.0 to 0.3. For all the mixes, compressive, flexural and split tensile strengths were determined at 28 days. The compressive, as well as the tensile, strengths increased with silica fume incorporation, and the results indicate that the optimum replacement percentage is not a constant one but depends on the water–cementitious material (w/cm) ratio of the mix. Compared with split tensile strengths, flexural strengths have exhibited greater improvements. As a result, the isolated effect of silica fume on the properties of concrete is yet to be exhaustively. Amudhavalli et.al.[8] to study the effaces Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect. Dilip Kumar et al [9 had studied Silica fume is a by-product in the production of silicon alloys such as ferro- chromium, ferro-manganese, calcium silicon etc. which also creates environmental pollution and health hazard. From the study carried out by Ray, it is found that compressive strength increased by about 21%, flexural strength by 35% and split tensile strength by 10% when silica fume was added (5-12.5) %with a increment of 2.5% on a high slump concrete. Joshiobserved that reduction in cement content at fixed water cement ratio was not detrimental to fresh and hardened concrete properties and may actually improve performance when silica fume was added as 10% by weight of cement content. During the extensive research work carried out by Vishnoi, it was concluded that SF concrete has a capability to withstand abrasion erosion with better construction feasibility, workability and surface finish. Faseyemi Victor Ajileye et.al [10] The specific gravity and chemical composition of silica fume and cement were replaced with micro silica from 0 to 25% in steps of 5% by weight, mix proportioning was based on 1:2:4 mix ratio. Cubes (150 x 150 x 150 mm) were produced and cured in a curing tank for 3, 7, 14 and 28 days. The cubes were subjected to compressive strength tests after density determination at 3,7,14 and 28 days respectively. The chemical composition and physical composition of micro silica and cement were determined Others chemical compositions for silica fume such as SiO2, moisture content, loss of ignition, carbon, > 45micron, bulk density. The study has shown that between 5 to 10% replacement levels, silica fume concrete will develop strength sufficient for construction purposes.

III. Methodology

A. *Scope of the Work*

The introduction of fly ash reduces the heat of hydration and improve workability. The aggregate size and quality should be considered seriously. The reinforcement bars should be good strength as per the specification.

1) *The Scope of this project work to*

The wide use of fly ash in reinforced concrete structures.
Use of industrial waste materials for construction industry.
Reduce the cost of construction.
Complete study of crack‟s pattern by applying the load.
Silica Fume and GGBS can be used as a part replacement of cement and their properties can be studied.

2) *Objective of the Work*

The main objective of our project is to make a comparative study and to determine the compressive strength, split tensile strength, flexural strength of the conventional concrete and the concrete in which cement is replaced with Fly ash, Silica Fume and GGBS. In this project, we are replacing the conventional aggregates by 10%, 20%,30%,and40% of its weight by the waste fly ash, silica fume and GGBS the compressive strength, split tensile strength, flexural strength are to be compared with the conventional concrete. We caste cubes, cylinders, beams of standard size, for each type of concrete mix, and have compared the compressive strength, split tensile strength, flexural strength of concrete replaced with fly ash, silica fume and GGBS with the ordinary conventional concrete at 7 days, 14 days, and 28 days of curing.

B. *Material and Its Properties*

Materials that go for making concrete for this study were tested before casting the specimens.

- Water
- Cement
- Sand
- Coarse Aggregates
- Fly Ash

C. *Concrete Ingredients*

1) *Water*

The water available in the campus was used for mixing and curing of concrete specimen.

2) *Cement*

Ordinary Portland cement (OPC) conforming to Indian standard code IS 8112-1995 was used.

- Normal consistency 31%
- Initial setting Time 79 min
- Final setting Time 150 min
- Specific Gravity 3.15

3) Sand

A concrete with better quality can be made with sand consisting of rounded grains rather than angular grains. River or pit sand must be used and not sea sand as it contains salt and other impurities. The sand used for all specimens was river sand. The sand used for experiment work was sieved through 0.6mm (600μ) sieve.
Specific gravity of fine aggregates = 2.60

4) Coarse Aggregates

There are the inert filler in the concrete mixture which constitute between 70 – 75% by volume of the whole mixture. Graded river sand passing through 1.18 mm sieve with fineness modulus of 3.05 and specific gravity of 2.35 was used as fine aggregate (Fa). It was clean and free from organic material and clay. Locally available crushed granite aggregate, passing through 12.5 mm sieve while being retained on 4.75 mm sieve with the fineness modulus of 4.03 and specific gravity of 2.88 (conforming to IS 383-1970) was used as coarse aggregate (Ca) and contained only so much fine materials as was permitted for various sizes in the specification.

5) Fly Ash

It is fine, silt size consisting largely of spherical ,hollow, glassy particles which are finer than cement. The fly ash samples were obtained from Mettur thermal power plant.

6) Chemical Composition of Fly Ash

The chemical composition in fly ash obtained from Mettur has

- Silica - 54.92%.
- Alumina - 23.04%,
- Calcium oxide - 3.84%,
- Magnesium Oxide - 2.82%,
- Iron - 6.62%,
- Phosphorous - 0.3%,
- Alkali Metals Oxide - 2.7%,
- Sulphur - 0.76%,
- Magnesium - 2.82%,
- Loss of Ignition - 2.88%.

7) Silica Fume

The Silica fume obtained from the M/s ELKEM Pvt Ltd, Bombay confirming to ASTM C1240 was used for this study.

8) Admixture

SUPER PLAST- 840 Is a high range high performance Super Plasticizers and Retarder based on sulphonated melamine condensate. It significantly reduces water content in concrete mixes and extends setting times to desired extent. Compared to conventional super plasticizers it possesses the ability to produce Rheoplastic concrete at low water cement ratios and retain workability for extended periods even in high ambient temperatures. Due to these combined effects ROFF SUPER PLAST 840 is highly effective over a wide range of temperature, cement and water cement ratio Different bases of New Generation Superplasticizers or High water Reducing Agents (HWRA) has different water reduction capacities. The advantages of this water reduction can be taken either to increase the strengths as in High Strength Concrete or to obtain a better flow ability. The Mechanisms of Action vary depending upon individual bases. The major mechanisms was absorption of superplasticizers on the cement grain which lead to electrostatic repulsion.

a) Primary Uses

- High cement content and low water cement ratio concrete
- To increase workability.
- To produce high strength
- Hot weather concreting

b) Typical Application

- SUPER PLAST 840 is used in areas of congested reinforcement where the flowing of concrete is desired
- In concrete mixes containing pozzolonic materials and sulphate resisting cements and cements containing fumed silica, fly ash etc.,
- Concreting of Bridge girders, Pre-stressed concrete members where high compressive strengths coupled with high workability is of paramount importance.
- Hot weather concreting where set retardation and avoidance of cold joints is essential.
- Under water concreting and diaphragm walls.]
- Pilling mixes.
- Fair faced concrete
- Industrial floors, roofs and floors toppings.

c) Advantages

- Highly effective over wide range of cement contents and water cement ratios.
- Increases durability and impermeability.
- Enable production of free flowing of concrete.
- Reduces problems in hot weather concreting because of extended setting times.
- Long vibration time maintains over long periods.

d) Properties

- Colour : Light Brown / Clear
- Specific Gravity : 1.2+_0.02 at 20 deg C
- Air Entraintment : NIL
- Chloride content : NIL
- Nitrate content : NIL

e) Dosage

Field trial should be conducted to determine optimum dosage rates of Super Plast 840 to achieve the desired results. The following figures should be utilized as starting.

IV. MIX DESIGN (IS 10262-2009)

A. *Stipulations for Proportioning*

a)	Grade Designation	:	M40
b)	Type of cement	:	OPC 53 Grade confirming to IS 8112
c)	Maximum Nominal Size		
	of aggregate	:	20mm
d)	Minimum Cement Content	:	320Kg/m^3
e)	Maximum W/C Ratio	:	0.45
f)	Workability	:	100mm (Slump)
g)	Exposure Condition	:	Severe for (reinforced concrete)
h)	Degree of Supervision	:	Good
i)	Type of Aggregate	:	Crushed Angular Aggregate
j)	Maximum Cement Content	:	450Kg/m^3

Table 1: Design Specifications

B. Test Data for Materials

a) Cement used :OPC 53 grade conforming to IS 8112
b) Specific gravity :3.15
c) Specific gravity of:
1) Coarse aggregate : 2.74
2) Fine aggregate : 2.74
d) Water absorption:
1) Coarse aggregate : 0.50 %
2) Fine aggregate : 1.0%
e) Free (surface) moisture :
1) Coarse aggregate : Nil
2) Fine aggregate : Nil
f) Sieve Analysis:
1) Coarse aggregate : Conforming to Table 2 of IS: 383
2) Fine aggregate : Conforming to Zone I of IS: 383

C. Target Mean Strength of Concrete:

For a tolerance factor of 1.65 and using Table 1 from IS 10262-2009, the standard deviation, s= 5 N/mm2. So the target mean strength for the specified characteristic cube strength is 40 + 1.65 x 5 = 48.25 N/ .

D. Selection of Water Cement Ratio:

From table 5 of IS 456-2000, maximum water cement ratio=0.45 Based on experience, adopt water-cement ratio as 0.40 0.40<0.45, hence O.K.

E. Selection of Water Content:

From Table 2 of IS 10262-2009, maximum water content = 186 litre (for 25 to 50 mm slump range) for 20 mm aggregate
Estimated water content for (100 mm) slump = 186 + 6/100 x186 = 197 litre
As superplasticiser is used the water content can be reduced up to 20 percent and above Based on trials with SP water content reduction of 29 percent has been achieved. Hence the water content arrived = 19 x 0.71 = 140 liters

F. Calculation of Cement Content:

Water cement ratio = 0.40
Water = 197
Cement = 140/0.40= 350 kg/
From Table 5 of IS 456, minimum cement content
Content for mild" exposure condition = 320 kg/m3
320 kg/m3< 350kg/m3 hence O.K. Maximum Cement Content 450 kg/m3
450>438.13kg/m3

G. Proportion of Volume of Coarse and Fine Aggregate Content:

From table 3, volume of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (zone- I) for water cement ratio of 0.50=0.60. In the presence of water-cement ratio is 0.5. Therefore volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.01. Therefore the corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.40=0.62. For pumpable concrete these values should be reduced by 10% Therefore volume of coarse aggregate=0.62x0.9=0.56.Volume of fine aggregate content=1-0.56=0.44

H. Mix Calculations:

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete $=1\ m^3$

b) Volume of cement $= \frac{\text{mass of cement}}{\text{specific gravity of cement}} \times \frac{1}{1000}$

$=[350/3.15] \times [1/1000]$

$= 0.111\ m^3$

c) Volume of water $= \frac{\text{mass of cement}}{\text{specific gravity of water}} \times \frac{1}{1000}$

$= [140/1] \times [1/1000]$

$=0.140 m^3$

d)Volume of all in aggregate $=(1-0.111-0.140)$

$=0.749\ m^3$

e) Mass of coarse aggregate $= 0.749 \times 0.56 \times 2.74 \times 1000$

$=1149.266/m^3$

f) Mass of fine aggregate $=0.749 \times 0.44 \times 2.74 \times 1000$

$=902.994\ Kg/m^3$

The mix proportion then becomes:

Cement	= 350 kg/m^3
Water	= 140 kg/m^3
Fine Aggregate	= 902 kg/m^3
Coarse Aggregate	= 1149 kg/m^3
Water-Cement Ratio	= 0.40

I. Tests for aggregates-specific gravity test

Specific gravity of aggregate is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required to be considered when we deal with light weight and heavy weight concrete. Average Specific gravity of rocks vary from 2.6 to 2.8

J. Sieve Analysis:

The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. The aggregate used for the making concrete normally of the maximum size of 40mm, 20mm, 10mm,4.75mm, 2.36mm,600 micron, 300 micron and 150 micron. The aggregate fractions from 40mm to 4.75mm are treated as coarse aggregate and those fractions from 4.75mm to 150 micron are termed as fine aggregate.

Fineness modulus is a empirical factor obtained by adding cumulative percentage of aggregate retained on the standard sieves ranging from 40mm to 150 micron and dividing this by arbitrary No. 100.
The following limits may be taken guidance,
Fine sand = fineness modulus = 2.2 to 2.6
Medium sand = fineness modulus = 2.6 to 2.9
Coarse sand = fineness modulus = 2.9 to 3.2

K. Fineness Modulus of Fine Aggregate

Total weight of fine aggregate = 1000 g.

No.	IS Sieve Size in mm	Weight Retained (g)	% of Weight Retained	Cumulative % of Weight Retai	% of Passing
1	4.75	40	4	4	96
2	2.36	40	4	8	92
3	1.18	520	52	60	30
4	0.600	280	28	88	12
5	0.425	100	10	98	2
6	<0.425	20	2	100	0

Table 2: Fineness Modulus of Fine Aggregate

Fineness modulus of fine aggregate = 3.58

L. Fineness Modulus of Coarse Aggregate

Total weight of Coarse Aggregate = 5000 g.

No.	IS Sieve Size in mm	Weight Retained (g)	% of Weight Retained	Cumulative % of Weight Retained	% of Passing
1.	20.0	800	16	16	84
2.	12.5	3900	78	94	6
3.	10.0	180	3.6	97.6	2.4
4.	6.3	100	2.0	99.6	0.4
5.	4.75	20	0.4	100	0
6.	<4.75	0	0	100	0

Fineness modulus of fine aggregate = 5.072

M. Cement:

Type : 53 grade
Portland Pozzolona Cement (PPC) Initial setting time : 100min
Final setting time : 460 min Soundness test : 3mm Brand name: ACC CEMENT

N. Water Absorption Test

A. For Fine Aggregates
Dry weight, W1 =1000 g.
Wet weight, W2 = 1010 g.
Water Absorption = (W2 – W1)/W1 = 100%
B. For Coarse Aggregates
Dry weight, W1 =1000 g.
Wet weight, W2 = 1005 g.
Water Absorption = (W2 – W1)/W1 = **0.50%**
TESTS FOR FRESH CONCRETE:

O. Workability Tests

According to Cement Manufacturer's Association India (n.d), a good concrete must has workability in the fresh state and also develop sufficient strength. It also mentioned that there are four factors that can affect the workability. They are as below:

1) Consistency: The degree of consistency is depended on the nature of works and type of compaction.
2) Water/cement Ratio or Water Control of a concrete: Water/cement ratio is the ratio of water in a mix to the weight of cement
3) Cement Content: The greater workability can be obtained with the higher cement content.

1) Slump Test:

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor it always representative of the place ability of the concrete.

However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. The result obtained from the

Slump test for all the 6 mixes are shown in the table 4.1. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimension as under:

Bottom diameter : 20 cm
Top diameter : 10 cm
Height : 30 cm

Fig. 2: slump Test

P. Compaction Factor Test on Concrete

The compacting factor is one of the most efficient tests for measuring the workability of concrete as per IS: 1199-1959. It is the most precise, sensitive and particularly useful for concrete mixes of very low workability as are normally used. The workability of fresh concrete is expected to be mild.

Compaction factor = weight of partially compacted concrete weight of fully compacted concrete
Assumed Mix Proportion = 1: 1: 2
Assumed Water-Cement Ratio = 0.450
Empty weight of Cylinder,
W1 = 6.36 kg.
Weight of Cylinder with partially compacted concrete,
W2 = 17.36 kg. Weight of partially compacted concrete,
Wp = W2 – W1 = 11 kg.
Weight of Cylinder with fully compacted concrete, W3 = 18.14 kg.
Weight of fully compacted concrete,
WF = W3 - W1 = 11.78 kg.
Compaction Factor (WP – WF) = 0.90

Q. Tests for Hardened Concrete

To evaluate the performance of different mix used in this work, following strength test were performed.

1) Compressive strength
2) Split tensile strength
3) Flexural strength

R. Compressive Strength

The compressive strength of concrete is one of the most important properties of concrete. Comparative strength if M40 grade of concrete for the replacement of cement by silica fume, fly ash and GGBS. In this test 150x150x150mm concrete cubes were cast, by using 25 MPa concrete. The mixing was done by cubes were remolded and placed under water and cured for 28 days. Then the cubes were tested for their crushing strength at 3, 7 and 28 days. As per IS: 4031:1968, load was applied at the rate of 140kN/min.

S. Split Tensile Strength

The test is carried out in a cylindrical specimen of 150mm diameter and 300mm length. The cylindrical specimen is placed horizontally between the loading surface of a compression testing machine and the load is applied until failure of cylinder, along the vertical diameter. The split tensile strength is given by the formula 2P / (πdl) and the stress value is in N/mm2. Where P – The ultimate load at which the cylinder fails. d, l – The diameter and length of the cylinder.

T. Flexural Strength

Concrete is relatively strong in compression and weak in tension. Direct measurement of tensile strength of concrete is difficult. Concrete beams of size 500x100x100mm are found to be dependable to measure flexural strength property of concrete. The systems of loading used in finding out flexural strength are central point loading and third point loading. The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the rate specified. Flexural strength is expressed as modulus of rupture which is given by M/Z.

Where M – the maximum moment that the beam can carry and Z – The modulus of section.

Fig. 3: Flexure Test

U. Details of Cast Specimens

Concrete cubes of size 150mmx150mmx150mm, cylinders of size 150mm diameter and 300mm height ,prisms of size 100mmx100mmx500mm were casted and remolded after 24 hours .by replacing 30%,60% and 100% of recycled coarse aggregates three cubes were tested to find compressive strength at the age of 7days and 28 days, three cylinders were tested to find out the split tensile strength at the age of 7 days and 28 days and three prisms were tested to find out the flexural strength at the age of 7 days and28 days.

Percentage of replacement (%)	Cubes (150x150x150m)			Cylinders (150x300mm)			Prisms (100x100x500mm)		
	7 days	14 days	28 days	7 days	14 days	28 days	7 days	14 days	28 days
0%	3	3	3	3	3	3	3	3	3
F10%	3	3	3	3	3	3	3	3	3
F20%	3	3	3	3	3	3	3	3	3
F30%	3	3	3	3	3	3	3	3	3
F.A30%,S.F10% & GGBS 10%	3	3	3	3	3	3	3	3	3
F.A30%&S.F20% & GGBS 10%	3	3	3	3	3	3	3	3	3
F.A30%&S.F30% & GGBS 10%	3	3	3	3	3	3	3	3	3
F.A30%&S.F40% & GGBS 10%	3	3	3	3	3	3	3	3	3

Table 4: Details of cast specimens

Fig. 4: Specimens Casted

V. TEST RESULTS AND DISCUSSION

A. Experimental Results:

1) Compressive Strength of Cubes

The cube compressive strength at the age of 7^{th},14^{th} and 28^{th} days of various percentages shown in table 5.1and their comparison is shown in fig.

S.NO	SPECIMEN	7 DAYS	14 DAYS	28 DAYS
1	C.S	14.53	29.26	38.33
2	F.A.10%	17.18	29.32	38.40
3	F.A.20%	22.44	31.36	39.22
4	**F.A.30%**	**26.95**	**34.75**	**40.44**
5	F.A.40%	20.14	28.73	32.73

Table 5: compressive strength(N/Mm2)-fly ash

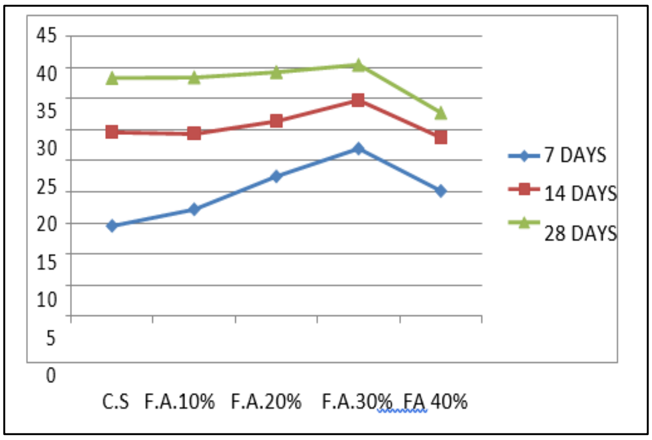

Fig. 5: Compressive Strength

S. NO	SPECIMEN	7 DAYS	14 DAYS	28 DAYS
1	C.S	14.53	29.26	38.33
2	F.A.30%,S.F10% & GGBS 10%	19.47	30.67	38.91
3	F.A.30%,S.F20% & GGBS 10 %	23.69	34.40	40.18
4	**F.A.30%,S.F30% & GGBS 10%**	**27.99**	**35.85**	**41.22**
5	F.A.30%S.F40% & GGBS 10%	21.03	29.92	30.33

Table 6: Compressive Strength (n/mm^2)- Fly Ash, Silica Fume & GGBS

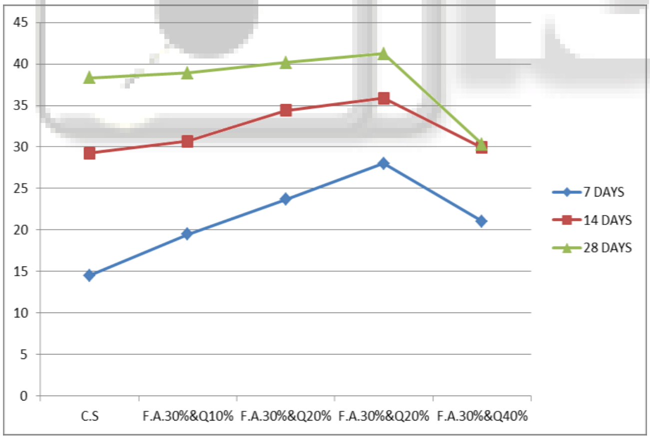

Fig. 6: Compressive Strength-Fly Ash, Silica Fume & GGBS

B. Split Tensile Strength of Cylinder

S.NO	SPECIMEN	7 DAYS	14 DAYS	28 DAYS
1	C.S	0.62	1.34	1.86
2	F.A.10%	0.64	1.45	1.89
3	F.A.20%	0.89	1.68	2.24
4	**F.A.30%**	**0.95**	**1.88**	**2.45**
5	F.A.40%	0.65	1.22	1.74

Table 7: Split Tensile Strength (N/Mm2)-Fly Ash

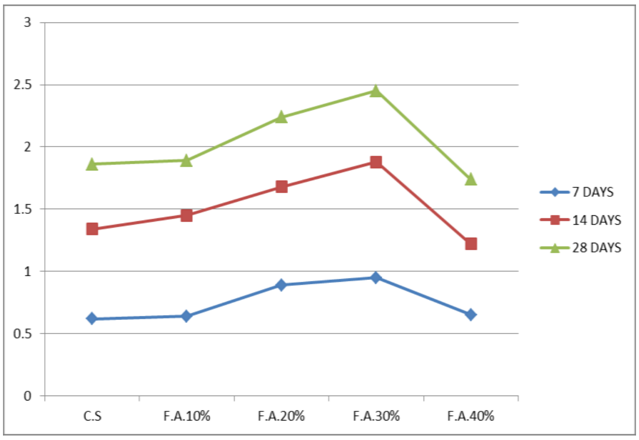

Fig. 7: Split Tensile Strength -Fly Ash

VI. CONCLUSION

- Mix M40 can be effectively used in reinforced concrete structure for increased durability and economy.
- Workability of concrete decreased as percentage of fly ash increase in cement.
- The specimen F.A 10%, F.A 20%, F.A 30%, F.A 40% are subjected to compressive strength, split tensile strength and Flexural strength results are tabulated.
- From test results it is observed that F.A 30% and Silica Fume 15 % (30%cement replacement by fly ash and 15% Silica Fume) hold good strength.
- Further in this experimental study, this F.A 30% ,Silica Fume, GGBS, and Polymer Fiber are also added in the cement concrete is modified by partially replacing the Cement, percentages such as 10%, 20%, 30%, 40%. From the test results, it is observed that 45% replacement of Cement concrete gives strength in all the aspects.
- Thus, when compared to conventional concrete 45% replacement of cement with fly ash, Silica Fume, GGBS are replacement of Cement has increase in compressive strength, split tensile strength and Flexural Strength.

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