EFFECT OF SILICA FUME ON HIGH STRENGTH HIGH VOLUME FLY ASH CONCRETE

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Abstract - Use of cement for making concrete has increased many folds in recent years. Cement causes pollution. To reduce its usage fly ash can be added in concrete as partial replacement of cement. Uses of fly ash as replacement of cement upto30% is approved in IS code books. Concrete having large volume of fly ash (usually above 50%) is termed as high volume fly ash concrete. Effort has been made to produce high volume fly ash concrete with silica fume. In concrete silica fume was added as admixture to produce high strength concrete. In this research work seven percentages of silica fume were used to prepare concrete cubes, cylinders, beams tests for compression, split tensile and flexural tests. The optimum addition of silica fume was found to be 10%. The high volume fly ash concrete with silica fume has better durability and flexural strength.

***Key Words*: Cement, Admixture, Silica, Concrete, Fly ash,Beams.**

1.INTRODUCTION

Cement is widely used in construction industry and has been in great demand all over the world. Cement production causes pollution at all stages of the manufacturing process. The amount of carbon dioxide emitted by cement industry is about 900kgs of carbon dioxide for every 1000kgs of cement production. To prevent this we can use fly ash which is a by-product from the thermal plants fly is left alone causes air pollution, land pollution and health issues to the humans. Use of fly ash in concrete is partial replacement of cement reduces these problems. More over fly ash is a cementitious material which improves the performance of concrete.

2. MATERIALS

2.1 CEMENT

Ordinary Portland cement (OPC) of grade 53 was used conforming to IS: 12269-2013. The initial setting time was found to be 30 minutes having a specific gravity of 3.10.

2.2 Sand (Fine Aggregate)

Sand is essentially quartz where clay is made of many other chemically active minerals like Illite, kaolinite, etc. Sand between 4.75 mm and 0.15 mm in size is called fine aggregate. Natural sand is available from local river beds or pits. An examination should made on the fineness of the sand and depends upon the fineness zone will be fixed. The fine aggregate used in the experimental were conformed to IS: 383-1970 specifications.

2.2 Coarse Aggregate

Coarse aggregate are used for making concrete. They may be in the form of irregular broken stone or naturally occurring rounded gravel. Material which are large to be retained on 4.7mm sieve size are called coarse aggregates. Coarse aggregate for structural concrete consists of broken stones of hard rock like granite. The coarse aggregate used in the experimentation were about 20mm in size and tested as per IS: 383-1970 specifications.

2.3 Fly Ash

Fly ash is used as a supplementary cementitious material (SCM) in the production of Portland cement concrete. A supplementary cementitious material, when used in conjunction with Portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. As such, SCM's include both pozzolans and hydraulic materials. A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but that will, in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties. Pozzolans that are commonly used in concrete include fly ash, silica fume and a variety of natural pozzolans such as calcined clay and shale, and volcanic ash. SCM's that are hydraulic in behaviour include ground granulated blast furnace slag and fly ashes with high calcium contents (such fly ashes display both pozzolanic and hydraulic behaviour). The potential for using fly ash as a supplementary cementitious material in concrete has been known almost since the start of the last century (Anon 1914), Historically, fly ash has been used in concrete at levels ranging from 15% to 25% by mass of the cementitious material component. The actual amount used varies widely depending on the application, the properties of the fly ash, specification limits, and the geographic location and climate. Higher levels (30%

to 50%) have been used in massive structures (for example, foundations and dams) to control temperature rise. In recent decades, research has demonstrated that high dosage levels (40% to 60%) can be used in structural applications, producing concrete with good mechanical properties and durability. Increasing the amount of fly ash in concrete is not without shortcomings. At high levels problems may be encountered with extended set times and slow strength development, leading to low early-age strengths and delays in the rate of construction. These drawbacks become particularly pronounced in cold-weather concreting. Also, the durability of the concrete may be compromised with regards to resistance to dicer-salt scaling and carbonation. For any given situation there will be an optimum amount of fly ash that can be used in a concrete mixture which will maximize the technical, environmental, and economic benefits of fly ash use without significantly impacting the rate of construction or impairing the long term performance of the finished product. The optimum amount of fly ash will be a function of wide range of parameters and must be determined on a case- by-case basin. For the present research work Class-F fly ash was taken from Gummidipoondi thermal plant as per pulverized fuel ash-specification given under the Indian standard code IS: 3812(part-1): 2003.

Table -1: Classification of fly ash

Dosage Level of Fly Ash	
Level of fly ash % by mass of total cementitious material	**Classification**
<15	Low
15-30	Moderate
30-50	High
>50	Very high

2.4 Silica Fume

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Silicon metal and alloys are produced in electric furnaces. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete.

Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO_2 content, silica fume is a very reactive pozzolan when used in concrete. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

Silica-fume concrete with low water content is highly resistant to penetration by chloride ions. More and more transportation agencies are using silica fume in their concrete for construction of new bridges or rehabilitation of existing structures. Silica-fume concrete does not just happen. A specifier must make a conscious decision to include it in concrete to achieve desired concrete properties. Assistance in specifying silica-fume concrete for high strength or increased durability can be obtained from the silica fume or from major admixture suppliers.

2.5 Water and super plasticizer

Potable water is used for making concrete and super plasticizer used was Ceraplast 300.

3. MIX PROPORTION

3.1 Mix proportion for conventional concrete using (ACI.211.4R-93)

Table-2 Mix proportion for 1m^3 conventional concrete

cement	Fine aggregate	Coarse aggregate	water	Super plasticizer
557.66	580.5	1179.36	162.84	4.461
1	1.04	2.11	0.29	0.007

3.2 Mix proportion for high volume fly ash concrete using (ACI.211.4R-93)

The following design procedure for the conventional concrete can be seen in Appendix A (page no: 32).

Table-4 Mix proportion for 1m^3 high volume fly ash concrete

Cement + Fly ash	FA	CA	water	Super plasticizer
278.83+278.83 = 557.66	528.40	1179.36	162.84	4.461
1	0.947	2.11	0.29	0.007

4. TEST RESULTS

4.1 COMPRESSIVE STRENGTH

For compressive strength test, cubes specimens of dimensions 150mmX150 mmX150mm were cast for M60 grade of concrete. The moulds were filled. Vibration was given to the moulds using table vibrator. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where they were allowed to cure for 7 , 28 , 56 & 90 days. After 7, 28, 56 & 90 days curing, these cubes were tested on compression testing machine as per IS: 516(1959). The failure load was noted. In each category three cubes were tested andtheir average value is reported.

Table -5: Results of Compression Test

Sl. No	Mix designation	Compression strength(N/mm^2)			
		7 days	28 days	56 days	90 days
1	CONVENTIONAL	53.33	59.60	-	-
2	HVFA50% & SF 0%	18.09	24.75	28.40	42.08
3	HVFA50% & SF5%	23.40	30.97	32.35	46.57
4	HVFA50% & SF10%	25.12	34.40	37.12	53.79
5	HVFA50% & SF15%	20.47	31.26	32.37	46.84
6	HVFA50% & SF20%	21.22	31.57	34.06	47.43
7	HVFA50% & SF25%	23.50	32.21	35.45	47.91
8	HVFA50% & SF30%	23.70	33.97	36.87	50.64

From the above table we can observe that HVFA concrete with 10% SF gives higher strength of 53.79N/mm^2 at 90 days which is near to the conventional concrete's strength of 59.60 N/mm^2 at 28 days.

4.2 SPLIT TENSILE TEST

In the following table we are going to see the results of the split tensile test and discuss them in details.

Table-6 Results of Split Tensile Test

Sl. no	Mix designation	Split tensile strength(N/mm^2)			
		7 days	28 days	56 days	90 days
1	CONVENTIONAL	3.61	4.23	-	-
2	HVFA50% & SF0%	2.78	2.9	3.17	3.39
3	HVFA50% & SF5%	2.85	3.13	3.39	3.81
4	HVFA50% & SF10%	2.94	3.32	3.67	4.22
5	HVFA50% & SF15%	2.79	3.14	3.3	3.74
6	HVFA50% & SF20%	2.80	3.17	3.38	3.88
7	HVFA50% & SF25%	2.84	3.23	3.42	3.95
8	HVFA50% & SF30%	2.88	3.28	3.57	4.14

4.3 FLEXURAL BEAM TEST

In the following table we are going to see the results of the flexural beam test and discuss them in details.

Fig.-1 Flexural beam test of specimen

Table-7 Results of Flexural Beam Test

SNo	Mix designation	Flexural strength (N/mm^2)			
		7 days	28 days	56 days	90 days
1	CONVENTIONAL	1.93	2.37	-	-
2	HVFA50% & SF0%	0.9	1.32	1.47	1.56
3	HVFA50% & SF5%	1.2	1.41	1.63	1.85
4	HVFA50% & SF10%	1.34	1.6	1.93	2.21
5	HVFA50% & SF15%	1.185	1.40	1.55	1.73
6	HVFA50% & SF20%	1.16	1.49	1.62	1.79
7	HVFA50% & SF25%	1.21	1.51	1.69	1.86
8	HVFA50% & SF30%	1.27	1.56	1.87	2.03

From the above table we can observe that HVFA concrete with 10% SF gives higher strength of 2.21N/mm^2 at 90 days which is almost equal to the conventional concrete's strength of 2.37N/mm^2 at 28 days.

5. CONCLUSION

The following conclusions have been taken from the present investigation

1. Addition of 10% silica fume to high volume fly ash (HVFA) concrete gives higher strength.
2. The strength of the fly ash concrete decreases with increase in fly ash content. By adding silica fume we can increase the strength.
3. High volume fly ash concrete with 10% of silica fume at 90 days gives nearly the same strength as that of conventional concrete at 28 days.
4. Addition of silica fume to HVFA concrete in excess of 10% also decreases the strength.
5. By using 50% fly ash as partial replacement reduction in cost can be achieved.
6. Both Conventional concrete and optimized silica fume concrete shows negligible chloride ion penetration, but silica fume concrete showed much more resistance to chloride ion penetration than Conventional concrete.

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