MANTECH Publications

Journal of Ceramics and Concrete Technology
Volume 5 Issue 1
ISSN: 2457-0826 (Online)

Experimental Study on Impact of Mortar Using Silica Fume in Varying Percentage

Dr. P. R. Dhevasenaa*, Dr. S. S Jayaaruna*

*Assistant Professor**

Department of Civil Engineering

Government College of Engineering, Srirangam, Trichy-12. Tamilnadu, India.,*

Corresponding Authors' Email id: *senaadheva@gmail.com, jayaarunasaravanan@gmail.com,*

Abstract

The main objective of our project is to evaluate the strength of mortar by using silica fume. Silica fume is a highly pozzolanic materials, because it consists of silica in non-crystalline form with a high specific surface. This study is an experimental on the nature of silica fume and its influences on the properties of mortar. The partially replacement of cement by silica fume shows the strength parameters of mortar. First the strength parameters of mortar without any partial replacement were studied then strength parameters by partial replacement with silica fume have been studied by placing cube on compression testing machine.

In this experimental investigation, Cement is replaced by silica fume with varying percentage of 5%,10%,15%,20%, and 25%. Compressive strength was conducted at 7 days, 14 days and 28 days. Silica fume were used to replace 0% to 25% of cement. The results showed that partial replacement of cement with silica fume had significant effect on the compressive strength of cube. The strength of mortar increases rapidly as we increase the silica fume content and the optimum value of compressive strength is obtained at 15% replacement.

Keywords: *Pozzolanic, non – crystalline, silica fume, compressive strength*

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

INTRODUCTION

Normal cement mortar is week in tension and has limited ductility and little resistance to cracking. The micro cracks with the application of load will lead to brittle failure of mortar. The research and investigation has been carried out to develop the material which performs better in comparison compared to conventional mortar.

Strength and durability of mortars can be attained through various methods such as increasing cement content, adopting better mixes and curing practice, adding supplementary cementing material. Silica fume is considered to be the most suitable material for increasing strength of mortars. Silica fume is a byproduct

Resulting from the reduction of high purity quartz with coal, in electric are furnaces in the production of silicon and ferrosilicon alloys. The materials which contains more than 80% of silica in non-crystalline state in the form of extremely fine particles, is highly pozzolonic. It is also collected as a byproduct in the production of other silicon alloys such as ferrochromium, Ferro magnesium and calcium silicon .Silica fume is a new pozzolonic material that has received a great amount of attention recently. This in part, is being accomplished by encouraging the use of cementitious material such as silica fume. This interest is due to availability of this material in various countries, and to the strict enforcement of pollution control measures to stop dispersing the material into the atmosphere. Furthermore, the availability of high range water reducing admixtures has opened up new possibilities for the use of silica fume as a part of the cementing material in mortar to produce very high strength or high durable mortar. Unlike natural pozzolans and fly ash, the silica reaction involving silica fume is rapid and therefore, a long curing period is not necessary. The history of silica is relatively short, the first recorded testing of silica fume in Portland cement based concretes was conducted in 1952 and it was not until the early 1970's that concrete containing silica fume came into even limited use. The early work done in Norway received most of the attention, since it had shown that Portland cement based concretes containing silica fume had very high strength and low porosities. Since then the research and development of silica fume made it one of the world's most valuable and versatile admixtures for concrete and cementious products.

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

Addition of silica fume to mortar has many advantages like high strength, durability and reduction in cement production. The optimum silica fume replacement percentage for obtaining maximum 28 days strength of mortar. Cement replacement up to 15% with leads to increase in compressive strength, for M36 grade of concrete mix.

SCOPE AND OBJECTIVES SCOPE

Scope

- Improve the strength of mortar using silica fume.
- Reduction of Cement content by the partial replacement of silica fume.
- Industrial waste, such as silica fume being used as a supplementary Cement replacement material.

OBJECTIVES OF OUR PROJECT

- Determine the suitability of replacing cement with silica fume using fine aggregate in masonry mortar.
- Study the effect of different replacement levels of silica fume on the strength development of mortar.
- Study of compressive strength of prepared mortar in 7days, 14 days and 28 days respectively.
- Study and compare the performance conventional mortal and prepared mortar.
- To understand the effectiveness of silica fume in strength enhancement.

LITERATURE REVIEW

Sellevoid. et.al. (1987) studied that during the hydration for the sealed cement paste, there is decrease in relative humidity and chemical shrinkage. The Portland cement paste incorporated 0.8% and 1.6% condensed silica fume and had water – cement plus silica fume ratio ranging between 0.2, 0.3 and 0.4.they founded that relative humidity (RH) decreased rapidly during the first two weeks and reached about 78% RH after more than a year for the lowest W/(C+SF) paste, the value for the highest W/(C+SF) being about 87% RH.

Haque M.N (1996), the incorporation of silica fume in concrete decrease the drying shrinkage and Cabrera et al (1990) shows that the permeability decreases with the addition of silica fume to concrete. Punkki

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

et al (1996) reported that the loss of workability due to the use of silica fume creates the difficulty to utilize silica fume concrete accurately.

Perumal & Sundararajan (2004) observe the Effect of partial replacement of cement with silica fume on the strength and durability properties of high grade concrete. Strength and durability properties for M60, M70, M110 grades of HPC trial mixes and to arrive at the maximum levels of replacement of cement with Silica fume, investigations were taken. The strength and durability characteristics of these mixes are compared with the mixes without SF. Compressive strength of 60N/mm2, 70N/mm2 and 110N/mm2 at 28 days were obtained by using 10 percent replacement of cement with SF. The results also show that the SF concretes possess superior durability properties.

Ajileye (2012) cement replacement up to 10 % with silica fume leads to increase in compressive strength for M30 grade of concrete. From 15 % there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. Compressive strength of M30 grade of concrete was increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%.

Amudhavalli & Mathew (2012) studied the Effect of silica fume on strength and durability characteristics of concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10, 15 and by 20%. A detailed experimental study in compressive strength, split tensile strength, flexural strength at age of 7 and 28 days was carried out. Shows that Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

Ghutke & Bhandari (2014) examine the influence of silica fume on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increases with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete.

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

EXPERIMENTAL INVESTIGATION

Materials

(a) Cement

The used for this project work is 43 grade Ordinary Portland Cement. The required quantity was produced as a single batch, stored in air tight bags and used for experimental programme.

Table 1 Test on (OPC)

S. No	Test	Result
1.	Fineness test	225 m^2/kg
2.	Initial setting time	28 min
3.	Final setting time	11.5 hours
4.	Consistency	34 %

(b) Fine Aggregate

The aggregates most of which pass through 4.75mm IS sieve are termed as fine aggregates.

According to the size, the fine aggregate may be described as coarse, medium and fine sands. In this experimental program, fine aggregate was locally procured and conformed to Indian standard specification IS: 383-1970.

Table 2 Test on Fine Aggregate

S. No	Test	Result
1.	Size	4.75 mm
2.	Specific gravity	2.6
3.	Water absorption	1% of weight
4.	Fineness modulus	2.53

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

Silica Fume

The term "Microsilica" is adopted to characterize the silica fumes which are used for production of concrete/ mortar. Microsilica or condensed silica fume (CSF) is a byproduct resulting from reduction of high purity quartz with coal in the electric furnace used in the manufacture of silicon, ferrosilicon and other alloys of silicon, CSF which is highly pozzolanic has high content of amorphous silicon dioxide in the range of 85% to 98% in the form of very fine spherical particles averaging diameters about 0.1 to 0.5 microns.

Physical Characteristics

The specific gravity of condensed silica fume from silicon metal of ferrosilicon alloy industries is close to that of amorphous silica that is approximately 2.2.The spherical shape of condensed silica fume can be confirmed by scanning electron microscope of well dispersed particles. Generally, the particles exist in the form of agglomerates.

Table.3 Physical Properties of Silica Fume

Colour	Varies from light to dark grey
Specific gravity	2.2
Bulk density	230 to 300 kg/m^3
Fineness	20,000 m^2/kg
Particle size	0.1µm (approx)

Table 4. Chemical Composition of Silica Fume

Constituent	Percentage
SiO_2	90-96
Al_2O_3	0.5-0.8
Fe_2O_3	0.2-0.8
MgO	0.5-1.5
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1.0

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

Chemical Composition of Silica Fume

Chemical composition of silica fume will mostly depend upon composition of the principle product being made by furnace. Additionally, the composition is also influenced by the furnace design: Generally furnace with a heat recovery system produce silica fume with lower ignition loss. The sio2 content of silica fume varies with the silica content of alloy being producer.

Advantages of Silica Fume:

- High early compressive strength.
- High tensile flexural strength and modulus of elasticity.
- High electrical resistivity andvery low permeability.
- Enhanced durability.
- Increased toughness.
- Higher bond strength.
- Economical in nature.

MIX PROPORTIONING

Concrete mix design in this experiment was designed as per the guidelines specified in ACI1234R -96 "Guide for the use of silica fume in concrete" by ACI committee 234 (7). All the samples were prepared using design mix. M36 grade of concrete eas used for the present mix design was done based on IS 10262-1982.

Mix proportion = cement: Fine aggregate

= 1:1.9

Cement –Sand Mortars

For the purpose of comparison of strength of cement – silica fume –sand mortar cubes with that of cement –sand mortar cubes, a total of 9 numbers of cement mortar cubes were casted and tested at 7,14 and 28 days. The specimens were made with mix proportion of 1:1.9, the water content is used for that mix is18%. The water content will give workable mortar for constructing brick masonry wall.

Cement –Silica Fume –Sand Mortars

27Nos.of Cement –Silica fume –Sand Mortars cubes were made with mix proportion of 1:1.9. The cement is replaced in pozzolana (Silica fume) is increase from 0%, 5%, 10%, 15%, 20% and 25% by weight of mix. The water content is used for each mix is 18%. There is no change in the water content due to the replacement of cement by silica fume. The mortar is workable and no extra water is added.

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

Table 5. Quantity of Material

MATERIAL	WEIGHT (in Kg)
Cement	0.738
Silica fume	0.553
Sand	1.401
Water	0.39

Table 6. Proportion of Raw Material

Percentage of silica fume added	Cement in kg	Silica fume in kg	Fine aggregate in kg
0%	0.738	0	1.401
5%	0.701	0.037	1.401
10%	0.664	0.074	1.401
15%	0.628	0.110	1.401
20%	0.590	0.147	1.401
25%	0.553	0.185	1.401

RESULT AND DISSCUSSION

Compressive Strength on Mortar

Compression test according to IS: 516 (1959) is carried out on these cubes. The specimens are loaded at a constant strain rate until failure. The results of compressive strength of mortar cubes for 7 days 14 days and 28 days are as follows. We can infer that when silica fume is added to cement, it resulted in a significant change in compressive strength of the mix. The addition of silica fume to mortar resulted in an improved bond between the hydrated cement matrix and sand in the mix, hence increasing strength.

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

Table: 7 Compressive Strength on Mortar

Mix proportion	7 Days	14 Days	28 Days
Conventional mortar	10.12	16	19.12
95%cement+5%silica fume+sand	11.12	19.40	23.56
90%cement+10%silica fume +sand	12.77	21.33	25.00
85%cement+15%silica fume +sand	14.66	23.28	25.51
80%cement+20%silica fume +sand	8.11	14.21	18.55
75%cement+25%silica fume +sand	7.20	9.43	12.2

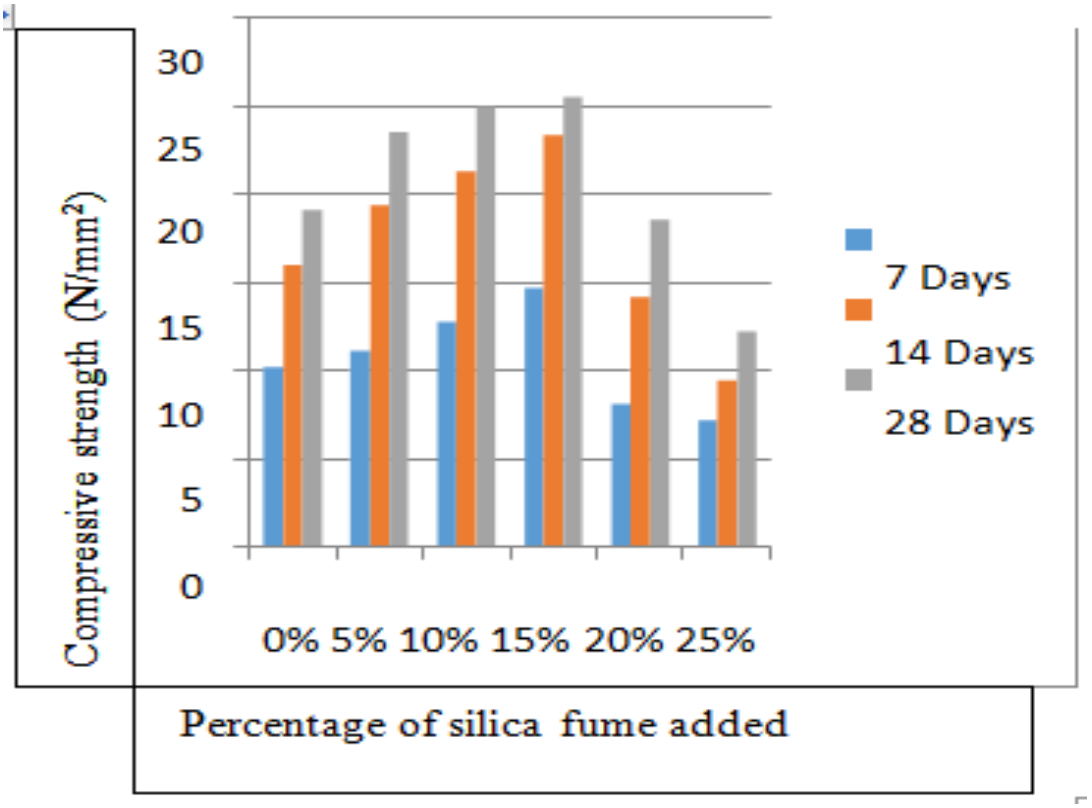


Fig 1. Compressive strength of cube in graph representation

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

CONCLUSION

On the basis of study carries out above the following conclusion may be drawn.

1) The compressive strength of mortar improves when a part of cement is replaced by certain percentage of silica fume.

2) After adding 5% silica fume in the mix, there is an increase in the strength of mortar cube after 7 days as compared to conventional mortar cube.

3) After 14 days and 28 days there is enormous increase in strength as compared to control mix.

4) By adding 15% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively.

5) The compressive strength tends to increase with increase percentage of silica fume in the mix and decreases after 15% replacement.

6) The optimum strength of cube is gain at 15 % replacement for all 7, 14 and 28 days respectively.

REFERENCES

I. Cook, D.J. 1985. Calcined clay, shale and other soils. Cement Replacement materials –concrete technology and design. 3:40 -70 survey university press. Chindaprasirt, P. and Rukzon , S. 2008. Strength, porosity and corrosion resistant of ternary blend port 20 Sasiekalaa And Malathy.

II. Arif , M.P. and kaushik, S.K.1996. Mortar modulus of ferro cement- a comparison for strategies. Journal of ferrocement. 29(3):179-187. ACI committee 549R-97, state of the Art report on ferrocement, pp-36.

III. Babu,K.G., Rao, G.S.N. and Prakash, P.V.S. 1993.In:Ravinthra, K.Dhir and Roderick Jones, M.,edited, Efficiency of pozzolanas in cement composites, concrete 2000, Published by E& FNSPON,p.497-509

IV. Hariharan,A.R., Santhi, A.S. and Mohan Ganesh , G.2011. Effect of ternary cementitious system on compressive strength and resistance to chloride ion

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved

penetration. International journal of civil and structural engineering (4).

V. Akkan , M.S. and Mazlum F.A. 1993. Comparative study of natural pozzolanas used inn blended cement production . In : Malhotra, V.M. edited, proceedings of the fourth international conference on fly ash, silica fume, slang and natural pozzolanas in concrete, Vol.I . Istanbul, Turkey , May 1992, ACI ; p.471 – 494.

VI. Naaman, A.E. 2000. Ferrocement and laminated cementitious composites. ANN Arbor, Michigan,USA; Tecno press 3000;2000,ISBN-0-9674939-0-0,370 pp. Memon,N.A. and ,Salihuddin, R.S.2006. Ferrocement a versatile composite structural material. Mehran University Research Journal of Engg. And Tech. 25(1):9-18.

VII. George, J., Xuz, Danie,F. and Watt,P.1995. Hudee effectiveness of mineral admixtures in reducing ASK expansion. Cement Concrete Research. 6 (25): 1225- 1235. Ruiz , AI. 1965. Strength contribution of a

VIII. Pozzolona to concretes. Proc J Amer Concrete Inst. 62: 315-324.

IX. Memon, N.A. and Salihuddin, R.S.2005. Evaluation of cement based composities proceedings of the third of international conference on innovation in architechture, engineering and construction, Vol.1, Rotter dam; the Netherlands,p. 303-310

X. Mattonem R. 1992.Ferrocement in low cost housing; an application proposal. Journal of Ferrocement.22 (2): 181-187.

XI. “An over view of micro silica concrete in the U.K.”. Concrete, Vol 23 Oct 1989, pp35

Page 7-17 © MANTECH PUBLICATIONS 2020. All Rights Reserved