An Experimental Investigation on Partial Replacement of Cement With Silica Fume

Dr. G.Tabitha[1], Maddila Appalaraju[2]
[1, 2]Dept of Civil engineering
[1, 2] Sanketika Vidya Parishad Engineering College, P.M Palem, Visakhapatnam, 530041

Abstract- *The construction activities in last few decades have increased very well in almost all the developing countries of the world. Cement is becoming a scarce commodity globally because of its growing demand day by day. It is the need of time to search such alternative materials that would partially or fully replace cement used in concretes and mortars without affecting its quality, strength and other characteristics. By addition of some pozzolanic materials, the various properties of concrete viz can be improved. Silica fume is known to improve both the mechanical properties and durability of concrete. The principle physical effect of silica fume in concrete is that of filler besides the pozzolanic activity, which because of its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains.*

In this experimental investigation an attempt has been made to determine the effects of silica fume on M30 grade concrete. This investigation involves partial replacement of cement with silica fume varying proportion of 0%,5%,10%, 15% by weight of cement. The characteristics of fresh concrete are determined by slump cone test to find the work ability of the concrete, and hardened properties of concrete such as compressive strength, flexural strength, tensile strength were carried out at 7 days and 28 days for various proportions of silica fume. The results of various tests conducted on control mix and other mixes with different proportions of silica fume have been compared. The results of experimental investigation indicates that the use of silica fume in concrete has increased the strength and at allage when compared to normal concrete. The workability of concrete is decreasing with increasing silica fume content ,thus the concrete containing silica fume require more water than the conventional concrete. The strength of concrete increases rapidly as we increases the silica fume content and the optimum value of compressive strength, flexural strength, split tensile strength is obtained at 10% replacement, After 10% its start decreasing.

I. INTRODUCTION

Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of ad mixtures, which improve the microstructure as well as decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction. The subsequent modification of the microstructure of cement composites improves the mechanical properties, durability and increases the service-life properties.

In addition of silica fume, the physical effect of the fine grains allows dense packing within the cement and reduces the effect in the transition zone between the paste and aggregate. This weaker zone is strengthened due to the higher bond development between these two phases, improving the concrete microstructure and properties. In general, the pozzolanic effect depends not only on the pozzolanic reaction, but also on the physical or filler effect of the smaller particles in the mixture. Therefore, the addition of pozzolans to OPC increases its mechanical strength and durability as compared to the referral paste, because of the interface reinforcement. The physical action of the pozzolanas provides a denser, more homogeneous and uniform paste. Silica fume is an industrial by product of silicon metal or some ferrosilicon alloys. The fume which has a high content of amorphous silicon dioxide and consists of very fine spherical particle particles (0.1-0.2 μm) is collected from the effluent gases escaping from the furnace.

Silica fume which is commonly used in cement based systems, contain 85 to 98% silica. Silica fume, in itself, does not have any cementitious properties but when reacts with Ca(OH)2 on hydration of cement produces the gel i.e. calcium-silicate- hydrate (C-S-H) which has good cementious properties. Silica fume is known to improve both the mechanical characteristics and durability of concrete. The principle physical effect of silica fume in concrete is that of filler, which because of its fineness can fit into space between

cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. As for chemical reaction of silica fume, because of high surface area and high content of amorphous silica in silica fume, this highly active pozzolan reacts more quickly than ordinary pozzolans. The use of silica fume in concrete has engineering potential and economic advantage. The use of silica fume will not significantly change the unit weight of concrete. Silica fume will produce a much less permeable and high strength concrete, but it will not produce a concrete with a higher mass per unit volume.

1.1 Pozzolana Material :

Pozzolans are silicate-based materials that react with (consume) the calcium hydroxide generated by hydrating cement to form additional cementitious materials. Typically pozzolans are used as cement replacements rather than cement additions. Adding pozzolans to an existing concrete mix without removing an equivalent amount of cement increases the paste content and decreases the water/cement ratio. In other words, adding more pozzolans to a mix changes the mix proportions. Replacing some of the cement with pozzolans preserves the mix proportions.

Generally the finer the pozzolan particles are, the more reactive they are. Silica fume is the finest with most particles averaging 0.3 µm (microns), metakaolin averages about 4 µm, Portland cement averages about 15 µm, and fly ash about 70 µm.

Many pozzolans are waste products from industrial processes. Fly ash comes from coal-fired power plants, and silica fume and slag comes from some steel refineries. As such the color, quality, gradation and properties can vary and are not controlled. Depending upon the particle size, chemical composition and dosage, different pozzolans will affect the concrete strength differently and at different times during curing.

Typical pozzolans include:

- Metakaolin
- Silica fume
- Flyash
- Slag
- VCAS(Vitrified Calcium Alumino-Silicate)

Metakaolin was successfully incorporated into the concrete with the original intention of suppressing any damage due to alkali-silica reaction. When used to replace cement at levels of 5 to 10% by weight, the concrete produced is generally more cohesive and less likely to bleed. As a result pumping and finishing processes require less effort. The compressive strength of hardened concrete is also increased at this level of replacement

IDENTIFY, RESEARCH AND COLLECT IDEA :

Silica Fume

Silica fume is a by-product resulting from the reduction of high-purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or ferrosilicon alloys. The silica fume, which condenses from the gases escaping from the furnaces, has a very high content of amorphous silicon dioxide and consists of very fine spherical particles.

Aggregate, and cement which is added to the concrete along with water during mixing. The chemical admixture will affect the setting and hardening characteristic for cement paste “BASF MasterRheobuild 920 SH” super plasticizer was used for this project confirming to ASTM C-494 Type B, D & G,IS 9130, EN 934-2: T11.1/11.2. the certified test data given in the following table

1.1.2 Specific Gravity Of Cement :

Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene is used which does not react with cement.

Procedure

1. Cleananddry thespecificgravity bottleand weightitwith thestopper w1

2. Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper w2
3. Fill the specific gravity bottle containing the cement , with kerosene (free of water) placing the stopper and weigh it w3.

S.No	W1	W2	W3	W4	W5	S_k	S_c
Trail1	25	55	90	65	75	0.80	3
Trail2	25	59	91	65	75	0.80	3.14
Trail3	25	62	91	65	75	0.80	3.04

1.1.3 Normal Consistency Of Cement

Normal consistency is defined as that percentage of water required to produce a cement paste of standard consistency. For determination purpose, normal consistency is taken as the water content at which vicat's plunger penetrates up to a point of 5 to 7mm from the bottom of the vicat's mould. When water is added to the cement, the paste starts stiffening and gains strength. During the process of stiffening the following phases of action take place.

1. Setting: means stiffening of cement or loosing of plasticity.
2. Hardening: means gaining of strength.

II. CONCLUSION

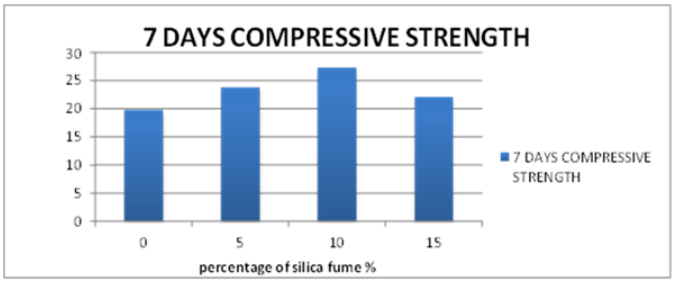
The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 0%, 5%, 10% and 15% silica fume with the cement. Based on present study, following conclusions are drawn.

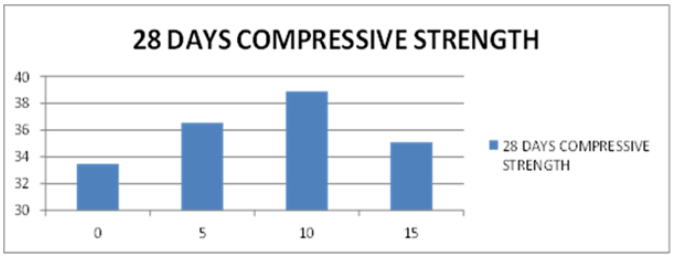
Workability:

The workability of the concrete has been decreasing with increasing silica fume content. In order to improve the workability super plasticizer was added. Desired workability was obtained with addition of 1% of super plasticizer.

Compressive strength:

1. After adding 5% silica fume in the mix, there is an increase in the compressive strength of cube after 7 days as compared to concrete without replacement. And after 28 days there is enormous increase in strength as compared to the control mix.
2. By adding 10% silica fume, there is large amount of increase in strength after 7, and 28 days respectively. The Compressive strength tends to increase with increase percentages of silica fume in the mix and decreases after 10% replacement.
3. Maximum compressive strength was obtained at proportion of SF10 i.e 10%of silica fume for all 7, and 28 days respectively.



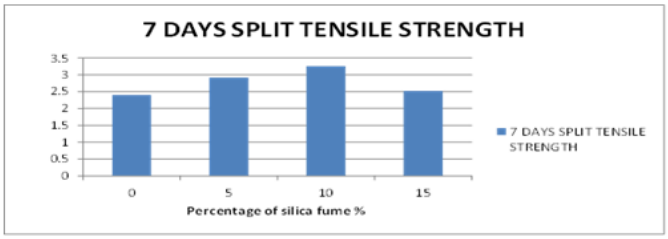


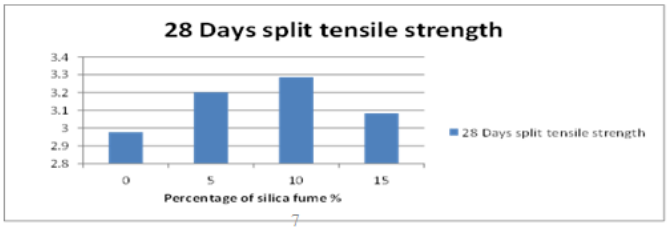
Split Tensile Strength :

1. After adding 5% silica fume in the mix, there is an increase in the strength of cylinder after 7 days as compared to concrete without replacement and 28days there is enormous increase in strength as compared to the control mix.
2. By adding 10% silica fume, there is large amount of increase in strength after 7, and 28 days respectively.

The split tensile strength tends to increase with increase percentages of silica fume till 10% and decreases after 10% replacement.

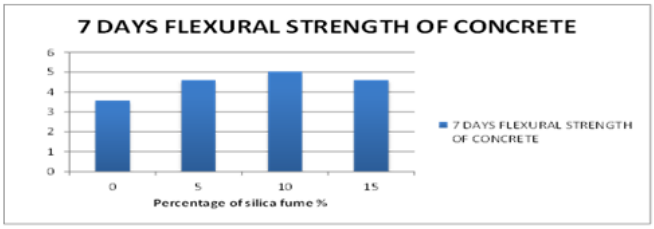
3. Maximum split tensile strength was obtained at proportion at 10% replacement for all 7, and 28 days respectively.

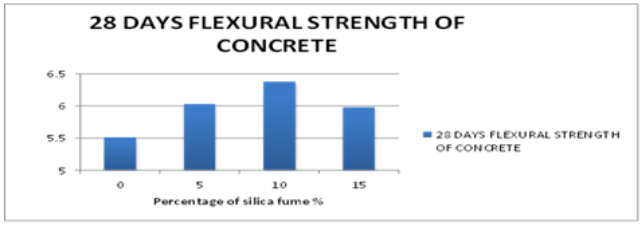




Flexural strength of concrete :

It was observed that, there was considerable increase in the flexural strength due to the partial replacement of silica fume with cement, The flexural strength of concrete with 0%, 5%, 10%, 15% partial replacement of cement with silica fume. When tested for 7 days were found to be 3.570Mpa, 4.600Mps, 5.040Mpa, 4.609Mpa respectively and when tested for 28days were found to be 5.980Mpa, 6.030Mpa, 6.378Mpa, 5.514Mpa respectively.





REFERENCES

[1] ACI, 234R-96.1996.Guide forthe useofsilica fume inconcrete.Reportedby ACI, Committee, 234, pp.151.

[2] Akshatha K.B(2018), "Experimental Study of Concrete using Silica Fume" international journal of emerging technology and advanced engineering e- ISSN: 2395-0056

[3] Dilip Kumar Singha Roy, Amitava Sil (2012). "Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete" international journal of emerging technology and advanced engineering, ISSN 2250-2459

[4] Gurdeep Singh, Rajwinder Singh Bansal (2017) "Effect Of Partial Replacement Of Cement By Silica Fume And Sand By Quarry Dust On Strength And Durability Of Concrete" international research journal of engineering and technology e-ISSN: 2395-0056, p-ISSN: 2395-0072

[5] IS4031(Part I): 1996.Methodsofphysicaltestforcement.

[6] IS 2386 (Part II):1963. Methods of test for aggregates for concrete particlesize and shap

[7] IS516:1959.Methodoftestforstrengthofconcrete

[8] IS383:1970.SpecificationforCoarseandFineAggregates.

[9] Is1199:1959 methodsofsampling andanalysisofconcrete.

[10] Is5816:1999 splittingtensile strengthofconcrete.

[11] IS10262:1982RecommendedGuidelines forConcreteMixDesign

[12] IS: 456:2000, "Plain and Reinforced Concrete", Code of Practice, Bureau of Indian Standards, New Delhi, 2000

[13] IS:2386(Part v) -1963, Methodsoftest for aggregates for concrete, Bureauof Indian standards, New Delhi, India

[14] Lakhbir Singh, Arjun Kumar, Anil Singh(2016) "Study Of Partial Replacement Of Cement By Silica Fume" international journal of advanced research.

[15] M. S. Shetty "Concrete Technology", 7th Edition, S. Chand & Company Limited

[16] M.L. Gambhir "Concrete Technology", 5th Edition, Mc Graw Hill Education (India) Pvt.Limited.

[17] VishalS.Ghutke,PranitaS,Bhandari(2014)"Influenceofsilicafumeonconcrete".journal of mechanical and civil engineering, e-ISSN 2278-1684.