Mechanical Properties on Concrete Using Polypropylene Fiber and Silica Fume

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Abstract: ***Aim of this study to determine Compressive strength, Tensile strength and Flexural strength of M20 grade concrete with use of polypropylene fibre and silica fume. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with mineral & chemical admixtures can improve the strength characteristics of concrete. Silica fume can be utilized to produce high strength and durable concrete composites. The Concrete specimens were cured on normal moist curing under normal atmospheric temperature. The Compressive strength determined at 7, 14 and 28 days as well as tensile strength, Flexural strength. The addition of Polypropylene fiber by the weight of concrete shows an increase strength property and Silica fume as cement replacement material shows early long term strength. This system that is Ordinary Portland Cement - Polypropylene fiber -Silica fume concrete was found to increase the Compressive, Tensile strength and Flexural strength of concrete on all ages when compared to concrete made with Polypropylene fiber and Silica fume.It was also noted that the highest compressive strength and flexural strength have been achieved by 10% replacement of silica fume with cement at all ages.***

Keywords: Compressive strength, flexural strength, Polypropylene fiber(PPF), silica fume(SF) concrete, split tensile strength

1. Introduction

Mineral admixture are widely used in concrete for various reasons especially for reducing the amount of cement required for making concrete which shows to a reduction in construction cost. Moreover most pozzolanic materials are byproduct materials. The use of these materials shows the reduction in waste, freeing up valuable land, save in energy consumption to produce cement and save the environment. Durability of portland cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, fire or another process of deterioration. In other words, cement concrete will be termed durable, when it keeps its form and shape within the allowable limits, while exposed to different environmental conditions. Durability of concrete has been a major concern of civil engineering professionals. Also, it has been of considerable scientific and technological interest over the last few decades [1, 2]. The American concrete institute (ACI) defines silica fume as a ‘‘very fine noncrystalline silica produced in electric arc furnaces as a byproduct of production of elemental silicon or alloys containing silicon’’. Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey colored powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementitious properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. Addition of silica fume to concrete improves the durability of concrete and also in protecting the embedded steel from corrosion. When fine pozzolana particles are dispersed in the paste, they generate a large number of nucleation sites for the precipitation of the hydration products. Therefore, this mechanism makes the paste more homogeneous and dense as for the distribution of the fine pores. This is due to the reaction between the amorphous silica of the pozzolanic and the calcium hydroxide produced by the cement hydration reactions [3].Silica fume is a byproduct and it is the most beneficial uses in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana. Concrete containing silica fume can have very high strength and can be very durable. In this paper the advantages of using silica fume in concrete in partial replacement of cement are found. The present experimentation has been carried out to determine the mechanical properties of conventional concrete and concrete using silica fume. Suitability of silica fume has been discussed by replacing cement with silica fume at varying percentage and the strength parameters were compared with conventional concrete.

2. Materials

2.1 Cement

The cement used in this experimental investigation is PPC manufactured by India cements. The basic properties were evaluated as per Indian specifications IS 8112-1989 and results were given in table 3.1.The following tests were conducted in accordance with IS codes.

Specific gravity (Le – Chatelier flask) (IS: 4031-1988 Part 11)
Fineness (IS:4031- 1996 Part 1)
Standard consistency (IS: 4031 – 1988 Part 4)
Initial setting time (IS: 4031 – 1988 Part 5)
Final setting time (IS: 4031 – 1988 Part 5)

Properties of Cement

• Initial setting time	85 minutes
• Final setting time	520 minutes
• Particle size	0.05 mm
• Specific gravity	2.90

2.2 Fine aggregate

Fine aggregate used in this investigation is clean river sand passing through 4.75mm sieve. The fine aggregate were tested, as per Indian Specifications IS 383-1970. The following tests were carried out on FA & CA as per IS codes.

Specific gravity (IS: 2386- 1968 Part 3).Sieve Analysis and Fineness Modulus (IS: 2386- 1968 Part 1)

Type : River sand
Specific Gravity : 2.5
Fineness Modulus : 2.94
Grading zone : Zone II

2.3 Coarse Aggregate

Coarse aggregate used in this investigation is locally available crushed aggregates having maximum size of 20mm. The coarse aggregate were tested, as per Indian Specifications IS 383-1970.

Type : Crushed
Specific Gravity : 2.72
Fineness Modulus : 7.164

2.4 Silica fume

The various physical properties of silica fume are;

Colour : Grey
Particle size : < 1 µm
Specific surface : 20000 m2/kg
Specific gravity : 2.2

2.5 Polypropylene fiber

Specific gravity = 0.91
Length = 10 – 20 mm
Melting point = 162 - 164°C

2.6 Water

Water conforming to as per IS: 456- 2000 was used for mixing as well as curing of concrete specimens.

2.7 CERAPLAST 300

Ceraplast300 disperses cement particles more rapidly in the concrete mix by reducing the surface tension of water and imparting repelling charges to the ions in solution. This makes the concrete highly workable and flowable even at lower water-cement ratios, resulting in increased strength. Conforms to ASTM C 494-9 type F and IS 9103-1999.

Supply form : liquid
Colour : Brown
Specific gravity : 1.2 ± 0.03
Chloride contents : nil

2.8 Mix Design

The following mix proportions were prepared as per IS 10262-2009 concrete with partial replacement of cement as silica fume and also including polypropylene fiber.

Table 1

Mix	Cement (Kg)	Water (Liters)	FA (Kg)	CA (Kg)	SF (Kg)	PP (Kg)	Admixture (Liters)
Control	372	186	695	1234	0	0	0
10% SF	297	154.2	673	1195	33	1.65	1.65
15% SF	280.5	140.2	720	1224	49.5	1.65	1.65
20% SF	270	130	725	1288	60	1.65	1.65

3. Experimental Procedure

The concrete has been placed in 150X150X150mm cube, 150mm diameter and 300mm high cylinder and 150mm X 200mmX1500mm beam moulds and vibrated with standard vibrator.

The 28 days characteristic compressive strength of concrete was 70.8 MPa and was used for casting the beam specimens. The beams were reinforced with two bars of 10mm face diameter at the compression face and two bars of 12mm diameter at the tension having yield strength of 436 MPa. The transverse reinforcement was provided with 8mm diameter having yield strength of 289 MPa spaced at 150mm spacing.

Curing regime has been taken as 24 hours in mould with clothes at (20 – 24)0 C followed by under water curing until the day of testing.

In the fresh state, compaction factor of each mix have been measured. In hardened state, 7 days and 28 days compressive strength of cubes and cylinder, split tensile strength and flexural strength have been measured.

4. Results and Discussion

A. Hardened State

1) Compressive Strength

Figure 1 when cement is replaced by 10% SF, the maximum 7 days cube compressive strength observed as 10.56 MPa,14 days strength obtained as 18.48 MPa and 28 days strength obtained as 26.99 MPa.

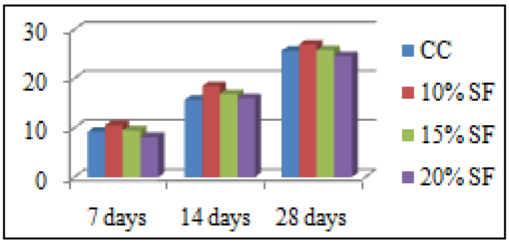

Figure 1

2) Tensile Strength of Cylinders

When cement is replaced by 10% SF, the maximum 7 days as 1.49 MPa,14 days strength obtained as 1.91 MPa and 28 days cylindrical compressive strength are found to be 2.89 MPa respectively when cement is replaced by SF as shown in figure 2.

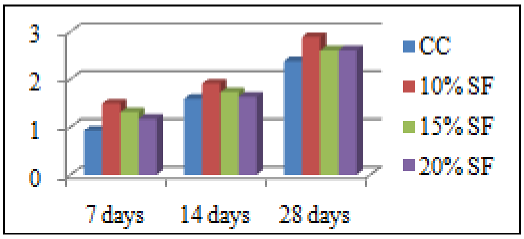

Figure 2

3) Flexural Strength of Beam

When cement is replaced by 10% SF, the maximum 7 days as 3MPa, 14 days strength obtained as 3.35 MPa and 28 days beam compressive strength are found to be 3.8MPa respectively when cement is replaced by SF as shown in figure 3.

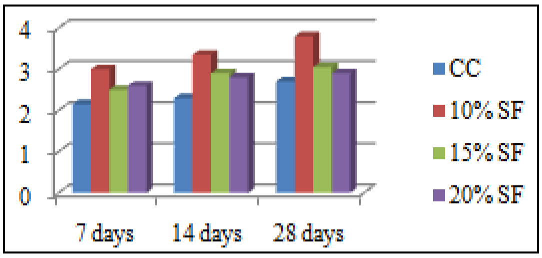

Figure 3

A total number of 4 beams were cast in each category and tested under four-point bending test. The investigation was mainly focused on load carrying capacity, deflection and ductility of the beams. The experimental test results of load and deflection at first crack, yield and ultimate stages of the beams. The ultimate load and its corresponding deflection is presented in Fig.

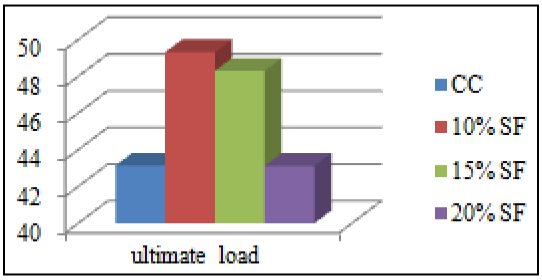

Figure 4

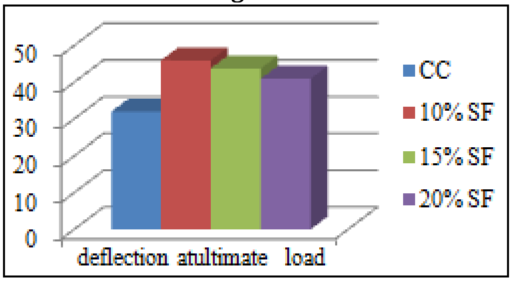

Figure 5

B. Ductility of Beams

An important parameter is to be considered in a structure is the ductility and it can be defined as its ability to sustain inelastic deformation without loss in load carrying capacity, prior to failure. The deflection ductility can be obtained as the ratio of mid-span deflection at ultimate load to the mid-span deflection at yield load. The ductility index was calculated for the tested beams.

Table 2

Specimen	Deflection at yield load	Deflection at ultimate load (mm)	Deflection Ductility	Deflection Ductility ratio
CC	20.69	32	1.57	1.00
10% SF	20.61	45	2.51	50.25
15% SF	20.59	43.80	2.22	41.40
20% SF	20.50	41	2.00	30.12

5. Conclusions

From the results it is conclude that the silica fume is a better replacement of cement. The rate of strength gain in silica fume concrete is high. After performing all the tests and analyzing their result, the following conclusions can be derived:

1) From this study, Mix design for M_{20} grade concrete was prepared. From the trial design mix, the selected cement content and water cement ratio are 300kg/m^3 and 0.5.The compressive strength of cube at 28 days is 16 N/mm^2.
2) The utilization of productive silica fume with polypropylene fiber will increases the strength characteristics in concrete.
3) Compressive strength and flexure tensile strength of concrete improves by addition of silica fume at all the ages. Incorporation of 10% silica fume resulted in highest compressive strength and flexural strength at all ages, however, with addition ,20% silica fume compressive strength and flexural strength decreased at all ages because there was not enough calcium hydroxide present in the mixture to continue the pozzolanic reaction.
4) If silica fume is used as an addition, there is no deleterious effect on early strength and it is noticeable strength increase on following moist curing periods of 7, 21 and 28 days.
5) As strength of 15% replacement of cement by silica fume is more than normal concrete.
6) The optimum silica fume replacement percentage is varies from 10 % to 15 % replacement level.
7) Workability of concrete decreases as increase with % of silica fume.
8) Compressive strength decreases when the cement replacement is above 15% of silica fume.

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