International Journal of Research in Engineering, Science and Management
Volume-3, Issue-1, January-2020
www.ijresm.com | ISSN (Online): 2581-5792


# A Study on Strength and Behavior of High Performance Concrete

Naeem A. Tadavi[1], Sanjay N. Vasave[2], Komal V. Sonawane[3], Dipti A. Thakare[4], Roshani S. Pawara[5]
[1,2,3,4,5]*Student, Department of Civil Engineering, SSBT's College of Engineering and Technology, Jalgaon, India*

***Abstract*: As we know, with the advent of concrete civil engineering has touched the highest peak of the technology and now concrete is the most commonly used material in the various types of constructions, from the flooring of small house to high rise infrastructures. As cement is the seemingly simple but actually complex material, because its properties mainly depends upon proportional constituents used in concrete making, which responsible for enhancement of its qualities and properties. Hence from that phenomenon, we take advantage as enhancing its strength by using silica fume and create "High Performance Concrete".**

**As the silica fume is the byproduct obtained from industry can be utilized to improve the strength and durability of the high performance concrete and that causes reduction of potentially dangerous effects of the environment. The behavior of silica fume as fractional replacement to pozzolona portland cement (ppc) on the parameters such as compressive strength, split tensile strength etc. has been discussed in this paper and also the effect of silica fume added in varying percentage (0, 5, 10, 15) and result were discussed and determine suitable concrete mix design for High performance Concrete.**

***Keywords*: High performance concrete, Pozzolona Portland Cement (ppc), Superplasticizer, Silica fume.**

## 1. Introduction

he development of high performance concrete has been seen over last two decades and was primarily introduced through private sector architectural design and construction such as high rise building and parking garages. These days in concrete mixtures, HPC is widely used as because it possesses high strength, high workability, high modulus of elasticity, high density, high dimensional stability, low permeability and resistance to chemical attack. As per ACI, we come to know that high performance concrete is the concrete which meets special performance and uniformity requirements that cannot always be achieved routinely by using conventional materials and normal mixing, placing and curing practices.

The supplementary cementitious materials (SCMs) such as alkofines, fly ash and ground granulated blast furnace slag are more commonly used as mineral admixtures in the development of HPC mixes. They generally used to resist compressive forces and also due to its pozzolonication the properties of the high performance concrete viz., workability, durability, strength, resistance to cracks and permeability can be improved. Here we use silica fume as the proportional replacement of cement to increase its strength. That silica fume is the by-product of the smelting process in the silicon and ferrosilicon industry. It can also be called as volatilized silica, micro silica, condensed silica fume, or silica dust. The color of Silica fume is either grey or premium white. Silica fume consist of very fine vitreous particles with a surface area between 13,000 and 30,000 {$m^2$/kg}. Its particles are 100 times smaller than the average cement particles. As it has extreme fineness and high silica content. Silica fume is a highly effective pozzolonic material. Compressive strength, bond strength and abrasion resistance are improved by silica fume and it also reduces permeability, and therefore helps in protecting reinforcing steel from corrosion.

These days high strength and high-performance concrete are being widely used all over the world. Most application high strength concrete have seen in high rise buildings, long span bridges and in some special applications in structures. In developed countries like Canada, Chicago, France, Denmark using high strength concrete in structures, today would results in both technical and economic advantage. It is necessary in high strength concrete to reduce the water/cement ratio and which results in increases the cement content. The application of such cement increases day by day because of its superiority to structural performance and environmental friend line and energy conserving implications.

## 2. Mechanism of HPC

Nevillie has said, "HPC is a concrete to fulfill specified purpose and no special mystery about it, no unusual ingredients or special equipments has to used. But to investigate the behavior of concrete this paper made efforts to produce a concrete mix within closely controlled tolerances".

## 3. Significance and objectives

The objectives of the present paper are to propose a modified method of mix proportioning of HPC for a target strength range of 50 MPa to 60 MPa using various ingredients namely cement, locally available coarse and fine aggregate, silica fume as mineral admixture and suitable plasticizer. To show the concern that how the HPC is future best constructing material for constructions of mega structures, which requires mega strengths as well as effects of silica fume controlled for particular amount or percentage on the properties of HPC such as compressive strength and durability etc. tests.

In this present experimentation, more prominence is given to study the HPC using Silica Fume and super plasticizer so as to yield better concrete composite and also to motivate the increased use of Silica Fume to maintain ecology.

## 4. Experimental program

Experimentation and examination have been carried out on the HPC specimens to determine the workability, compressive strength, split tensile strength and elastic modulus of the designed trial mixes.

### *A. Materials Used*

Natural aggregates are used as per IS 383-1970 and sand is taken as per requirements of IS 383-2007.

Portland pozzolona cement of 53 grade is used as per IS 1489-1991.

Silica fume as mineral admixture get from ELKEM INDIA (P) LTD, Mumbai and Super plasticizer (chemical admixture)

### *B. Mix Design for HPC*

Since there are various methods for mix design suitable for HPC, a simplified mix design procedure, is formulated by combining available literatures on HPC using Silica Fume.

*1) Water content*

IS 456 maximum water-cement ratio 0.32 is adopted.

Similarly, as per table 2 of IS 10262 water content for the 20 mm aggregate is adopted as 140 kg (for 25 to 50 slump).

*2) Cement content*

As per we get water cement ratio 0.32 and water content 140 kg, cement content has been got as 437.5 kg i.e. nearly 438 kg. It is checked as per table 5 of IS 456 clause 8.2.4.2, which says cement content should be less than 450 kg hence it is ok.

*3) Proportion volume of aggregate content*

IS 10262-2009, volume of coarse aggregate corresponding to 20 mm size of fine aggregate (zone) 0.62 is adopted.

Then total volume of aggregate investigates as subtracting difference between volume of cement and volume of water from 1 cubic meter volume of concrete. Which results in 0.735 cubic meter.

*4) Mass of coarse and fine aggregates*

From the found total volume of aggregate 0.735 $m^3$, mass of coarse aggregate got by product of total volume of aggregate, volume of coarse aggregate, specific gravity and 1000.

Mass of coarse aggregate get 1275.96 kg per $m^3$

Mass of fine aggregate get 754.11 kg per $m^3$.

*5) Binder content*

To increase the workability there is added the super plasticizer in the 2% of water added to the mix. Because of many assumptions underlying the forgoing theoretical calculations, the trial mix proportions must be checked, if necessary the mix proportion should be modified by adjusting the % replacement of cement by Silica fume, % dosage of super plasticizer to improve the workability and strength of the mix proportion. Fresh concrete should be tested for workability as well as Specimens of hardened concrete should be tested at the specified age.

### *C. Mixer Proportions and Casting of Specimens*

Mix proportions are arrived for M60 grades of concrete based on the above formulated mix design procedure by replacing 0, 5, 10 and 15% of the mass of cement by Silica Fume and the material requirements per $m^3$ of concrete.

Curing was done under water for various desired periods.

## 5. Tests on fresh and hardened concrete

Workability tests such as slump test, compaction factor test were carried out for fresh concrete as per IS specifications, keeping the dosage of super plasticizer as constant at 2% by weight of water. For hardened concrete cube compression strength test on 150x150x150 $mm^3$ size cubes at the age of 7 days, 28 days curing were carried out using 3000kN capacity compression testing machine. Also compression strength test and split tensile strength on 150mmx300mm cylinders were carried out on 28 days cured specimens as per BIS specifications.

## 6. Results and discussions

### *A. Tests on Fresh Concrete*

The test results of workability are listed in shown in figures 2. It was observed that the workability of concrete decreased as the percentage of Silica Fume content was increased.

### *B. Tests on Hardened Concrete*

The results of cube compression strength, split tensile strength are shown Figure 2 & 3 and table 1 and 2 below.

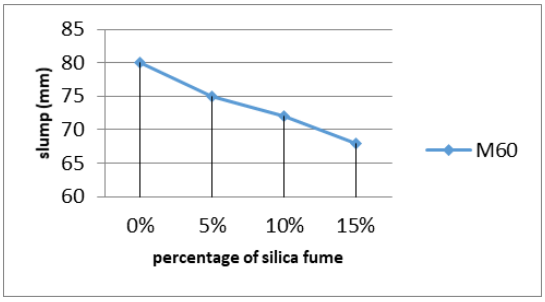


Fig. 1. Workability through slump values

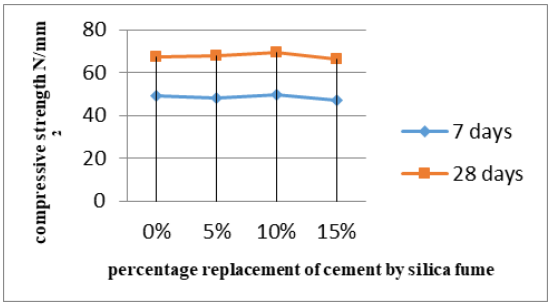


Fig. 2. Compressive strength of HPC with various amount of silica fume

Table 1
Compressive strength of HPC with various amount of silica fume

| % of silica fume | Compressive strength | |
|---|---|---|
| | 7 days | 28 days |
| 0% | 49 | 67.2 |
| 5% | 48.3 | 67.9 |
| 10% | 49.7 | 69.3 |
| 15% | 46.9 | 66.5 |

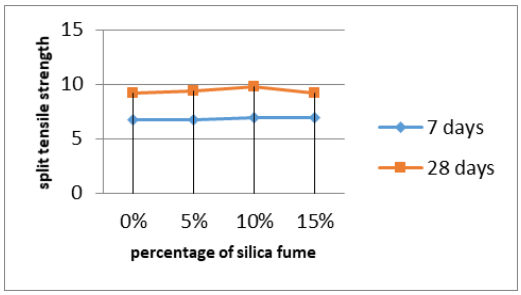

Fig. 3. Split tensile strength of HPC with various amount of silica fume

Table 2
Split tensile strength of HPC with various amount of silica fume

| % of silica fume | Split tensile strength | |
|---|---|---|
| | 7 days | 28 days |
| 0% | 6.73 | 9.22 |
| 5% | 6.75 | 9.35 |
| 10% | 6.93 | 9.78 |
| 15% | 6.81 | 9.21 |

## 7. Conclusion

Based on the investigations carried out on HPC mixes the following conclusions are drawn.

1) Cement replacement up to 10% with silica fume leads in compressive strength for M60 grade.
2) Beyond 10% there is decrease in compressive strength for 28 days curing period.
3) The maximum replacement level of silica fume is 10%for M60 grade of concrete.
4) Use of silica fume gives significant result on properties of concrete as compared to normal concrete.
5) The applications of concrete will necessitate the use of high performance concrete incorporating new generation chemical admixtures (super plasticizer) and available mineral admixtures.
6) The success of the high performance concrete requires more attention on proper mix design, production, placing and curing of concrete. For each of these operations controlling parameters should be achieved by concrete procedure for an environment that a structure has to face.
7) High performance concrete can be prepared to give optimized performance characteristics for a given loading and exposure conditions along with the requirements of cost, service life and durability.
8) From the test results, it is observed that the percentage of saturated water absorption of the HPC mixes containing silica fume was lower when compared with that of HPC mixes without silica fume.

## References

[1] Neville, "Properties of Concrete," 4th and final edition, Pearson education Asia Pte. Ltd, England, 2000.
[2] Vara Lakshmi and Adiseshu, "a study on preparing of high performance concrete using silica fume and fly ash," volume 5, 2016.
[3] Kannan S. U. and Raja M. A, "Influence of industrial by-products on the behavior of high performance concrete," *International journal of civil engineering and technology (IJCIET)*, vol. 10, pp. 804-810, 2019.
[4] Shah and Ahmad, High performance concretes and applications, Edward Arnold, London, 1994.
[5] Reddy and Rajasekhar, "study and performance of high strength concrete using with nano silica and silica fume," *IJCIET*, vol. 6, pp. 184-196, 2015.
[6] Pranab Chakraborty, "investigation on flexural strength of high strength silica fume concrete", *International research journal of engineering and technology (IRJET)*, vol. 4, 2017.
[7] Basu, "NPP Containment structures: Indian experience in silica fumes based HPC," *The Indian concrete journal*, vol. 75, no. 10, pp. 656-664, October 2001.
[8] Swati Chaudhari and Rishab Bajaj, "study of high performance concrete," *The Indian Concrete Journal*, vol. 73, no. 9, pp. 561-568, September 1999.
[9] Supratip Mondal and Sulagno Banerjee, "High strength and high-performance concrete," *International Journal of civil engineering and technology*, vol. 8, no. 6, pp. 782-786, June 2017.
[10] K. Perumal, "Experimental Investigation on strength characteristic of high performance concrete using Silica Fume and super plasticizer," *International journal of trend in scientific research and development*, Vol. 2, Oct. 2018.
[11] Aminul Islam Laskar, "Mix design of high performance concrete," National Institute of Technology, Silchar, India, 2011.
[12] S. U. Kannan, "Experimental investigation on high performance concrete using silica fume and fly ash," *International journal of engineering research and development*, vol. 13, pp. 42-49, Oct. 2017.
[13] Somesh Singh, Abhishek Arya, "High performance concrete and fundamentals," *Seminar International journal of advanced science and research*, Vol. 3, pp. 194-196, March 2018.
[14] Suresh Kumar A. and Aravind Raj M, "Behavior of high-performance concrete with micro silica and fly ash," *International journal of scientific research engineering and technology*, vol. 7, May 2018.
[15] L. V. A. Seshasayi and M. Sudhaker, "Relationship of Water-Cementitious Materials Ratio and Compressive Strength of Silica Fume Concrete," *ICI Journal*, vol. 5, no.1, June 2004, pp. 11-14.