International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON HIGH PERFORMANCE CONCRETE USING SILICA FUME, FLY ASH AND GLASS POWDER

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Abstract*: This paper presents the experimental investigation on high performance concrete using silica fume, fly ash and glass powder. The modern world is accepting high performance concrete due its increased workability, durability and high tensile strength. The use of these materials in concrete provides enhanced resistant to chemical attack and has better durability and impermeability. The awareness about waste materials like fly ash, glass powder, silica fume etc., is growing worldwide. The aim of this study was to investigate the possibility of developing high performance concrete using silica fume, glass powder and fly ash. Properties of concrete like compressive strength, split tensile strength and flexural strength, workability and durability for M60 grade concrete at 7days and 28days are studied. Materials like fly ash, silica fume and glass powder used in this experiment reduces carbon dioxide.*

Keywords: High Performance Concrete (HPC), Silica Fume, Fly Ash, Glass Powder, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

Concrete is the most extensively used construction material in the world. High performance concrete structures experienced fast development in the last few years. The advantages of this high performance concrete is good compressive strength, tensile strength, volume stability, low water and chemical ions permeability and high chemical resistance. High performance concrete is made with high quality ingredients and it is characterized with low water cement ratios, ranging from 0.2 to 0.45.

Silica fume, a byproduct of silicon metal or Ferro silica is pozzolanic. Silica fume also helps in reducing air pollution. The use of silica fume in concrete is known to produce high strength concrete.

Glass powder, admixture of a number of metallic silicates increases the mechanical properties such as compressive strength and tensile strength to some extent.

Fly ash one of the pozzolanic material which blended with Portland cement can produce durable concrete. It also forms silicate hydrate gel around cement which is less porous.

Superplasticizers are used to achieve the required workability. The main objective of the present investigation is to study the behaviors of high performance concrete (replacement cement with silica fume, fly ash and glass powder).

2. MATERIALS AND MIX PROPORTIONS

The materials used and their properties are given below.

Table- 1 Chemical composition

Chemical composition	Cement	Fly ash	Silica fume	Glass powder
Silicon dioxide(SiO_2)	20.78%	35%	90%	67.33%
Aluminum oxide(Al_2O_3)	4.44%	27%	0.6%	2.62%
Ferric oxide(Fe_2O_3)	2.88%	4.5%	0.2%	1.42%
Calcium oxide(CaO)	63.78%	1.2%	0.3%	12.45%
Magnesium oxide(MgO)	3.66%	0.3%	0.75%	2.73%
Sodium oxide(Na_2O)	0.4%	1.5%	0.7%	12.05%

Table -2 Physical properties

Property	**Cement**	**Fly ash**	**Silica fume**	**Glass powder**
Specific gravity	3.15	2.5	2.2	2.6

2.1 Superplastizers:

Commonly available Sulphonated naphthalene formaldehyde (Conplast SP430) was used as chemical admixture to improve workability.

2.2 Mix proportions

The mix design of M60 grade is designed as per IS 10262:2009. Mix proportion of 1:0.77:1.31:0.36 (cement: fine aggregate: coarse aggregate: water) for M60 grade was calculated. Ordinary Portland cement of 53 grade was used, water cement ratio of 0.36 was maintained for all mixes. Cement was replaced with fly ash, silica fume and glass powder at 7.5%, 10% and 12.5%. Mix proportions are given in the below table.

Table-3 Mix proportion

Mix	% of silica fume	% of fly ash	% of glass powder
M1	0	0	0
M2	2.5	2.5	2.5
M3	3.33	3.33	3.33
M4	4.16	4.16	4.16

3. EXPERIMENTAL SETUP

Cube of mould size 150mm x 150mm x 150mm, cylinders of mould size 100mm x 200mm and beam mould of size 1000mm x 150mm were cast and cured.

4. TESTS AND RESULTS ON CONCRETE

The mix design of M60 grade is designed as per IS 10262:2009. Mix proportion of 1:0.77:1.31:0.36(cement: fine aggregate: coarse aggregate:water) for M60 grade was calculated.

4.1 Basic Tests on Materials

Specific gravity test was done on fine and coarse aggregates using pycnometer. The fineness modulus was calculated using sieve analysis test.

The impact test was done to determine the toughness using impact testing machine, abrasion test was done using Los Angels abrasion machine. The consistency of cement was found using Vicat's Apparatus. The results of these tests are tabulated in Table-III.

4.2Tests on Fresh Concrete

The workability of fresh concrete is measured using the Vee Bee Consistometer apparatus. This test is used to measure the change in the concrete shape from slump cone to cylinder by mode of vibration.

4.3Tests on Hardened Concrete

Compressive strength

Compressive strength tests were carried out on concrete cubes in Universal Testing Machine (UTM) of capacity 2000kN under 140kg/sq.cm/min loading rate, until the resistance of the specimen to the increasing load can be sustained. The results are shown in Table-IV. The compressive strength of concrete can be calculated using Equation (1).

$$f_{cu} = P / A \ (N/mm^2) \ (1)$$

where,
f_{cu} = compressive strength of concrete (N/mm^2)
P = load applied (N)
A = cross sectional area (mm^2)

Flexural strength

The flexural strength or modulus of rupture of concrete was determined for the beams cast. The results are shown in Table-V. The flexural strength of concrete can be calculated using Equation (2).

$$f_{cr} = PL / bd^2 \ (N/mm^2) \ (2)$$

where,
f_{cr} = flexural strength of concrete ($N/mm^{2)}$
P = load applied (N)
L = effective span (mm)
b = breadth (mm)
d = depth (mm)

Split tensile strength

Cylindrical specimens were cast and cured to determine the split tensile strength of concrete. They were loaded in compression side along the diameter plane. The results of the split tensile strength are tabulated in Table-VI. the formula to calculate the split tensile strength is given in equation (3).

$$f_t = 2P / \Pi DL (N/mm^2) \ (3)$$

where,
f_t = split Stensile strength of concrete (N/mm^2)
P = load applied (N)
D = diameter (mm)
L = effective span (mm)

5. RESULTS

The results of the compressive strength, split tensile strength and flexural strength are shown below in table 4,5,6.

6. CONCLUSIONS

Based on the experimental study of high performance concrete using silica fume, fly ash and glass powder, the following conclusions are made:

- The use of silica fume, fly ash and glass powder to a certain percentage of addition enhanced the strength of concrete.
- The maximum compressive strength, split tensile strength and flexural strength was found at 10% replacement of cement with fly ash, silica fume and glass powder (3.33% of fly ash, 3.33% of silica fume and 3.33% of glass powder).
- On further addition of silica fume, fly ash and glass powder the compressive strength, split tensile strength and flexural strength of concrete was found to decrease

Table-4 : Compressive strength

Mix	%of silica fume	% of fly ash	%of glass powder	7 days N/mm^2	28 days N/mm^2
M1	0	0	0	43.3	53.67

M2	2.5	2.5	2.5	47.6	58.7
M3	3.33	3.33	3.33	51.3	61.7
M4	4.16	4.16	4.16	48.3	57.7

Chart -1: Compressive strength

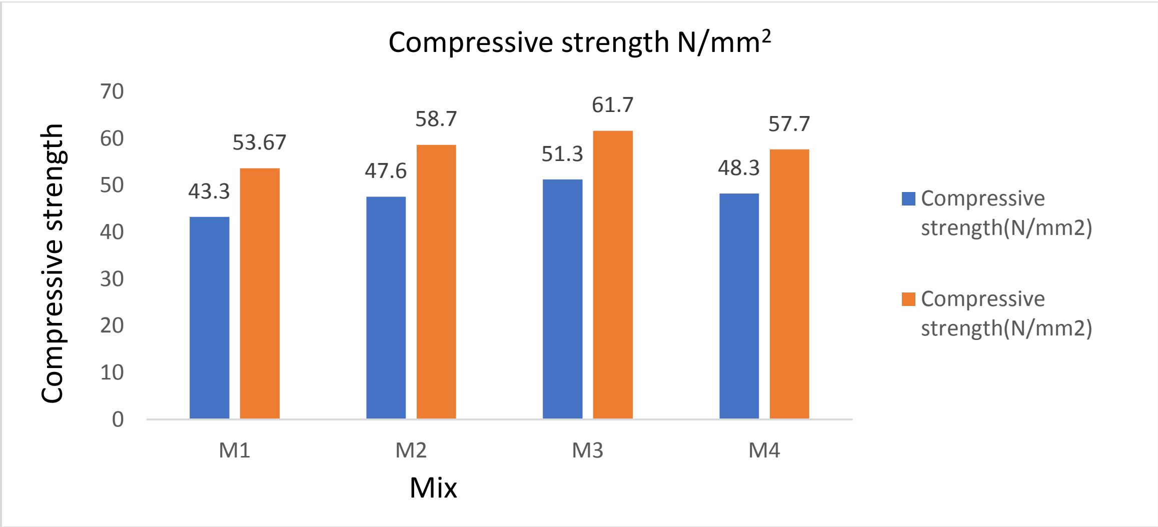


Table-5: Flexural strength

Mix	%of silica fume	% of fly ash	%of glass powder	28 days N/mm²
M1	0	0	0	4.0
M2	2.5	2.5	2.5	5.1
M3	3.33	3.33	3.33	5.6
M4	4.16	4.16	4.16	4.8

Chart -2: Flexural strength

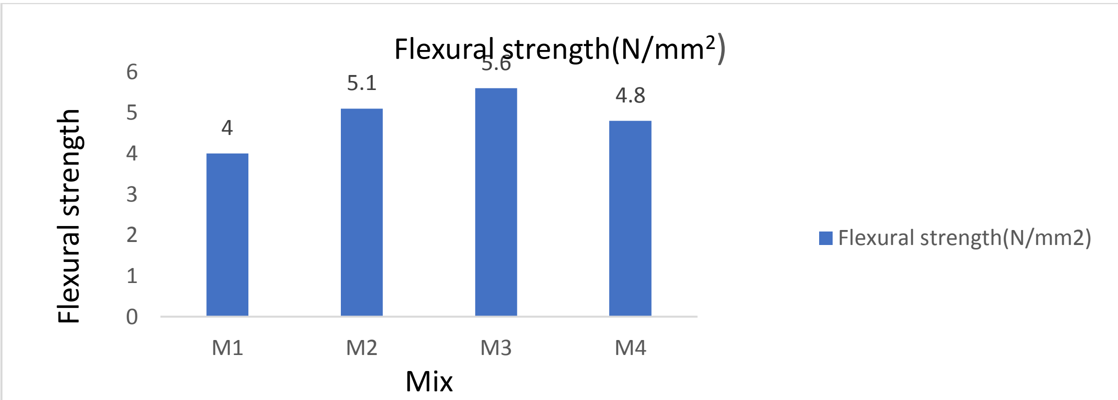
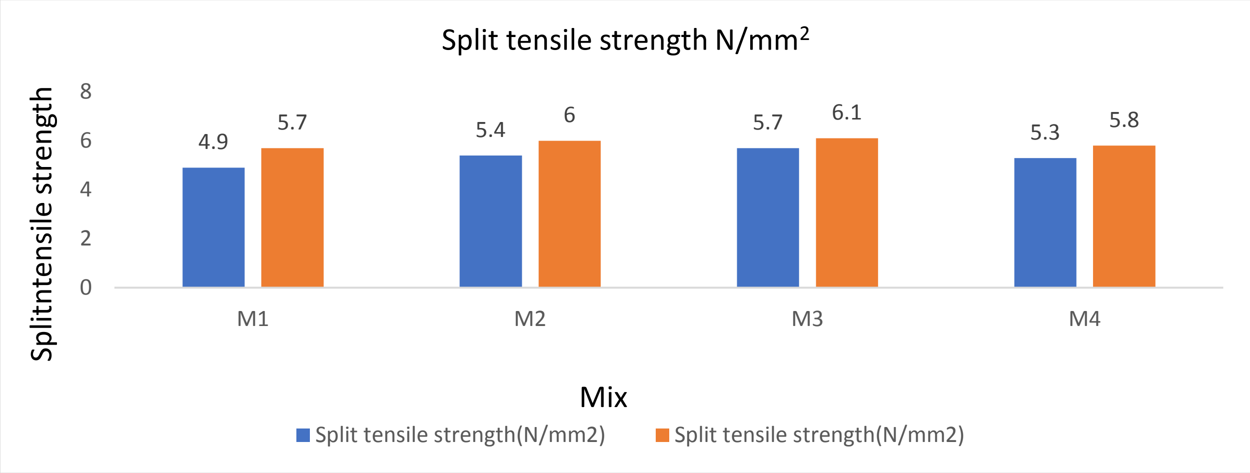


Table-6: Split tesnsile strength

Mix	%of silica fume	% of fly ash	%of glass powder	7 days N/mm²	28 days N/mm²
M1	0	0	0	4.9	5.7
M2	2.5	2.5	2.5	5.4	6.0
M3	3.33	3.33	3.33	5.7	6.1
M4	4.16	4.16	4.16	5.3	5.8

Chart -3: Split tensile strength



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