

STUDY OF MECHANICAL PROPERTIES OF HIGH PERFORMANCE CONCRETE USING SILICA FUME AND ROBO SAND

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ABSTRACT:

In the engineering industry, the improvement of existing materials allows for technology advancement and the construction of more reliable structures without over design. High Performance Concrete (HPC) is a widely utilized material in heavy structures, construction. This paper given the characteristics of HPC and the influence of strength.HPC is a concrete meeting special combination of performance and uniformity with normal mixing.

In this paper, we used two grades of concrete, which are high strength concretes, M_{40} and M_{50} . We have used to the mineral admixtures are Silica fume and Robo sand contributed by various reputed industries in India. The reduction in the source of natural sand (quarry dust) and for reducing the production cost of concrete it needs to identify alternative material substitute to sand as fine aggregate in the production of concrete. Attempts have been study to the mechanical properties of concrete and investigate some properties of quarry dust and silica fume, and the properties of those suitable materials to enable them to be used as partial replacement materials for sand and cement relative in concrete.

Keywords: Compressive strength, Concrete, Silica Fume, ROBO Sand (Quarry dust)

I. INTRODUCTION

Concrete is the mostly used material in various types of construction, from the flooring of a hut to a multi storied high rise structure, pathway to runway of an airport, underground tunnels, deep sea platforms, high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of economy and performance while greatly varying from architectural masterpieces to the simplest utilities. It is difficult consider to another material of construction which is versatile as concrete material. [1 and 2].

Invention of large plant of constructions and construction equipments around the world added to the increased need of material. This leads to the use of alternative additive materials to enhance the quality of concrete in construction. As an outcome of the investigation and researches, cement based concrete which having special quality performance with respect to strength, workability and durability is known as “HIGH PERFORMANCE CONCRETE” was developed.

The use of large quantities of concrete, it's used for large amount of cement produces increasing CO₂ emissions and also major for the Green House Effect in Environment. The requirement of reduction of source of cement content in concrete mixes is replacements with other Pozzolanic materials. In recent investigations it is

recognized that the use of silica fume as a mineral admixture enhances the strength properties and durability of concrete. The use of Robo sand (Quarry Dust) as partial replacement for sand, reduces the natural sand in concrete production and also reduces cost of concrete. As a result it is identified to find the alternative suitable material substitute to sand as fine aggregates in the production of concretes [3 and 4].

1.1 Silica Fume

Silica fume define as “very fine non-crystalline silica particle, which is produced in electric arc furnaces as a by-product of the production of alloys or elemental silicon containing silicon”. It is usually a gray colored, some similar properties to Portland cement or some fly ashes [5].

Silica fume is usually categorized as a supplementary cementitious material. This term refers to materials that are used in concrete in addition to Portland cement. These materials can exhibit the following properties:

- a) Cementitious - will gain strength when mixed with water
- b) Pozzolanic and Cementitious - a combination of both properties.

1.2 Silica Fume Properties and Reactions in Concrete

Silica fume affects both the fresh and hardened properties of concrete. The effects on concrete are a result of the physical and chemical properties of silica fume.

- a) Chemical Properties
- b) Physical Properties
- c) Reactions in Concrete
- d) Comparison with Other Supplementary Cementitious Materials.

1.3 Chemical Properties of Silica Fume

- a) Amorphous
- b) Silicon dioxide >85%
- c) Trace elements depending upon type of fume.

1.4 Robo Sand

Robo sand (Quarry dust) is one type of sand manufactured in the quarries of stone. It is a substitute material for the river sand used in production of concrete in construction. River sand, which is one of the constituents material used in the concrete production, has become expensive and scarce recourses. So there is higher demand for the alternative materials used in the fine aggregates.

The production of Quarry dust from the granite crushers is one of the alternative source materials for river sand. The utilization of Quarry dust can be known as Robo sand, it has been accepted as construction materials. Number of research has been done regarding the Robo as alternative materials for river sand. They have used the Robo sand of particle size passed through 75 microns sieve.

II. EXPERIMENTAL DETAILS

2.1 Purpose of the Experiment

In the present paper work, it is planned to conduct lab Experiment using both mineral and chemical admixtures in different proportions, for two concrete grades are M_{40} and M_{50} .

The main benefit of this Experiment is to develop the properties of the construction material to use mineral and chemical admixtures in relevant proportions in civil engineering constructions.

The following Experimental tests were conducted on the concrete specimens:

- Compressive strength
- Split tensile strength
- Flexural strength

2.1.1 Test Program

The cubes and cylinders are of standard sizes with dimensions 150mmx150mmx150mm and 150mm x300mm.

2.1.2 Testing of Materials

In the present investigation the following materials were used.

- Zuari -43 grade cement confirming to IS: 12269-1987.
- Fine aggregate and coarse aggregate confirming to IS: 383-1970.
- Admixtures

2.2 Materials Used in Present Project and their Properties

2.2.1 Cement

It is a binding material. It is the combination of two raw materials called calcareous and argillaceous. Birla Super 43-grade Portland pozzolana cement grade ordinary Portland cement confirming to IS: 12269-1987 was used in concrete.

Table 1: Properties of Cement

S.NO	PROPERTY	VALUES
1.	Fineness of Cement	225 m ² /kg
2.	Specific gravity	3.05
3.	Normal consistency	33%
4.	Setting Time	
	a)Initial setting time	39mints
	b) Final setting time	6 hours

2.2.2 Aggregate

As coarse aggregate crushed granite rock of 20mm maximum size was used. The fineness modulus is found for fine aggregate and the fineness modulus of coarse aggregate is also found.

Table 2: Physical Properties of Aggregate

Specific gravity of fine aggregate	2.64
Specific gravity of coarse aggregate	2.48

2.2.3 Fine Aggregate

The fine aggregate was passing through 4.75 mm sieve and had a specific gravity values is kept 2.64. The Zone of grading of fine aggregate was zone II as per Indian Standard specifications.

2.2.4 Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock the coarse aggregate maximum size of 20 mm and specific gravity of 2.48 [6 and 7].

2.2.5 Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalies, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

2.2.6 Mineral Admixtures

The finally these mineral admixtures which can be used to replace cement partially can be used as minerals admixtures like silica fume and robo sand in this project.

2.2.6.1 Silica Fume

Silica fume is a by-product of producing elemental silicon metal or ferrosilicon alloys, its production by using electric arc furnaces. Usually; these alternative materials have no impact on the performance of silica fume in concrete.

Table 3: Physical Properties of Silica Fume

S.NO	DESCRIPTION	VALUES
1.	Particle size (typical)	< 1 μm
2.	Bulk density (as-produced) (densified)	130 to 430 kg/m^3 480 to 720 kg/m^3
3.	Specific Gravity	2.2
	Specific Surface	15,000 to 30,000 m^2/kg

2.2.6.2 Robo Sand

Robo sand (quarry dust) is sand manufactured in the stone quarries. Number of research has been done regarding the Quarry dust as alternative materials for river sand. They have used the crusher dust of size which has been passed through 75 micron. ROBO sand are obtained from granite crushers was used in present concrete to cast the cubes and cylinders. The bulk density of ROBO sand is 1768 kg/m^3 and the specific gravity is 2.45 and the fineness modulus is 3.02.

2.2.6.3 Chemical Admixture

Super plasticizer used in the present work.

2.3 Experimental Investigation

In this experimental investigation, high strength grade of concretes M_{40} & M_{50} are studied by using alternative materials of Silica fume as partial replacement with cement and Robo sand as partial replacement with the fine aggregate. Cubes & Cylinders were cast with grade of concretes M_{40} and M_{50} .

2.3.1 Compressive Strength

Compression test is the most common test conduct on hardened concrete, it can be easy test to perform the concrete strength, and the most of the desirable characteristic of concrete properties are qualitatively related to its strength of compressive test.

The specimen of the cubes $150\text{mm} \times 150\text{mm} \times 150\text{mm}$ was cast to test various concrete mixtures for compressive strength. The cubes after the moulding were stored in curing tanks and on removal of cubes from water at 3,7,28

days and 90 days the compressive strength was conducted. The water and grit on the cubes was removed before testing the cubes. The test was carried as per IS:516-1959.

Using the formula the compressive strength is

$$1. \text{ Compressive strength } f_c = P/A$$

Where f_c = Compressive Strength in N/mm^2

P = Cube load in N

A = cross section area of cube in mm^2

2.3.2 Splitting Tensile Strength

Splitting tensile test is the most common test conduct on hardened concrete, it can be easy test to perform the concrete strength, and the most of the desirable characteristic of concrete properties are qualitively related to its strength of split tensile test.

The cylinder specimen of 150mmx 300 mm was cast to test various concrete mixtures for tensile strength. The cylinders after the moulding were stored in curing tanks and on removal of cubes from water at 28 days the split tensile strength was conducted. The water and grit on the cylinders was removed before testing the cubes.

Using the formula the compressive strength is

$$1. \text{ Split tensile strength} = 2P / (\pi dl) \text{ in } N/mm^2$$

Where P = cylinder load in N

πdl = surface area in mm^2

2.4 Results and Discussion

2.4.1 Compressive Strength Test

The program of the experimental was designed to compare the properties of high strength concrete i.e., Compressive Strength of Cubes 150mmx150mmx150mm with high strength grade of concrete mix design M40 and M50 and with different replacement levels of Ordinary Portland cement with Silica Fume and Robo sand.

Table 4: Test Results For M₄₀ Grade of Concrete

S.NO	Mix Description	Compressive Strength of Cubes in N/mm^2			
		3 days	7 days	28 days	90 days
1.	0% S.F+100% C.C	21.78	32.00	49.19	51.56
2.	5% S.F+95% C.C	22.81	36.59	52.44	54.22
3.	10% S.F+90% C.C	24.74	39.11	56.74	58.96
4.	15% S.F+85% C.C	25.04	40.00	58.96	60.89
5.	20% S.F+80% C.C	24.00	38.67	56.56	58.67
6.	25% S.F+75% C.C	23.11	37.78	55.70	57.48

Table 5: Test Results For M₄₀ Grade of Concrete

S.NO	Mix Description	Compressive Strength of Cubes in N/mm ²			
		3 days	7 days	28 days	90 days
1.	15% S.F+0% R.S	25.78	41.19	59.56	61.78
2.	15% S.F+5% R.S	25.93	42.07	60.74	62.22
3.	15% S.F+10% R.S	24.89	40	59.11	61.93
4.	15% S.F+15% R.S	24.59	33.78	45.78	58.37
5.	15% S.F+20% R.S	24	33.48	49.78	51.56
6.	15% S.F+25% R.S	20.89	30.22	45.19	49.19
7.	15% S.F+30% R.S	18.67	26.22	43.56	47.56

Table 6: Test Results For M₅₀ Grade of Concrete

S.NO	Mix Description	Compressive Strength of Cubes in N/mm ²			
		3 days	7 days	28 days	90 days
1.	0% S.F+100% C.C	25.19	39.11	57.93	59.56
2.	5% S.F+95% C.C	26.07	40	60.30	62.96
3.	10% S.F+90% C.C	28.00	41.19	61.78	63.85
4.	15% S.F+85% C.C	29.04	42.22	64	65.78
5.	20% S.F+80% C.C	28	41.04	62.52	64.74
6.	25% S.F+75% C.C	27.11	40.74	60.89	63.26

Table 7: Test Results For M₅₀ Grade of Concrete

S.NO	Mix Description	Compressive Strength of Cubes in N/mm ²			
		3 days	7 days	28 days	90 days
1.	15% S.F+0% R.S	29.78	42.96	65.33	66.37
2.	15% S.F+5% R.S	30.52	45.93	66.22	68.15
3.	15% S.F+10% R.S	27.56	44	64.89	68
4.	15% S.F+15% R.S	26.67	36.89	55.11	64.15
5.	15% S.F+20% R.S	26.37	36.59	54.37	57.33
6.	15% S.F+25% R.S	22.37	32.74	49.78	54.81
7.	15% S.F+30% R.S	20.44	29.19	47.85	52

2.3.2 Split Tensile Strength Test

The test results of split tensile strength of design mix M₄₀ and M₅₀ on standard 150x300mm cylinder at 28 days age obtained are tabulated in the table.

Table 8: Test Results for M₄₀ Grade of Concrete

SL.NO.	Mix Description	Split tensile strength of cylinders in N/mm ²						
		C.C	5%	10%	15%	20%	25%	30%
1.	C.C+S.F	4.10	4.48	4.53	4.67	4.95	4.43	-
2.	S.F+R.S	4.81	5.00	4.62	4.57	4.34	4.2	4.1

Table 9: Test Results for M₅₀ Grade of Concrete

SL.NO.	Mix Description	Split tensile strength of cylinders in N/mm ²						
		C.C	5%	10%	15%	20%	25%	30%
1.	C.C+S.F	4.81	5	5.14	5.23	5.38	4.95	-
2.	S.F+R.S	5.71	5.61	5.05	4.86	4.72	4.53	4.39

2.3.3 Observations and Discussion on Compressive and Splitting Tensile Strength

It has been observed that with the addition of silica fume and Robo sand, the compressive strength of concrete at the age of 3,7,28 and 30 days has conducted and has increased with various proportions of the mix and also conducted splitting tensile strength of concrete at the age of 28 days has increased with various proportions. The increased strength range 15% S.F - 20% R.S for M₄₀ grade of concrete and also 15% S.F – 15% R.S for M₅₀ grade of concrete.

GRAPHICAL REPRESENTATION FOR M₄₀ & M₅₀ MIX FOR 3,7,28 AND 90 DAYS

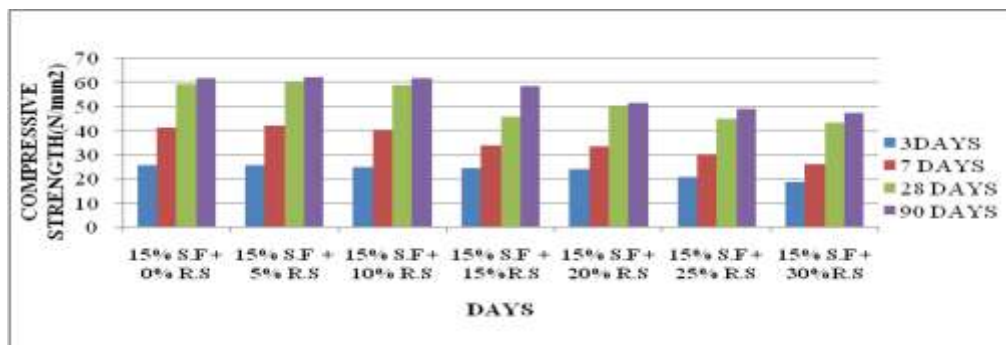


Fig.1

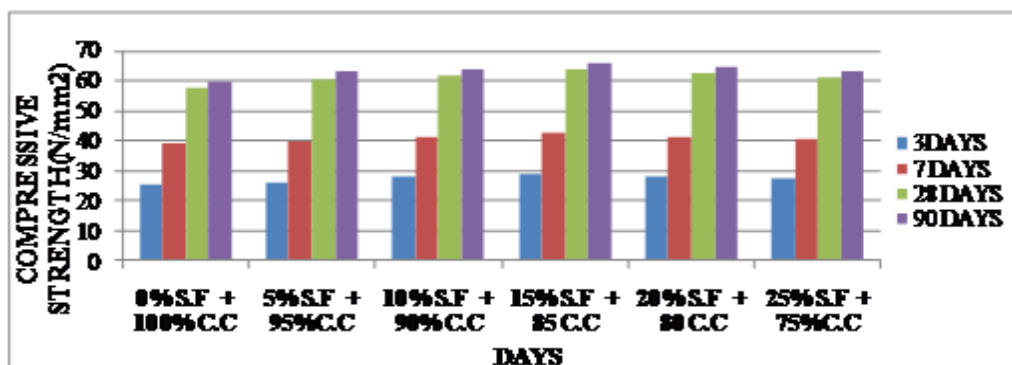


Fig.2

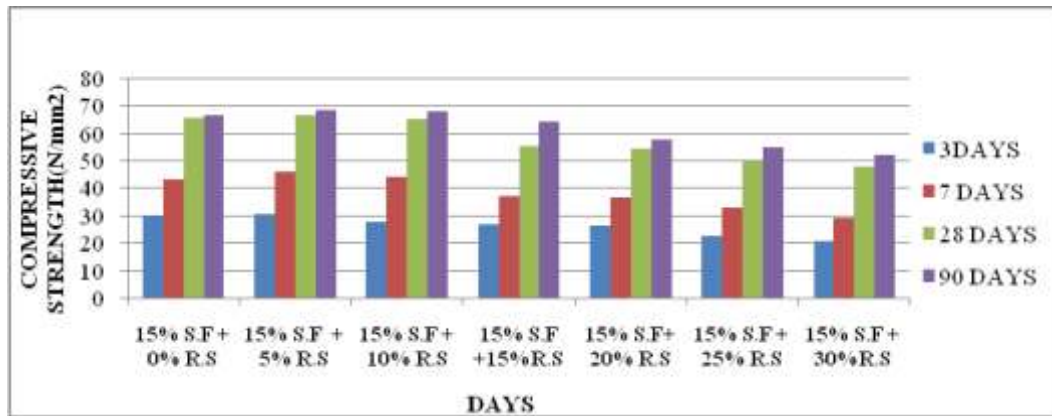


Fig.3

III. CONCLUSION

Based on the present experimental investigation, the following conclusions are drawn.

1. In HIGH PERFORMANCE CONCRETE design of mix proportion, as water- cement ratio adopted is low value, super plasticizers are necessary required to maintained workability.
2. In concrete grade of M_{40} , the water-cement ratio of 0.4 is insufficient for providing good Workability, hence super plasticizers are necessary for those grades of concrete.
3. For M_{40} grade with silica fume of 15%, the percentage increase in compressive strength, and split Tensile strength is maximum.
4. For M_{50} grade with silica fume of 15%, the percentage increases in compressive strength and split tensile strength is maximum.
5. It is observed that for M_{40} grade of concrete the maximum compressive strength is achieved at 15% replacement of silica fume and 10% replacement of ROBO sand.

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REFERENCES

- [1]. Indian standard code recommended by the method of concrete Mix Design (IS: 10262-2009).
- [2]. M.S.Shetty, concrete technology & practice, published by S.Chand & Company, 5th edition.
- [3]. N. Krishna Raj, Design of concrete mix published by 4th edition.
- [4]. The author of Venkatesh Babu DL, Natesvan SC. Some investigations of Silica fume replacing by concrete, The Indian Journal of publication, September 2004, pp. 57-60.
- [5]. Gaitero, J. J., I. campillo, and A. Guerrero. Reduction of the Calcium Leaching Rate of Paste of Cement by Addition of Nano silica particles. Cement and Concrete Research, Vol. 38, 2008, pp. 1112-1118.
- [6]. Constantinides, G., and F.-J. Ulm., The Effect of Two Types of C-S-H on the cement Elasticity -Based Materials: Results from Nanoindentation and Micromechanical Modeling. Cement and Concrete Research, Vol. 34, 2004, pp. 67-80.

- [7]. Constantinides, G., F.-J. Ulm and K. van Vliet. On the Use of Nano- indentation for Cementitious Materials. *Materials and Structures/ Matériaux et Constructions*, Vol. 36, No. 257, 2003, pp. 191–196.
- [8]. A.K. Mullick “Performance of with Binary cement blends” the *Indian Concrete Journal*, January 2007.
- [9]. Surendra P. Shah, et al. “Controlling Properties of Concrete through Nano Technology” (ACBM Centre, North Western University, USA), *Proc. of the International Conference on advances in Concrete, ICI-ACECON 2010*, 5-9 Dec., IIT, Madras, India, PP 1-8.