Study of Compressive Strength of High Volume Fly Ash Concrete with Varying Proportion of Fly Ash and Silica Fume

Srila Dey
Assistant professor, Department of Civil Engineering, Batanagar Institute of Engineering, Management and Science
(A unit of Techno India Group), Kolkata-700141, West Bengal, INDIA.

Abstract

Concrete is the most widely used construction material in the world. Fly Ash utilization is a global thinking as its addition to cement concrete supplements for durable concrete. Then the high volume fly ash has been used in many high rise buildings, industrial structures, water font structures, concrete roads and rolled compacted concrete dams. Addition of silica fume and Super plasticizer to high volume fly ash concrete found to increase the strength properties. Fly ash improves the quality of concrete, leading to the increased service life of concrete structures. Concretes having large amounts of fly ash (usually from 50%) are termed as high-volume fly ash (HVFA) concrete. Silica fume, which is found to be more reactive than the fly ash and it significantly, improves the strength of concrete. In the present investigation, an attempt is made to study the effect of compressive strength of high volume fly ash concrete with varying proportion of silica fume and fly ash. Cement is replaced by fly ash and silica fume 50 to 80% and 0 to 15% by weight respectively. The compressive strength development of silica fume modified high-volume fly ash mixes immersed in water up to 7 to 45 days is reported. As the water content is low in high volume fly ash concrete, the bleeding is very low and often negligible. Setting time is little longer than that of conventional concrete. This is because of low cement content, low rate of reaction and high content of super plasticizer. The investigation revealed that by maintaining a constant dosage of high performance super plasticizer along with fly ash and silica fume, it is possible to maintain a optimum slump value i.e. workability, thereby satisfying most of the modern structural applications. Also the isolated effect of silica fume on the high volume fly ash concrete with a water cement ratio of 0.40 has been studied. The results indicate that there is a remarkable increase in the compressive strength of concrete on replacement of cement by silica fume and fly ash and also obtained 10% replacement of silica fume by cement on high volume fly ash concrete gives higher compressive strength in the present investigation.

This document gives formatting instructions for authors preparing papers for publication in the Proceedings of an SSRG International Journals Journal. The authors must follow the instructions given in the document for the papers to be published. You can use this document as both an instruction set and as a template into which you can type your own text.

Keywords—*Cement, Compressive strength, Fly ash, High volume fly ash concrete, Silica fume, Super plasticizer, Workability.*

I. INTRODUCTION

The high volume fly ash (HVFA) concrete has become very popular in India during the last few decades due to various reasons, such as; to minimize consumption of Ordinary Portland Cement required producing high-quality concrete for different types of applications, performance, cost and practiciability.HVFA concrete is one of the solutions to eliminate the environmental degradations being caused by cement industry. Concrete having large amount of fly ash (FA) (usually from 50% of the total binder material) is termed as HVFA. It has been used in many high rise buildings, industrial structures, water front structures, concrete loads and roller compacted concrete dams. FA is one of the industrial by-products produced abundantly throughout the world. The physical properties of a FA contribute to improvement of concrete quality. Workability of concrete is improved with the addition of ash because of the increased in paste content, increase in the amount of fines, and the spherical shape of the FA particles. The use of FA may retard the setting of concrete. FA concrete is less permeable because FA reduces the amount of water needed to produce a given slump. The main contribution of the silica fume (SF) to the strength development in hardened concrete at normal curing temperatures takes place from about 3 days onwards. At 28 days the strength of SF concrete is always higher than the strength of the comparable Portland cement concrete. As the proportion of SF increases, the workability of concrete decreases nevertheless its short term mechanical property such as 28-day compressive strength improves.

II. MATERIALS AND METHODS

The methodology adopted comprised of both preliminary and experimental investigations carried out using the study material and these are presented as follows:

A. *Preliminary Investigations*

For the preliminary investigations, silica, Fly ash and cement was subjected to physical and chemical analyses to determine whether they are in compliance with the standard used. The present investigation is an effort towards developing a better insight into the effect of compressive strength on varying proportion of fly ash and silica fume concrete with a water cementitious material ratio of 0.40 and silica fume and fly ash replacement percentages of 0, 5, 10, 15% and 50, 60, 70, 80% respectively by weight of total binder with water reducing admixtures for opmizing its effect on concrete. The specimen of standard cubes 150 x 150 x 150 mm for 7, 28 and 45 day's compressive strength. Also tested non-destructive tests to find out compressive strength characteristics.

B. *Experimental Investigations*

1) Cement

Ordinary Portland cement (OPC) conforming to Indian standard code IS 8112-1995 was used.

2) Silica Fume (SF):

A high quality very active SF supplied by Elkem India Pvt Limited was used for the present study.

3) Fly Ash (FA):

A siliceous FA conforming to IS: 3812 (2003) Part – I (mixtures of I & II fields from ESP) from Kolaghat Thermal Power Plant was used.

4) Fine and Coarse Aggregate:

River sand confirming to Zone III of IS:383 and Crushed, angular graded coarse aggregate of 12.5 mm nominal maximum size as per IS:383 was used.
Water and Chemical Admixture: Potable water and Conplast SP-430was used.

C. *Fresh State Properties of HVFA:*

Slump flow and compaction factor test were performed in the laboratory to find workability.

D. *Compressive strength of HVFA:*

Compressive strength was determined in the lab using 150 mm3 concrete with 7, 28 and 45 days of moisture curing.

III. RESULTS AND DISCUSSION

Strengths were measured at 7, 28 and 45 days on samples of 150 x 150 x 150 mm cube specimens. The values at age levels of 7, 28 and 45 days have been presented in table. The table depicts the compressive strengths at different SF (0, 5, 10 and 15% by weight of cement) and FA (50, 60, 70, and 80% by weight of cement) replacements with water cement ratio of 0.40. The 7, 28 and 45 days moist curing gives higher compressive strength when cement replaced with 50% FA and SF of 0 to 15% than cement replaced with 60 to 80% FA and SF of 0 to 15% by its weight. In other hand, when cement is replaced with SF of percentage 0 to 15% with FA replacement of 50 to 80%, 10% replacement of SF gives higher compressive strength than 0, 5 and 15% SF. For FA of 50 to 80% with SF 0 to 15%, rebound number trends to increases continuously i.e. at initial replacements of FA and SF, rebound number decreases. In general, it is observed that at 10% SF replacement with FA 50 to 80%, rebound value increases. Higher Rebound value indicates that concrete mixes confirm to good quality as per IS: 13311 part II.

Increasing trends of silica fume shown higher USPV value, where fly ash kept constant for each silica fume percentages. Maximum and minimum values of USPV values have been obtained as 4.0 and 2.9km/sec respectively at 0.40 w/cm ratio. Compressive strength graphs are shown in figure 1 to 5.

Table 1:

Properties	Cement	Fly Ash	Silica Fume
Specyfic Gravity	3.15	2.09	2.2
Standard Consistency(%)	34	-	-
Initial Setting Time(Minutes)	240	-	-
Final Setting Time(Minutes)	300	-	-
Physical Form	-	Powder Form	Powder Form
Class	-	F	-
Chemical Composition (%)			
Silicon Di Oxide(SiO2)	25.02	60.78	88.7
Aluminium Oxide (Al2O3)	6.26	23.67	0.5-0.6
Ferric Oxide(Fe2O3)	1.24	6.76	0.3-0.6
Magnesium Oxide(MgO)	2.28	0.99	0.6-1.2

Table2: Physical and Mechanical Characteristics of Aggregates Used

Particulars	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.7	2.6
Water Absorption (%)	1.17	0.6
Bulk Density(t/m3)	1.63	1.61
Los Angeles Abrasion value (%)	27	-

Elongation index (%)	18	-
Flakinesss Index (%)	30	-

Table 3: Compressive Strength Results

Fly ash	Silica fume	Compressive Strength (Mpa)		
		7 Days	28 Days	45 Days
50	0	19.0	25.0	27.5
60	0	15.5	22.5	23.5
70	0	11.0	14.5	16.0
80	0	7.5	9.0	12.5
50	5	24	30.5	31.0
60	5	18.5	26.0	26.0
70	5	12.5	17.0	23.5
80	5	8.5	10.5	11.5
50	10	26.0	34.0	37.0
60	10	19.5	29.0	30.5
70	10	13.5	18.5	25.0
80	10	9.5	13.0	15.0
50	15	21.0	32.0	32.0
60	15	16.5	24.5	27.0
70	15	11.5	16.0	22.0
80	15	8.0	11.5	13.0

Table 4: Rebound Indices and Ultrasonic Pulse Velocity Results at 28 Days

Rebound Number (N)	USPV(km/sec)
34	3.7
35	4.0
42	4.4
39	4.2
36	3.5
37	3.8
38	3.9
36	3.6
38	3.3
35	3.4
36	3.5
30	3.6
23	2.9
25	3.1
26	3.4
24	3.2

Figures:

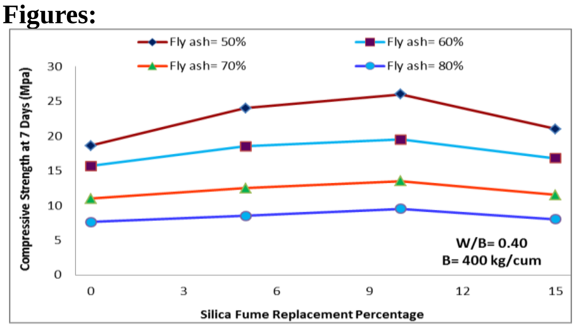

Fig.1: Relationship Between Compressive Strength At 7 Days And Different Silica Fume Replacement Percentage.

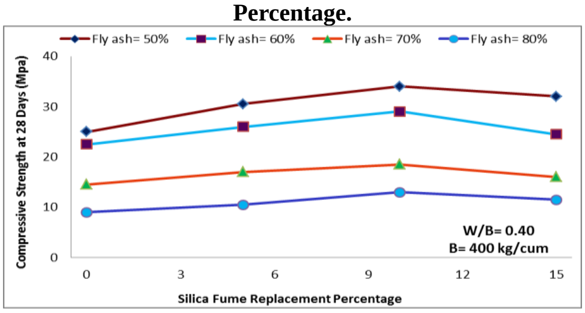

Fig.2: Relationship Between Compressive Strength at 28 Days and Different Silica Fume Replacement Percentage.

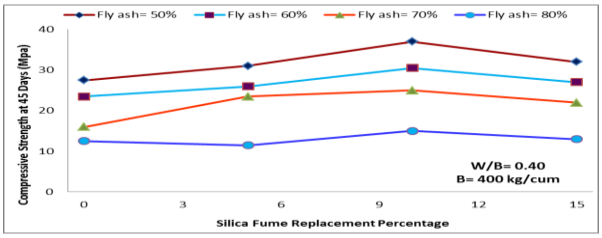

Fig.3: Relationship Between Compressive Strength at 45 Days And Different Silica Fume Replacement Percentages.

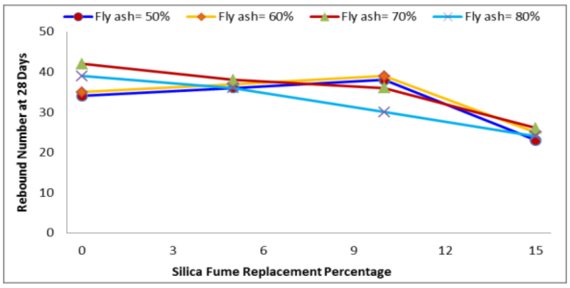

Fig.4: Relationships Between Silica Fumes and Rebound Number Replacement Percentages.

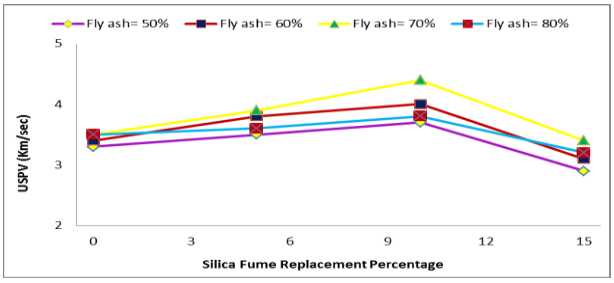

Fig.5: Relationship Between USPV and Silica Fume Replacement Percentage

IV. CONCLUSION

Following conclusions have been drawn up from the present investigation.

- Compressive strength of fly ash in concrete generally decreases due to addition of fly ash, while presence of silica fume in concrete increases the strength. In the present investigation cement is replaced by high volume fly ash as well as silica fume. So that strength of concrete is increased up to a certain level of silica fume and fly ash percentages.

- Replacement of cement by fly ash and silica fume in different proportions has resulted considerable variation in the properties of fresh concrete like cohesiveness, flow ability of the mix, segregation and reduced bleeding etc.
- It was also observed that cement replaced by silica fume and fly ash, gives higher strength at 50% fly ash and 10% silica fume.
- 10% addition of Silica fume is considered optimum which gives highest compressive strength.
- Generally addition of fly ash to the concrete decreases the workability while subsequent addition of silica fume increases the workability and strength characteristics. In present studies, both were used in concrete, so that workability is increased to an acceptable limit.
- As the silica fume percentage increases rebound values increases. However at 15% replacement level, the rebound value decreases marginally, indicating reduction in strength.
- For 80% fly ash replacement with all percentages of silica fume (0, 5, 10 and 15%) gives lower strength than concrete carrying fly ash 50, 60 and 70% with same percentages silica fume.
- As silica fume content is increased, ultra sonic pulse velocity values increases up to 10% silica fume replacement percentage. However at 15% level, the corresponding USPV value decreases marginally, indicating reduction of strength.
- For 10% silica fume with 50% fly ash replacement percentages, the strength at 28 days was 34 Mpa, where as the strength at 7 days and 45 days were 26 Mpa and 37 Mpa respectively.
- As silica fume content increases, USPV values increases up to 10% silica fume replacement percentage. However at 15% level, the corresponding USPV value decreases marginally.
- It is observed that as USPV increases, strength increases.

REFERENCES

[1] Dr. Seshadri Sekhar et.al "Studies on Relationship between Water/Binder Ratio and Compressive Strength of High Volume Fly Ash Concrete", American Journal of Engineering Research (AJER), 2013.

[2] S. LOKESH et.al "Effective Utilization of High Volume Fly ash with Light Weight Aggregate in Concrete for Construction Industry", International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 02, No. 04, October 2013.

[3] A.A. Elsayed; "Influence of Silica Fume, Fly Ash, Super Pozz, and High Slag Cement on Water Permeability and Strength of Concrete", Modern Academy for Engineering and Technology Cairo, EGYPT, Vol. 3 (4) – December 2012.

[4] V.M. Malhotra, "Super plasticized Fly Ash Concrete for Structural Applications", Concrete International 8 (12) (Dec. 1986) 28-31.

[5] M. Vaishnavi et.al "Durability of High Volume Fly Ash Concrete", International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 8, August – 2014.

[6] Alaa M. Rashad et.al "Effect of Silica Fume on Compressive Strength and Abrasion Resistance of HVFA Concrete", International Journal of Concrete Structures and Materials Vol.8, No.1, pp.69–81, March 2014.

[7] Ganesh Babu K et.al "Strength Properties of High Workable and High Volume Fly Ash Roller Compacted Concrete", Journal of Engineering Research and Studies.

[8] ACI Committee Report NO. 226, BR8 "Use of Fly ash" ACI Material Journal Sept/Oct 1987.

[9] S. Tanveer Hussain et.al "Study of Strength Properties of Concrete by using Micro Silica and Nano Silica", International Journal of Research in Engineering and technology eISSN: 2319-1163 | pISSN: 2321-7308.