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HIGH PERFORMANCE SUPERPLASTICIZED SILICA FUME MORTARS FOR FERROCEMENT WORKS

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P. Rathish Kumar

Department of Civil Engineering, National Institute of Technology,
Warangal Andhra Pradesh, India

Abstract. *Ferrocement works demand cement mortars of good workability and high strength. Reduction in water-cement ratio combined with a refined pore structure increases the compressive strength in addition to the enhancement of durability characteristics, but the workability decreases. Workability becomes important, as the mortar has to easily penetrate between the layers of the mesh wires. A reasonably workable high strength cement mortar can be obtained by using a high cement content coupled with the use of superplasticizers. These were also found to retain the cohesiveness and check undesirable bleeding and segregation.*
An experimental program was conducted to study the functional efficacy of an SNF condensate used as a water reducing superplasticizer. The compressive strength and flow characteristics of the mortars were determined to decide their suitability for ferrocement works. The parameters included the mix proportions, the grade of cement, age of curing and the dosage of superplasticizer. It was concluded from the study that the addition of an optimum dosage of superplasticizer improved the workability and strength characteristics of silica fume mortars. There was a late gain in the compressive strength of silica fume mortars.

Key words: *Compressive Stength, Performance, Ferrocement, Superplasticizer, Silica fume.*

1. INTRODUCTION

Superplasticizers, like many other types of admixtures are introduced in mortar/concrete to perform special functions; consequently they are frequently described according to their functional properties. Superplasticizers have been classified as High Range Water Reducing admixtures (HRWRA) to distinguish them from other categories of less effective chemical admixtures that initially served to decrease the water content of mortars/concretes. The ASTM [1] has classified Class F admixtures as High range water reducing ones, while Class G are classified as water reducers and retarders. Superplasticizers

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find special applications in mortar mixes where water-cement ratio is strictly controlled to achieve impervious mortars and at the same time desired workability. Such impervious mortars are required for ferrocement works. Ferrocement is a form of thin reinforced concrete where finely divided wire meshes are distributed spatially in the mortar matrix [2,3,4]. The selection of constituent materials e.g. cement, aggregate, mixing and placing of mortars should be carefully executed. The performance of the mortars depends on the chemical composition of cement, the nature of the aggregate and water-cement ratio. A void free mortar with low permeability is most desirable in ferrocement applications. The use of chemical and mineral admixtures reduce the water content and increase the strength and durability [5]. Ferrocement technology normally uses cement rich mortars.

The recommendations of various concrete codes around the world specify the use of limited water for getting mortars of structural grade. The combined use of mineral admixtures and super plasticizers resulted in synergistic effects and gives a range of modifications enabling durable mortars to be used in a variety of conditions [6,7,8]. An attempt is made in this study to use a superplasticizer in mortars for ferrocement works. The optimum dosage of superplasticizer was fixed on the basis of workability and it was concluded from the study that a replacement of cement with 10% silica fume coupled with the optimum dosage of superplasticizer improved both the workability and strength characteristics.

2. EXPERIMENTAL PROGRAMME

Three mortar mixes 1:1/0.34, 1:1.15/0.35 and 1:1.2/0.37 were selected from a systematic and series of experiments conducted using different grades of cement (43,53 and slag cement) and for different mix proportions. From the previous studies conducted by the authors [9,10,11]on High Performance Mortars, an optimum dosage of 10% silica fume by weight of cement was found to give improved strength and durability. For each of these three mixes, mortar cubes of standard size were cast and tested for compressive strength at the end of 3, 7 and 28 days. The optimum dosage of superplasticizer to be added in silica fume mortar was obtained by studying the flow characteristics of silica fume mortar as per BIS: 5512 [12].

2.1 Materials

Cement Three grades of cement ie: C43, C53 and slag cement were used. They conformed to IS:12269, IS:8112 and IS:455 respectively with specific gravities 2.88,3.16 and 3.161 [13,14,15].

Sand Locally available river sand confirming to IS:650 [16] and passing through IS:120 sieve with a Fineness modulus of 2.4 and a specific gravity of 2.44 was used.

Water Potable water was used for mixing and curing purpose.

Silica fume The mineral admixture was obtained from a local Ferro Alloys Industry and had a specific gravity of 1.84.

Superplasticizer Sulphonated Naphthalene Formaldehyde condensate (SNF) was used for the present study. Its specific gravity was 1.18 at 25°C and had a good compatibility, with Portland and Slag cements. Different dosages of Superplasticizer were used for finding the flow values of the mixes.

2.2 Casting

Standard mortar cubes were cast for determining the compressive strength. The cast specimens were demoulded at the end of 24±2 hours and kept in water for the required number of days for curing.

2.3 Testing

The cured specimens were tested using Tinius Olsen Testing machine of capacity 1810 KN for determining the compressive strength.

3. INTERPRETATION AND DISCUSSION OF TEST RESULTS

3.1 Compressive Strength and Flow of Silica Fume Mortars

Replacement of cement with 10% silica fume improved the compressive strength of all the three mortar mixes using the three grades of cement. However, there was a noticeable decrease in the flow. Further the slag cement led to a significant increase in the compressive strength and a reduction in flow as compared to the 43 and 53 grade cements. Table 1 presents the details of these values obtained from the investigation. It is evident from the table that the addition of silica fume showed a gain in strength with age. An increase in the compressive strength of mortar was also obtained with a higher grade of cement. However, use of higher grade cements led to a decrease in the flow. Addition of an optimum dosage of superplasticizer to such a mix was, therefore, necessary to increase the flow of the mortar to be used for ferrocement works.

Table 1 Strength and flow values of mortars with 10% silica fume replacement

Cement type	Mixture proportion	Compressive strength (MPa)			Flow (%)	(7/28) Ratio of compressive strength
		3 Days	7 Days	28 Days		
OPC 43 grade	1:1/0.34	23	38	57	50	0.67
	1:1.15/0.35	20	40	61	58	0.66
	1:1.2/0.37	18	43	57	60	0.75
OPC 53 grade	1:1/0.34	30	46	69	45	0.67
	1:1.15/0.35	27	43	67	50	0.64
	1:1.2/0.37	25	36	68	53	0.53
Slag cement	1:1/0.34	41	52	73	35	0.71
	1:1.15/0.35	38	50	70	42	0.71
	1:1.2/0.37	37	48	75	42	0.64

3.2 Optimizing dose of Superplasticizer

Maintaining the optimum dosage of silica fume at 10%, the variation in the dosages of superplasticizers (0.2, 0.4, 0.6, 0.8 and 1.0 % by weight of cement) was studied on flow for all the three mixes and all the three grades of cement. The results are shown in Table-

2. From the table it is evident that the optimum dosages of superplastizer in the mix may be kept at 0.6%.

3.3 Compressive Strength of Superplasticized Silica fume mortars

The addition of optimum dosage of superplasticizer(0.6%) resulted in flow greater than 100% (Table 2). Table 3 shows the strength results of the superplasticized silica fume mortars. From the table it is clear that the use of slag cement, silica fume and optimum superplasticizer content resulted in an increased compressive strength and good workability. A maximum compressive strength of 81 MPa and flow of 118% was noted for mix 1:1/0.34. Hence high strength and high flowability mortar mixes for use in ferrocement applications can be developed and these mortars are High Performance Mortars.

Table 2 Flow values for varying dosages of superplasticizer in optimised silica fume mortar

% SP	Flow values (%)								
	43 grade cement			53 grade cement			Slag cement		
	1:1/0.34	1:1.15/0.35	1:1.2/0.37	1:1/0.34	1:1.15/0.35	1:1.2/0.37	1:1/0.34	1:1.15/0.35	1:1.2/0.37
0	50	55	60	50	52	58	35	42	53
0.2	87	91	112	77	97	95	75	82	91
0.4	100	111	120	107	111	120	92	97	112
0.6	110	120	127	120	122	128	118	130	132
0.8	113	122	128	122	128	130	121	125	128
1.0	115	124	130	126	131	134	123	132	131

Table 3 Compressive strength of superplaticized silicafume mortars

Cement type	Mixture proportion	Compressive strength (MPa)			Ratio of (7/28) days compressive strength
		3-Days	7-Days	28-Days	
43 grade	1:1/0.34	26	40.0	62.0	0.65
	1:1.15/0.35	24	38.0	58.0	0.66
	1:1.2/0.37	21	31.0	55.0	0.56
53 grade	1:1/0.34	27	42.0	70.5	0.60
	1:1.15/0.35	23	38.5	63.0	0.61
	1:1.2/0.37	23	33.0	61.0	0.54
Slag cement	1:1/0.34	38	58.0	81.0	0.72
	1:1.15/0.35	38	63.0	76.0	0.83
	1:1.2/0.37	34	53.0	78.0	0.68

4. CONCLUSIONS

The following conclusions can be drawn from the compressive strength and flow studies on mortar mixes using silica fume and a SNF superplasticizer.

1) A 10% replacement of cement by silica fume appears to increase the compressive strength at all ages compared to a control mix, for all the three mixes and all the three grades of cement. There is also a significant gain in strength with age upto 28 days.
2) The large surface area of silica fume requires the use of an increased amount of superplasticizer to maintain consistency and flow of mortar as compared to the control mixes.
3) Higher grades of cement resulted in a drop in the flow values for all the mixes. The use of Sulphonated Naphthalene Formaldehyde (SNF) condensate as superplastizer improved the flow above 100%, which is desirable for ferrocement works.
4) For a constant cement/silica fume ratio, the performance characteristics improved for lower aggregate /cement ratio, for all the three grades of cement and was more so for slag cement.
5) The 7 to 28 days compressive strength ratio increased with the addition of silica fume, leading to a later gain in strength.
6) High performance mortars can be obtained by modifying the conventional mortars by reducing the water-binder ratio and adding mineral and chemical admixtures.

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VISOKE PERFORMANSE MALTERA SA SUPERPLASTIFIKATORIMA OD SILIKATNE PRAŠINE KOD FEROCEMENTNIH RADOVA

P. Rathish Kumar

Zahtevi ferocemnetnih maltera su dobra obradivost i visoka čvrstoća. Smanjenjem vodo-cementnog faktora u kombinaciji sa rafiniranim porama strukture, se povećava čvrstoća i poboljšavaju se karakteristike trajnosti, ali je obradivost teža. Obradivost postaje važna, kad malter mora da lako da prodre između slojeva mreže žica. U osnovi, visoke čvrstoće cementnog maltera mogu se dobiti pomoću visokog sadržaja cementa uz korišćenje superplastifikatora. Takođe je utvrđeno da se zadržava kohezija uz kontrolu nepoželjnog curenja i segregacije.

Eksperimentalni program je sprovedena na studiji funkcionalne efikasnosti SNF kondenzata korišćenjem vode i redukcije superplastifikatora. Čvrstoća na pritisak i tečne karakteristika maltera određuju primenu ferocementa. Parametri su: razmere mešavine, kvalitet cementa cementa, dužina negovanja i doze superplastifikatora. Zaključeno je iz studije da dodatak optimalne doze superplastifikatora poboljšava obradivost i karakteristike čvrstoće maltera sa silikatnom prašinom Dobilo se najzad pojačanje čvrstoće na pritisak maltera sa silikatnom prašinom.

Ključne reči: *Čvrstoća na pritisak, ponašanje, ferocement, plastifikator, silikatna prašina*