MECHANICAL PROPERTIES OF HIGH-PERFORMANCE MORTAR BLENDED WITH SILICA FUME

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ABSTRACT

Mortar is the most important engineering material and the addition of some other mineral and chemical admixtures may change the properties of mortar. High performance mortar at present used extensively in construction industry. The mineral admixtures play a vital role to produce the High Performance Mortar. Silica fume is one of the mineral admixtures and is very fine non crystalline material. The effect of silica fume on the mechanical properties of ordinary Portland cement mortar was investigated in this report. The Ordinary Portland cement was partially replaced with silica fume at different percentages such as 1, 3 & 5 % of the total weight of cement was added to each sample. The results showed that after 7 days and 28 days of curing, the compressive strength and the tensile strength of the cement mortars with silica fume where higher than the conventional cement mortar.

Keywords: - *Mortar, Silica fume, and Portland cement*

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1. INTRODUCTION

High performance mortar is a construction material which is being used widely in now a days due to its high strength durability properties than conventional mortar. Based on the code reference ASTM-C270 [11], if the 28 days compressive strength of mortar is higher than 17.2 N/mm^2 is said to be high performance mortar.

Several investigations have studied the strength and durability properties of cement mortars containing mineral admixtures. Studies done shows that adding mineral admixtures to cement mortar increases the strength properties. P. Rathish Kumar [1] have examined the compressive strength and flow characteristics of silica fume. The results shows that 10% replacement of cement by silica fume become visible to increase the compressive strength at all ages and all grades of cement. Higher grades of cement resulted in a drop in the flow values for all the mixtures. B. Damodhara Reddy etal [2] proved that replacement of 5 % micro silica increase the compressive strength of mortar. S. Thokchom et al[3], Studied that 28 days compressive strength of low calcium fly ash by activation with a mixture of sodium hydroxide and sodium silicate solution and cured thermally. 10% by weight magnesium sulphate solution has been used to soak the specimen up to 24 weeks. It was proved that after 24 weeks, specimen retained maximum strength of 89.7%. Sowmya Kumari S[4] have investigated that the different mechanical properties of polyester mortar cured in ambient temperature and 80 degree Centigrade were investigated. It was proved that it is possible to prepare polymer mortar using 8 to 30 % polyester resin to get desirable properties. Sudarsana Rao. Hunchate et al [7] proved that the silica fume content of HPC increases the compressive strength up to 15% and then decreases. From the above investigation mortar/concrete mixed with silica fume has got the greater strength. This paper only reports the strength properties of mortars mixed with silica fume.

2. EXPERIMENTAL PROGRAMME

A cement mortar mix 1:2 was selected and water/binder ratio of 0.35%. The blended cement mortar was prepared with ordinary Portland cement that was partly substituted by silica fume, as explained in Table-1.

TABLE -1: MIX PROPORTIONS OF BLENDED CEMENT MORTAR

Components	Replacement levels of Silica Fume			
	SF-0%	SF-1%	SF-3%	SF-5%
Water / Cement Ratio	0.35	0.35	0.35	0.35
Cement	1	0.9	0.7	0.5
Silica Fume	-	0.1	0.3	0.5
Fine Aggregate	2	2	2	2
Super plasticizer (% of cement)	1	1	1	1

2.1 Cement

The cement used was OPC53 grade confirming to IS: 12269: 1987. The specific gravity and consistency of cement was 3.15 and 32 % respectively.

2.2 Sand

Locally available river sand confirming to IS: 2386 and passing through Sieve 4.75 mm to 150-micron sieve with a specific gravity of 2.8 and a fineness modulus of 3.7%.

2.3 Water

Potable water was used for mixing and curing purpose of cement mortar

2.4 Silica Fume

The physical properties and chemical composition of silica fume are given in table 2 & 3 respectively.

Table -2: Physical Properties Of SF

Particle Size	< 1 µm
Bulk density	576 kg/m^3
Specific gravity	2.2
Surface area	20000 m^2/kg

Table -3: Chemical Properties Of SF

SiO_2	Al_2O_3	MgO	Fe_2O_3	CaO	Na_2O	LOI

90-96 %	0.5-0.8 %	0.5-1.5 %	0.2-0.8 %	0.1-0.5 %	0.2-0.7 %	0.7-2.5 %

2.5 Super Plasticizer

Enfiiq SP400 was used for the present study. Its specific gravity was 1.17 to 1.19 at 30degree centigrade as per manufacture's catalogue.

3. RESULTS AND DISCUSSION

3.1 Compressive Strength

The compressive strength, as one of the most important properties of hardened mortar, in general is the characteristic material value for classification of the mortar. 28 days cube compressive strength is tested on cubes of size 70.6 x 70.6 x 70.6 mm. Three cube samples each for various percentage of silica fume replaced by weight of cement were tested to determine the 7 days and 28 days compressive strength using a 1000 KN compression testing machine. The improvement of compressive strength compared to the control is tabulated below. Here, as the optimum dosage of silica fume was obtained at a percentage of 5% as replacement of cement and of super plasticizer was obtained at a percentage of 1% by weight of cement. For control cement mortar the compressive strength was found to be 41.12 N/mm 2 at 28 days .On the other hand, for cement mortar cubes casted with silica fume, the compressive strength obtained was 48.15 N/mm 2 , 51.66 N/mm 2 and 52.86 N/mm 2 are 1%, 3% and 5% of silica fume replaced by cement respectively. Hence the compressive strength increased when the silica fume percentage is increased.

Table -4: Test Results Of Compressive Strength

Replacement level of SF (%)	Compressive strength (MPa)	
	7^{th} Day	28^{th} Day
0	16.72	41.12
1	19.56	48.15
3	22.56	51.66
5	**25.66**	**52.86**

3.2 Splitting Tensile Strength

Splitting Tensile Strength is an indirect method used for determining the tensile strength of mortar. Tests are carried out on 100mm x 200 mm cylinders confirming to ASTM-C 496 to attain the splitting tensile strength at the age of 7 days and 28 days. In the splitting tensile test, the mortar cylinder is placed with its axis horizontal, between plates of the testing machine and the load is increased until the failure occurred by splitting in the plane containing the vertical diameter of the cylinder specimen. The magnitude of the tensile stress is given by $2P/\pi\pi DL$, where P is the applied load, and D, L are the diameter, Length of the cylinder respectively. The test results are tabulated below.

Table -5: Test Results Of Split Tensile Strength

Replacement level of SF (%)	Split tensile strength (MPa)	
	7^{th} Day	28^{th} Day
0	1.24	2.07
1	1.35	2.94
3	1.50	3.50
5	**1.86**	**3.66**

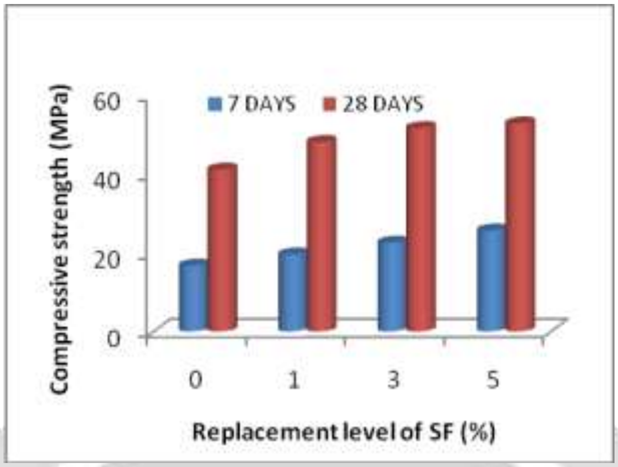

Chart -1: Compressive Strength Of Mortar At 7 And 28 Days

From the experimental results, the split tensile strength of blended mortar was higher than conventional mortar. The cement replaced with 5% of SF, which can increase the split tensile strength up to 76% than conventional mortar.

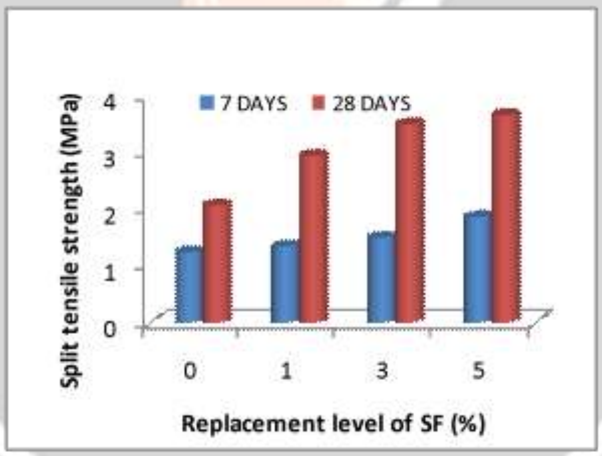

Chart -1: Split Tensile Strength Of Mortar At 7 And 28 Days

4. CONCLUSIONS

The following conclusions can be drawn from the compressive and split tensile strength on high performance mortar mixtures using silica fume and Enfiiq super plasticizer 400.

1. The Mechanical properties such as compressive and split tensile strength of HPM can be improved by silica fume.
2. From the above experimental results it is proved that silica fume can be used as a admixture for HPM. Based on the results, the compressive and split tensile strength are increased when the silica fume percentage is increased.
3. The percentage of increase in compressive strength is 48.68% and 28.55% at the age of 7^{th} day and 28^{th} day up to maximum limit of 5% of silica fume respectively.
4. The percentage of increase in split tensile strength is 68% and 76% at the age of 7^{th} day and 28^{th} day up to maximum limit of 5% of silica fume respectively.

5. REFERENCES

[1]. High performance super plasticized silica fume mortars for ferro cement works P. Rathish Kumar, Architecture and Civil Engineering Vol. 8, No 2, 2010.
[2]. An Experimental Investigation on the Performance of Mortar Cubes by Partial Replacement of Portland Slag Cement with and without Admixtures B.Damodhara Reddy et al, (ISSN 2250-2459, Volume 3 Issue 1 of IJETAE 20, January 2013).
[3]. Performance of Fly ash Based Geopolymer Mortars in Sulphate Solution S. Thokchom et al, Journal of Engineering Science and Technology Review 3 (1) (2010) 36-40.
[4]. Mechanical Properties of Polyster Mortar Soumya Kumari.S, International Journal of Research in Engineering and Technology, may 2014.
[5]. A Study on the Effect the addition of thermally treated Libyan Natural Pozzolan has on the Mechanical Properties of Ordinary Portland cement Mortar. Mohamed -A-Aboubakar, et al, International Journal of Science and Technology , January 2013.
[6]. Experimental Study on Durability Characteristics of High Performance Concrete Er. Magudeaswaran. P, International Journal of Emerging Technology and Advanced Engineering , Volume 3, Issue 1, January 2013.
[7]. Mix Design of High Performance Concrete Using Silica Fume and Superplasticizer, Sudarsana Rao.Hunchate, et al, International Journal of Innovative Research in Science, Engineering and Technology , Vol. 3, Issue 3, March 2014 .
[8]. Experimental Investigation on High Performance Concrete Using Silica Fume and Superplasticizer P. Vinayagam , International Journal of Computer and Communication Engineering, Vol. 1, No. 2, July 2012.
[9]. ASTM C109 “Standard test method for compressive strength of hydraulic cement mortar”.
[10]. ASTM C496 “Standard test method for split tensile strength of cylindrical concrete specimens”.
[11]. ASTM c270 “Standard Specification for Mortar for Unit Masonry”.