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EXPERIMENTAL STUDY ON BEHAVIOR OF HIGH STRENGTH CONCRETE WITH SILICA FUME AS AN ADMIXTURE

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ABSTRACT

This experiment is directed towards developing a better understanding on the isolated contribution of silica fume on the compressive strengths of high-strength concrete (HSC). Extensive experimentation was carried out over water–binder ratio as 0.26, silica fume ranges from 0 to 25%. For all the mixes, compressive, 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. The main objective of the present investigation is to study the behavior of high strength reinforced concrete beams (replacement of cement with silica fume). Super plasticizer is used to achieve require workability.

Keywords: High strength Concrete, Compressive strength, Split tensile strength, Silica fume.

I. INTRODUCTION

The development of concrete technology has been a gradual process over many years. With the advent of new admixtures and cementations materials, it becomes possible to produce highly workable concrete with superior mechanical properties and durability. This newly developed concrete is being called high strength concrete (HSC). HSC has a high very high degree of durability, which is obtained by using supplementary cementations materials like fly ash, silica fume and GGBS etc, to replace a certain percentage of OPC. The use of these replacing materials improves the properties of concrete, both in fresh and hardened stages

Production of HSC

Silica fume and fly ash are common mineral admixtures used in developing high strength concrete mix. Silica fume as its size is smaller than cement grains fills the voids in between the cement grains. This leads to a decrease in water demand. But its high specific area increases the water demand. Combination of these two effect results in net increase in water demand compared to normal strength concrete for a given level of workability. Super plasticizer is used to reduce the water demand. This also help the silica fume to be well dispersed in concrete mix

Chemical mechanism

This is a chemical mechanism, silica fume reacts with the calcium hydroxide, which is liberated during process of hydration, about 22-24 percent and produces calcium-silicate-hydrate (C-S-H). The following are the chemical reactions that are taking place.

Portland cement reaction: C3+H=C-S-H+CH

Portland reaction of silica fume: S+CH+H = C-S-H

Glass Fiber Reinforced Polymer (GFRP)

Concrete is extremely strong in compression but weak in tension. If the tensile nature of the concrete increases the flexural behavior. Tensile strength can be increased by many techniques. One of the latest techniques is Fiber Reinforced Polymer (FRP). FRP is available in many forms such as mats, pultruded sections, fibers etc. In most of cases it combines with resin to give to give a composite technique. But in this project the fibers are mixed in concrete to have a composite action with concrete.

II. MATERIAL PROPERTIES

Cement

Tests were conducted to find the specific gravity, consistency, setting time and compressive strength of OPC and the results are tabulated in Table 1. This table also compares the results obtained and the requirement as per IS: 8112-1989.

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Table 1 Properties of 53 grade OPC

Test Particulars	Result Obtained	As per IS:8112-1989
Specific gravity	3.15	3.10-3.15
Normal consistency (%)	32	30-35
Initial setting time (min)	28	30 minimum
Final setting time (min)	560	600 maximum

Aggregates
Tests were conducted to obtain specific gravity and fineness modulus of the fine aggregate and coarse aggregate used in this study as per IS: 2386-1983 and the results are tabulated in Table 2.

Table 2 Properties of Aggregates

Test particulars	Result obtained	
	Fine Aggregate	Coarse Aggregate
Specific gravity	2.63	2.69
Fineness modulus	2.31	5.67

Silica Fume
Silica fume which is also known as micro silica is a very fine pozzolanic material, composed of amorphous silica produced by electric arc furnaces as a byproduct of the production of elemental silicon or ferrosilicon alloys. As the quartz is heated to 2000˚C and an electric arc is fired through the furnace, it releases silicon monoxide gas. This gas rises and reacts with oxygen in the upper parts of the furnace and condenses as it cools, into the pure spherical particles of micro silica.

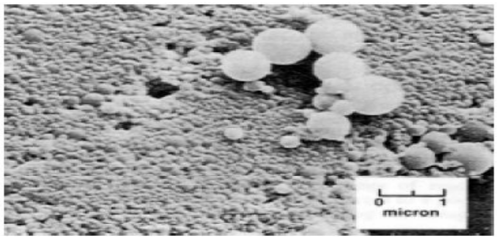

Fig. 1 Micrograph from scanning electron microscope showing typical silica fume

Table 3 Physical properties of silica fume

Colour	Pale grey to Dark grey
Specific gravity	2.2
Specific surface area	20,000m2/kg
Particle size	0.1 - 1 µm

Table 4 Chemical properties of silica fume

Constituent	Percentage (%)
SiO_2	90-96
Al_2O_3	0.5-0.8
MgO	0.5-1.5
Fe_2O_3	0.2-0.8
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1.0

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C	0.5-1.4
S	0.1-0.4

Glass Fibers

The use of fibers in concrete increases the mechanical properties such as compressive strength, tensile strength of concrete to some extent. Hence the flexural behaviour can be increased to some extent. It also possesses the ability to reduce plastic shrinkage in concrete. Cem-Fil Anti Crack Fibers used in this study is shown in Fig. 2

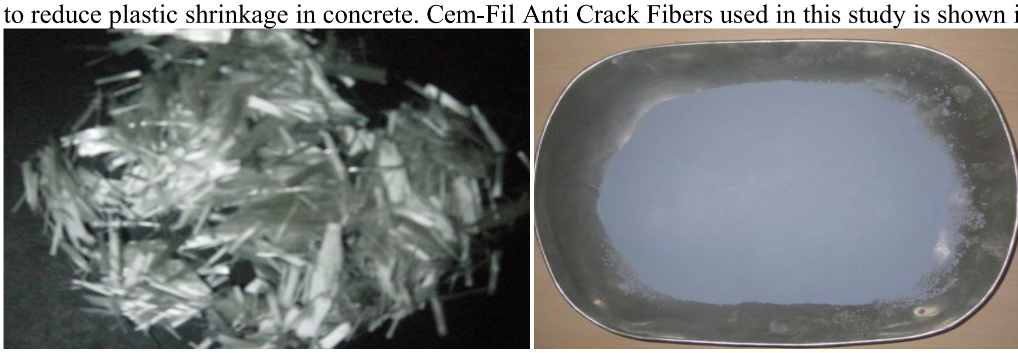

Fig. 2 Cem-Fil Anti Crack Fibers and Silica Fume Sample

Table 5 Material Properties of Fiber

Density	2.6 t/m3
Elastic modulus	73 GPa
Tensile strength	1700 MPa
Number of fibers	220 million / kg
Filament diameter	14µ
Specific gravity	2.6
Length	6 mm
Aspect ratio	857:1
Specific surface area	105m2/kg

Super Plasticizer

Super plasticizers are the modern type of water reducing admixtures, basically a chemical or mixture of chemicals that imparts higher workability to concrete. Super plasticizers are used in concrete, the normal dosage of conventional super plasticizers in HPC lies in the range of 5-20 liters per m3. Very high content of super plasticizer can affect the process of hydration. Super plasticizer used in this study is shown in Fig. 3

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Fig. 3 Super plasticizer Sample

III. EXPERIMENTAL METHODOLOGY

Mix Design

Absolute Volume Method of mix design is adopted for proportioning of concrete Mix M80. Mix proportioning details are tabulated.

Table 6 Mix Proportions Ratio

Mix	% of silica fume in cement	Glass fibers (%) in total volume	Ratio
M1	0	0	1:0.99:1.88:0.26
M2	10	0	1:0.99:1.88:0.26
M3	15	0	1:0.99:1.88:0.26
M4	20	0	1:0.99:1.88:0.26
M5	10	0.3%	1:0.99:1.88:0.26
M6	15	0.3%	1:0.99:1.88:0.26
M7	20	0.3%	1:0.99:1.88:0.26

Experimental Works and Procedures

Experimental investigations carried out on the test specimens to study the workability and strength-related properties of high strength concrete using Silica fume and Cem-Fil anti crack fibers. The details of test specimen are tabulated in the Table 7

Table 7 Types of Tests and Specimen Size

Properties studied	Specimen	Specimen size (mm)
Compressive strength	Cube	100 x 100 x 100
Split tensile strength	Cylinder	100 x 200
Water Absorption	Cube	100 x 100 x 100
Flexural	Beam	100x200x2000

Compressive Strength Test

The compressive strength of concrete cube was determined based on IS: 516 –1959. The specimen was placed in the compression testing machine in such a manner that the load applied should be to the opposite sides of the cubes as cast, that is not to the top and bottom. The compressive strength test is conducted in the Compression Testing Machine of 2000 kN capacity, the test set up is shown in Fig 4.

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Fig.4 Testing of Cubes in CTM

Split Tensile Strength Test

The splitting tensile strength of concrete cylinder was determined based on IS: 5816 –1999. The load shall be applied nominal rate within the range 1.2 N/ (mm2/min) to 2.4 N/ (mm2/min)

Water Absorption Test

The water absorption of concrete cube based on ASTM C 642 - 81 was determined. After curing, Specimens were dried in an oven at 105º C for 24 hours. The dry specimens were cooled to room temperature and weighed accurately and noted as dry weight. Dry specimens were immersed in water container. Weight of the specimens was taken after wiping the surface with dry cloth. This process was continued not less than 48 hours or up to constant weight was obtained in two successive observations.

Experimental Test Set Up For Beam Specimens

A total of seven beams were cast. Out of those seven beams cast, one is conventionally reinforced concrete beam. Remaining six beams were separated into two categories and were cast with concrete, one with the 5%, 7.5% & 10% silica fume replacement and the other with above mentioned replacement of silica fume in addition to the glass fibers. All the beams were tested for flexure under a loading frame of capacity 1000kN. These beams were tested on a effective span of 1500mm with simply supported conditions under two point loading. Deflections were measured under the loading point and at the mid span using Linear Variable Differential Transducers (LVDTs). A typical two point loading experimental set up is shown in the Fig.5 The crack patterns were also recorded at every load increment. All the beams were tested up to failure.

Fig 5 Experimental Setup for the Flexure Beam

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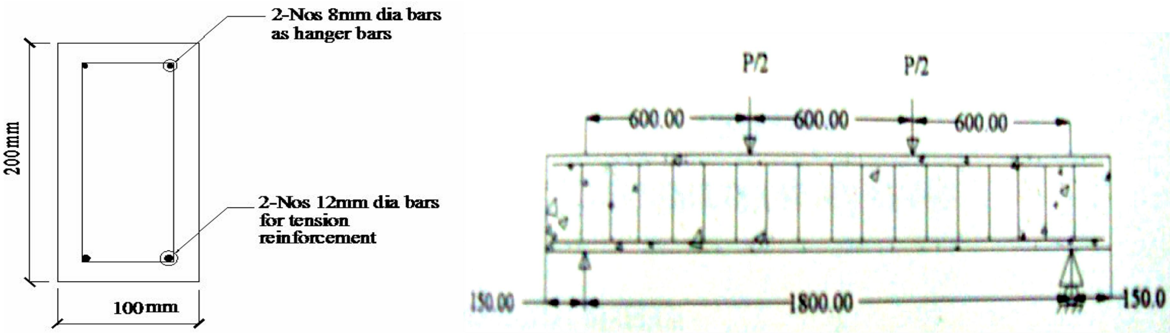

C/S of Beam *L/S of Beam*

Fig 6 Reinforcement detailing of Flexure Beam

IV. RESULTS AND DISCUSSION

Compressive Strength Test

The test results are the Variation of Compressive strength is shown in Fig 7

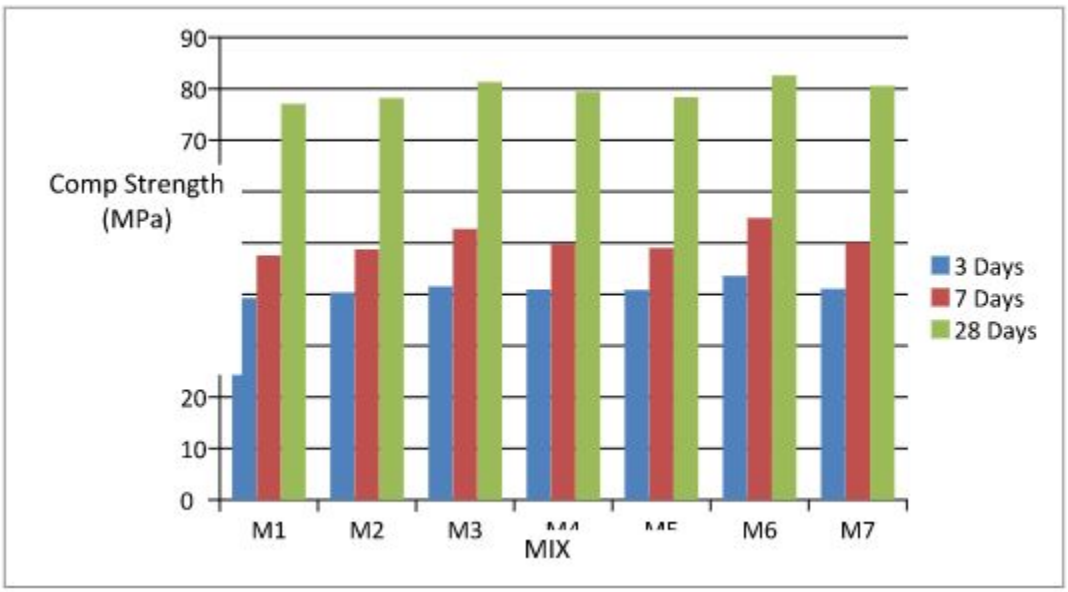

Fig 7 Variation of Compressive strength at various Mix

Split Tensile Strength Test

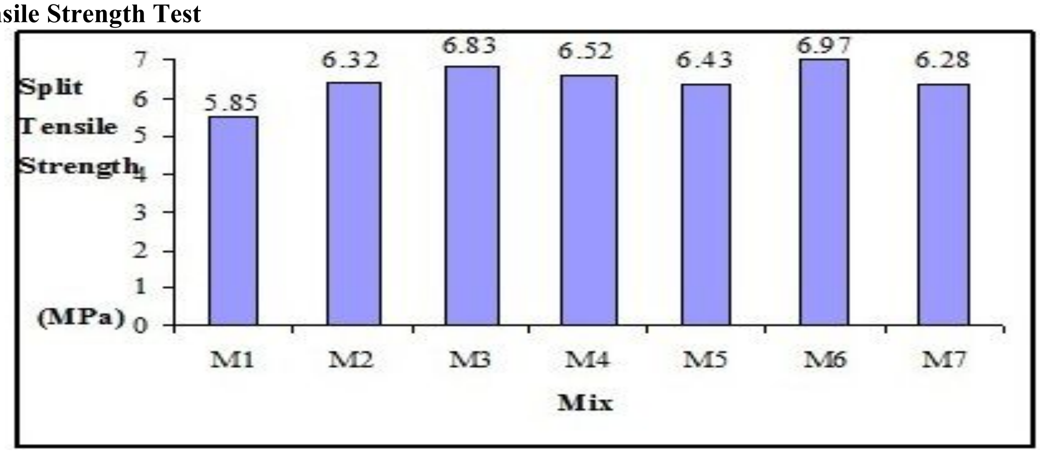

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Fig 8 Split tensile strength of various mixes

Water Absorption Test

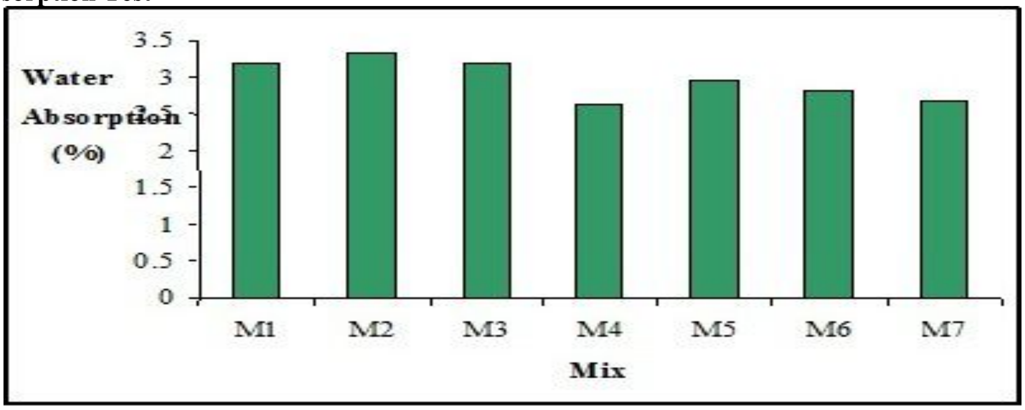

Fig 9 Water Absorption for various mixes

Beam Test Results

Testing of beam was carried out as per the procedure and the experimental set up. The Failure and the Crack pattern of flexure beam are shown Fig.10. The test results for beam tested for Flexure are shown in Table 8.

Fig 10 Crack pattern for the beam for flexure after loading

Table 8 Test Results for Flexure Beam

Specimens	% of SF	Fiber (%)	First Crack Load (kN)	Ultimate load (kN)	Deflection at Ultimate Load (mm)
M1	0	0	18	36	8.94
M2	10	0	20	38	10.67
M3	15	0	23	41	12.52
M4	20	0	21	40	11.07
M5	10	0.3	21.5	41	11.85
M6	15	0.3	25.5	45	15.67
M7	20	0.3	22.5	42.5	13.45

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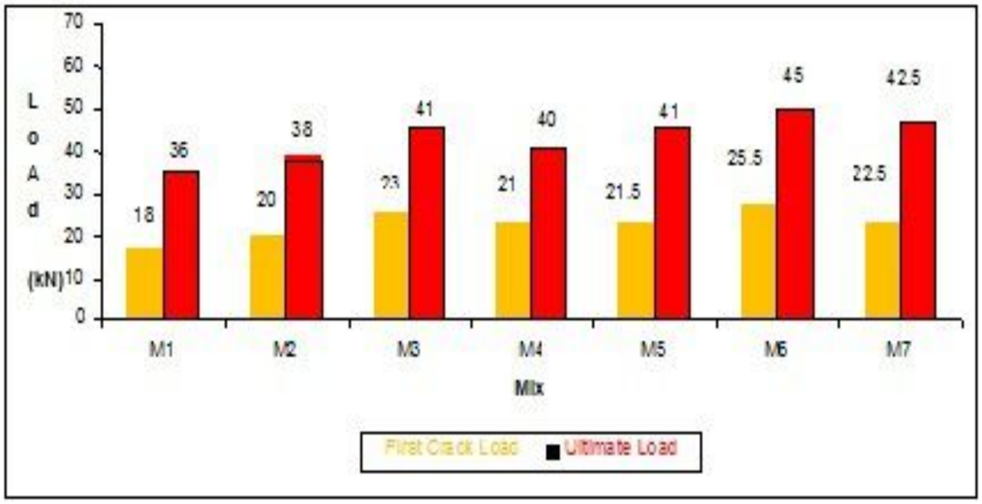

Fig 11 Comparison for First crack load and Ultimate Load

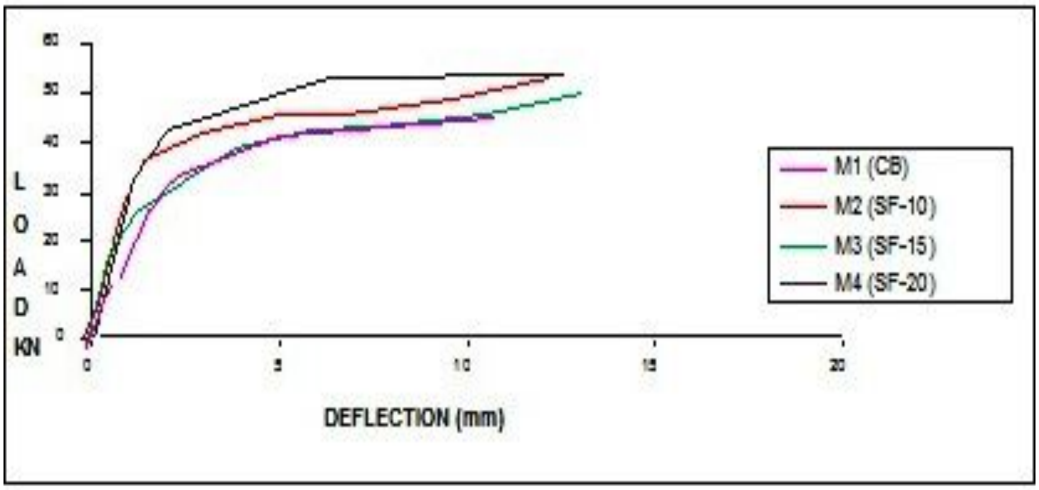

Fig 12 Load Vs Def curves for Flexure Beam (M1, M2, M3, and M4)

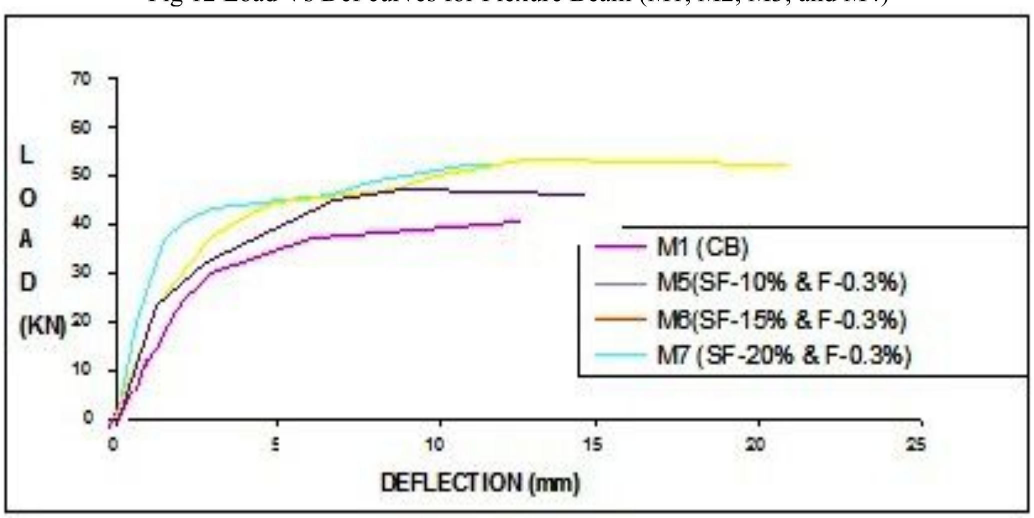

Fig 13 Load Vs Def curves for Flexure Beam (M1, M5, M6, and M7)

V. CONCLUSION

The addition of silica fume results in a more cohesive concrete which results in a good concrete which is less prone to segregation. The M3 mix which is without fiber give maximum compressive strength of concrete without addition of fiber (ie) 81.32 MPa which is 5.54% greater than control mix.

It is observed that M6 mix shows the maximum compressive strength. For M6 mix with 15% silica fume and 0.3 % glass fiber, the 28 days compressive strength is 82.59 MPa which is 7.19% greater than control mix.

The M3 mix which is without fiber give maximum split tensile strength of concrete without addition of fiber (ie) 6.83 MPa which is 16.75% greater than control mix. The M6 mix which is with fiber give maximum tensile strength of concrete without addition of fiber (ie) 6.97 MPa which is 19.14% greater than control mix.

Water absorption test shows that when more pozzolanic material is added the tends to decrease in water absorption about 0.1 to 0.18%. The inclusion of fiber increases the load carrying capacity for M6 beam about 25% compared with the Control specimen M1 and with the optimum SF content of 15 % the increment is 14%. The initial crack is delayed when compared with the beams without inclusion of fibers.

REFERENCES

1. ***H. Abdul Razak. and H.S. Wong, (2012),*** *"Re Evaluation of Strength and Stiffness Relationships for High-Strength Concrete",Asian Journal of Civil Engineering (building and housing) Vol. 5, Nos 1-2(2012)" pp. 85-99.*
2. ***S. Bhanjaa,, B. Sengupta(2015),"*** *Influence of silica fume on the tensile strength of concrete" "Cement and Concrete Research 35 (2015)" pp.743–747.*
3. ***J.M.R. Dotto, A.G. de Abreu, D.C.C. Dal Molin, I.L. Meuller (2014),*** *"Influence of silica fume addition on concretes physical properties and on corrosion behaviour of reinforcement bars" "Cement & Concrete Composites 26 (2014)" pp.31–39.*
4. ***R. Duval and E.H. Kadri(2011),*** *"Influence of Silica fume on the Workability and the Compressive Strength of High-Performance Concretes" "Cement and Concrete Research, Vol. 28, No. 4(2011)" pp. 533–547.*
5. ***M.I. Khan, C.J. Lynsdale(2013)*** *"Strength, permeability, and carbonation of high-performance concrete, "Cement and Concrete Research 32 (2013)" page no. 123–131*
6. ***M. Mazloom , A.A. Ramezanianpour , J.J. Brooks (2014)*** *"Effect of silica fume on mechanical properties of high-strength concrete", "Cement & Concrete Composites 26 (2014)" pp. 347–357*
7. ***IS 10762-1982*** *"Recommended guidelines for concrete mix design" bureau of Indian standards, New Delhi.*
8. ***IS.456:2000*** *Plain and reinforced concrete –code of practice.*