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Compatibility of Sulphonated Naphthalene Formaldehyde and Lignosulphonates based Superplasticizer with Portland Slag Cements

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ABSTRACT

Most of the constructions require pumpable and workable concrete. Thus, chemical admixtures are required to be added to the fresh concrete mix. Granulated blast furnace slag (GGBS) based Portland slag cements are required for offshore structures, sewage treatment plants etc., to have high resistance to chlorides and sulphates. Early age strength of concrete and slump loss have been studied. To achieve high workability in fresh state and desired compressive strength in hardened state of normal concretes, *sulphonated naphthalene formaldehyde and lignosulphonates* based chemical admixture has been incorporated. It was observed that the setting behavior varied significantly from one brand of cement to another, though the cement type and the chemical admixture are the same. Hence, it is required to study the compatibility between the superplasticizer and Portland slag cements before a suitable combination is used in concrete, especially when high workability, slump retention and early age strength are required.

KEYWORDS:

Pumpable concrete, workability, slump-retention, superplasticizers, setting time

INTRODUCTION

In the construction industry pumpability and high workability of concrete play an important role especially where concrete is produced away from actual job site, for example as 'ready mixed concrete (RMC)' is produced at a batching plant. To achieve high workability in the fresh state and to have considerable slump-retention apart from cement, aggregates and water, a fourth ingredient namely a superplasticizer is introduced in the concrete. Aitcin (1998) has stated that modern concretes almost always possess additives, either in the mineral or chemical form. Particularly, chemical admixtures such as water reducers and set controllers are invariably used to enhance the properties of fresh and hardened concrete. If a particular brand of cement and superplasticizer are not compatible, it may lead to adverse effect on performance of concrete. Common problems include flash setting, delayed setting, rapid slump loss, improper strength gain, inordinate cracking etc. These issues in turn affect the hardened properties of concrete, primarily strength and durability. The properties of blended cements like Portland slag cements (PSC) are mentioned in Tables 1 and 2. PSCs are relatively cheaper when compared with ordinary Portland cements (OPC).

Table 1 Chemical analysis of cements

S.No	Constituents determined	Percentage by mass			Specified limits as per IS 455 (1989)
		Cement A	Cement B	Cement C	Maximum Value
1	Loss in ignition(%)	0.81	1.01	1.34	5.0
2	Magnesia (Mgo)(%)	6.27	4.83	3.51	8.0
3	Insoluble residue(%)	0.99	0.84	1.34	4.0
4	Sulphuric anhydride (So_3)	1.94	2.1	1.13	3.0
5	Total chlorides (%)	0.007	0.003	0.003	0.05
6	GGBFS (%)	70	50	70	As stated by manufacturer

Table 2 Physical properties of cements

S.No	Property	Cement A	Cement B	Cement C	Specified limits as per IS 455 (1989)
1	Specific gravity	2.765	2.81	2.82	---
2	cosistency of cement(%)	28	30	31	---
3	Initial setting time(minutes)	48	56	65	30Minutes(Minimum)
4	Final setting time(minutes)	188	203	208	600Minutes (Maximum)
5	3 days strength (MPa)	17.1	16.76	17.11	16MPa(Minimum)

Ramachandran et al (1998) have stated that superplasticizers are used to enhance the properties of fresh and hardened concretes. In cement pastes addition of superplasticizer results in a decrease in viscosity, change in other rheological parameters. See the review of Jaysree et al (2011), for the mechanism of action of the superplasticizer and the interaction between cement and superplasticizer. Mehta (1997) and Neville (1997) have stated that setting times of concrete differs widely from setting times of cement. The setting time of concrete depends upon the water cement ratio, temperature conditions, type of cement, mineral admixture and superplasticizers. Janardhana et al., (2004) have studied the effect of combination of admixtures on setting times of concrete. Superplasticizing and retarding admixtures were added in different dosages to the cement concrete made up of with ordinary Portland cement. They stated that the initial setting times of concrete decrease with increase in grade of concrete and superplasticizers prolong the setting times of concrete. The setting time of concrete are determined as per IS 8142 (1976) using penetration resistance apparatus. Mortar passing through 4.75mm sieve is separated from concrete for this test. According to IS 8142 (1976), the initial setting time (IST) is the elapsed time, after initial contact of cement and water, required for the motor (sieved from the concrete) to reach a penetration resistance of 3.43 N/mm^2 and the final setting time (FST) is the elapsed time, after initial contact of cement and water, required for the mortar (sieved from the concrete) to reach a penetration resistance of 26.97 N/mm^2. For concrete mix design, the water cement ratio selected was lower than the maximum value of 0.50 for M25 and 0.40 for M40 as per IS 456 (2000).Water cement ratios of 0.45 for M25 grade concrete and 0.35 for M40 grade concrete are chosen. Two grades of concretes of compressive strengths of 25MPa and 40 MPa are considered for this study. Factory blended superplsticizer of 'SNF and lignosulphonate' based chemical admixture was mixed with fresh concrete to achieve a high workability of 150 to 160 mm slump in fresh state. Tests were conducted for evaluating workability, slump retention, compressive strengths and setting times of concrete and their results are discussed.

EXPERIMENTAL INVESTIGATIONS

Three brands of GGBFS based PSCs, conforming to IS 3812 (1981), were used in the present study and are denoted by Cement A, Cement B, Cement C. One variety of superplasticizer conforming to IS 9103 (1978) is used in the study. Chemical composition of cements was determined at the National Council for Cement and Building Materials (NCB), Hyderabad. The physical properties of cements are carried in-house at the JNTUH College of Engineering, Hyderabad. Two concrete mix design mixes as given in Table- 3 for compressive strengths 25 MPa and 40 MPa were prepared with 10-20 mm and 5-10 mm coarse aggregates, sand conforming to zone- II and with water - cement ratio 0.45and 0.35 respectively. Concrete mix design was carried out as per IS 10262 (2009). Dosage of superplastizer (percentage by weight of cement) as given in Table 4 was chosen by trial and error, for each brand of PSCs to achieve an initial slump of 150 to 160 mm and a workable slump of 50 to 60 mm after one hour. Experiments were carried for finding out the compressive strength as per IS 9013 (1978) by resorting to accelerated curing and also with normal curing. The compression test on concrete cubes was carried out as per IS 516 (1959). The 28 day compressive strength of concrete were predicted as per IS 9013 (1978) and conventional strength of concrete at 3, 7 and 28 days was determined. The initial and final setting times of concrete estimated as per the IS 8142 (1976) as shown in the Table 5.

Table 3 Mix proportion per cu.m of concrete in kgs

Brand of cement	concrete design strength (MPa)	Cement	Fine aggregate	Coarse aggregate		Water cement ratio
				10mm	20mm	
A	25	370	684.488	464.372	691.341	0.45
	40	430	582.814	491.732	732.07	0.35
B	25	370	685.08	464.5	691.53	0.45
	40	430	582.3	491.3	731.43	0.35
C	25	370	686.54	465.49	693.01	0.45
	40	430	584.51	493.16	734.2	0.35

Table 4 Dosage of chemical admixture

Brand of cement	Design compressive strength of concrete (MPa)	Dosage (percentage by weight of cement)of superplsticizer to achive about 150mm to 160mm slump
		SNF and lignosulphonated based
A	25	1.1
	40	1.25
B	25	1
	40	1.35
C	25	0.8
	40	1

Table 5 Initial and final setting times of concrete

Brand of cement	Design compressive strength of concrete (MPa)	Type of chemical admixture	
		SNF and lignosulphonated based	
		IST(Hours)	FST(Hours)
A	25	15.33	18.3
	40	12.08	16.15
B	25	10.32	13.39
	40	16.03	21.25
C	25	8.59	13.32
	40	10.36	14.16

DISCUSSION OF TEST RESULTS

It was observed that the dosage of superplasticizer was different for three brands of cement though they are of the same category (i.e., GGBFS based PSCs). It was observed that the cement C required relatively lesser dosage of superplasticizer when compared with other two brands, to achieve an initial slump of 150mm. It was also observed that slump-retention after 30 and 60 minutes varied significantly among the three brands of cements for given type of superplasticizer (corresponding results are shown in the Table 6). It was observed that slump-retention after 30 minutes for cements A and B was comparable whereas it was relatively higher for cement C. The initial and final setting times of the three types of cements are different. It indicates that the interaction with the chemical admixture influences the setting response of concrete considerably. The initial and final setting times of cement concrete with cement C are the lowest among the remaining cement concretes.

Table 6 Slump retention test of concrete with SNF and lignosulphonate based superplasticizer

Brand of cement	Design compressive strength of concrete(MPa)	Dosage of superplasticizer(%)	Slump (mm)		
			Initial	After 30 minutes	After 60 minutes
A	25	1.1	172	104	76
	40	1.25	168	101	64
B	25	1	154	93	51
	40	1.35	150	92	53
C	25	0.8	168	98	55
	40	1	150	82	51

Table 7 Compressive strengths of concrete with SNF and Lignosulphonates based superplasticizer

Brand of cement	Design compressive strength of concrete (MPa)	Pridicted strength (accelerated curing) N/mm^2	Conventional curing of concrete		
			3 day strength N/mm^2	7 day strength N/mm^2	28 day strength N/mm^2
A	25	31.65	17	23.2	32
	40	48.74	23.1	34	49.6
B	25	34.82	17.2	23	32.5
	40	49.2	22.7	32.2	48.27
C	25	34.47	18.39	24.2	34.2
	40	48.65	25.1	35	49.8

Compressive strengths of concretes are shown in Table 7 for different ages of concrete. The predicted 28 day compressive strengths of concrete, by resorting to accelerated curing, as well as the strength obtained with normal curing were also reported. By resorting to accelerated curing, it will be convenient to assess the strength of concrete within 30 hours from the time of casting. If required the concrete mix design may be revised. It was observed that the early age strengths of concrete for the three brands of cement were comparable. However, there was considerable difference in the 28 days compressive strengths between one brand of cement to another. It was observed that predicted compressive strength of concrete obtained from accelerated curing of concrete was not always comparable with that of the strengths obtained from conventional curing. Hence, it can be concluded that care should be exercised while predicting the 28 day strength of PSC concrete by adopting accelerated curing.

CONCLUSIONS

On the basis of experimental investigations and studies carried out in the present work, it is concluded that though the concrete mix proportion is approximately the same in all the mixes, the workability, compressive strengths and setting times of cement concretes are considerably different depending on the brand of the cement. The dosage of superplsticizer required is less for cement C when compared with cements A and B**.** The setting times of cements A and B are relatively higher when compared with that of cement C. The compressive strengths of concrete made with cements A and B are relatively lesser when compared with that of cement C. The reason could be requirement of higher dosages of superpalsticiser for concretes made with cements A and B. It was observed that the different brands of cements (GGBFS based PSCs) behaved differently even if the coarse and fine aggregates, water and family of chemical admixture and the method of concrete mix design were kept constant. Hence, it is essential to know the interaction of the superplasticizer with the cement, even if they are of similar kind, and trial concrete mixes have to be studied in a laboratory before actually using them at site.

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