Compatibility between Various Super Plasticizers and Portland Pozzolona Cements

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Abstract— Workability of concrete is the major concern and interest of the construction engineers today. To achieve high workability, chemical admixtures like superplasticizers are required to be added to the concrete mix in the fresh state. Blended cements like PPC are being used quite commonly instead of OPC either due to the non-availability of the latter in the market or to improve the durability of concrete. Three brands of fly ash based PPCs were used to achieve two different grades of concrete, 25 and 40 MPa (M25 and M40). To achieve high workability in the fresh state and desired characteristic compressive strength in the hardened state, of the normal concretes, five different chemical admixtures namely, sulphonated naphthalene polymer(two different families), modified lignosulphonate, combination of 'sulphonated naphthalene formaldehyde (SNF) and melamine' and another combination of 'SNF and lignosulphonate' have been used in the present study, to investigate their compatibility with various brands of cement (PPCs). It was observed that for each and every type of chemical admixture considered in this research, the setting behaviour varied significantly from one brand of cement to another, though all the three brands of cement were of fly-ash based PPCs. The early age strength and slump loss were also found to be varied significantly. Hence, a strong case was made for studying the compatibility between various kinds of superplasticizers and cements (PPCs) before a suitable combination was used in concrete, especially when high workability and early strength were required.
Key words: (SNF), (PPCs), Ready Mixed Concrete (RMC)

I. Introduction

In the construction industry, pumpability and high workability of concrete play a vital role especially where concrete was produced away from actual job site, for example as 'ready mixed concrete (RMC)' 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. Blended cements like portland pozzolona cements (PPC) are being used quite commonly instead of ordinary portland cement (OPC) either due to the non-availability of the latter in the market or to have relatively better durability characteristics. Cost savings is also one of the reasons for usage of PPCs.

This paper discusses the usage of fly-ash based PPCs available in the south India. Two grades of concrete having compressive strengths of 25 and 40 MPa were considered in this study. Four different kinds(families) of superplasticizers viz., (i)sulphonated naphthalene polymer from two different families , (ii)modified lignosulphonate (MLS), (iii)combination of 'sulphonated naphthalene formaldehyde (SNF) and melamine' and (iv) 'SNF and lignosulphonate' based chemical admixtures (superplasticizers) were incorporated in the fresh concrete to achieve a high workability of about 150 to 160 mm slump in the fresh state. Tests were conducted for evaluating workability, slump retention, compressive strengths and setting times of concrete and their results are discussed.

II. Experimental Investigations

Three brands of fly-ash based PPCs were used in the present study, and are denoted as A, B and C. Four varieties of chemical admixtures (superplasticizers), viz., (i)sulphonated naphthalene polymer from two different families, (ii)modified lignosulphonate, (iii) combination of 'SNF and melamine' and (iv) combination of 'SNF and lignosulphonate' based chemical admixtures (superplasticizing admixtures) conforming to IS 9103 (1999) were used in the study. The chemical composition of the cements was determined at the National Council for Cement and Building Materials (NCB), Hyderabad. The physical characterisation was done in-house at the JNTUH College of Engineering, Hyderabad, and the results were also shown in the Table 2. Two design mixes of compressive strength 25 MPa and 40 MPa were prepared with 10-20 mm and 5-10 mm size coarse aggregates, sand conforming to Zone-II, and with water cement ratios of 0.45 and 0.35, respectively. Concrete mix design was carried out as per IS 10262 (1982). The dosage of superplasticizer (percentage by weight of cement) was chosen, by trial-and-error, for each brand of PPC to achieve a high slump of 150 to 160 mm.

For determination of the initial and final setting times of concrete, the fresh concrete was sieved through a 4.75 mm IS sieve. The mortar that passed through this sieve was remixed by hand and placed in standard concrete cubes (150 mm), to a depth of 140 mm. A pipette was used for drawing-off free water from the surface of mortar placed in the cubes. The initial and final setting times of concrete are different from that of cement. Initial setting time (IST) of concrete is the elapsed time required for the mortar to reach a penetration resistance of 3.43 N/mm^2. Final setting time (FST) of concrete is the elapsed time required for the mortar to reach a penetration resistance of 26.97 N/mm^2. It should be noted that Mehta (1997) and Neville (1997) have stated that the setting times of concrete do not coincide with the setting times of the corresponding cement. The initial and the final setting times, as measured by penetration resistance methods, do not mark any specific change in the physical-chemical characteristics of the cement paste. The initial setting time defines the limit of handling and the final setting time defines the beginning of development of mechanical strength. Janardhana et al. (2004) have reported the effect of the combination of superplasticizer and retarder on the setting times of OPC concrete. Aloke Chandra Das (2007) has studied the compatibility between different OPCs and superplasticizers in concrete for evaluating setting times of concrete and compressive strength. Rambabu et al.,

(2009) have discussed compatibility of a SNF based superplasticizer with three different brands of PPCs. To find the setting times of concrete, a spring reaction based device known as the 'Proctor probe' (penetrometer conforming to IS 8142:1976) was used. Removable needles, having bearing area of 645, 323, 161, 65, 32 and 16 mm^2, were attached to the penetrometer depending on the resistance offered by the mortar. The bearing surface of the needle was brought into contact with mortar surface. A vertical downward force was applied gradually and uniformly, on the mortar until the needle penetrates to a depth of 25 mm in 10 seconds (approximately). The force required for this penetration and the time of application of the force was recorded. The time was measured as elapsed time after initial contact of cement with water. An initial penetration test was conducted after an elapsed time of 4 to 7 hours, and subsequent tests were carried out at intervals of 30 minutes to one hour. The procedure was continued till all the needles mentioned have offered resistance by the mortar against penetration. The results were plotted showing penetration resistance as the ordinate and elapsed time in hours as abscissa for 25 and 40 MPa concretes, respectively. The initial and final setting times of concrete were estimated as per the IS 8142 (1976). Experiments were carried out for finding out the compressive strength by resorting to both accelerated curing (boiling water method) as per IS 9013 (1978) and also with normal (conventional) curing. The compression test on concrete cubes was carried out as per IS 516 (1959). The 28 day compressive strength of concrete was predicted by adopting accelerated curing method (Boiling water method). The conventional strength of concrete at 3, 7 and 28 days was determined by resorting to normal curing.

III. Discussion of Test Results

It was observed that the dosage of superplasticizer was different for the three brands of cement though they are of same category (i.e., fly ash based PPCs). The dosage of superplasticizer required for the cement brand B was higher compared to the cement brand A, but it was lesser for the brand C when compared with that of the brand A. Though all the concrete mixes had initial high slump values of 150 to 160 mm, it was observed that slump-retention after 30 and 60 minutes varied significantly among the three brands of cements and five different kinds of plasticizers. It was observed that the slump retention after 30 minutes for the cements A and C was comparable whereas it was less for the cement B. The initial and final setting times indicate that the setting behavior of three cements was considerably different. It indicates that the interaction with the chemical admixture influences the setting response of concrete significantly. The compressive strengths of concretes were shown in the Tables for different ages of concrete. The predicted 28 days compressive strengths of concrete, by resorting to accelerated curing, as well as the strength obtained with normal curing were also reported. 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 from 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 when predicting the 28 day strength of PPC concrete by adopting accelerated curing.

IV. Conclusions

The following conclusions are drawn from the experimental results: The compatibility of three brands of portland pozzolona cements with four different kinds of chemical admixtures (superplasticizers) has been studied. It has been illustrated that the proper selection of superplasticizer for each and every cement is necessary to understand the behaviour of the concrete. It was observed that the different brands of cements (PPCs) behaved differently even if the coarse and fine aggregates, water and chemical admixture and the method of concrete mix design were constant. Hence, it is advisable 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.

References

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Brand of cement	Design compressive strength of concrete (MPa)	Dosage of superplasticizer to achieve 150 mm slump (by % weight of cement)				
		SNF base		Lignosulphonate & SNF base	Modified lingo sulphonate	Modified melamine & naphthalene polymer basement227
		BASF	FOSROC			
A	25	0.8	0.8	1	1.2	1
	40	1.2	1.2	1.2	1.6	1.4
B	25	1.2	1.0	1.4	1.2	1.2
	40	1.4	1.4	1.6	1.8	1.7

C	25	0.6	0.8	0.8	0.8	1
	40	1.0	1.0	1	1.4	1.4

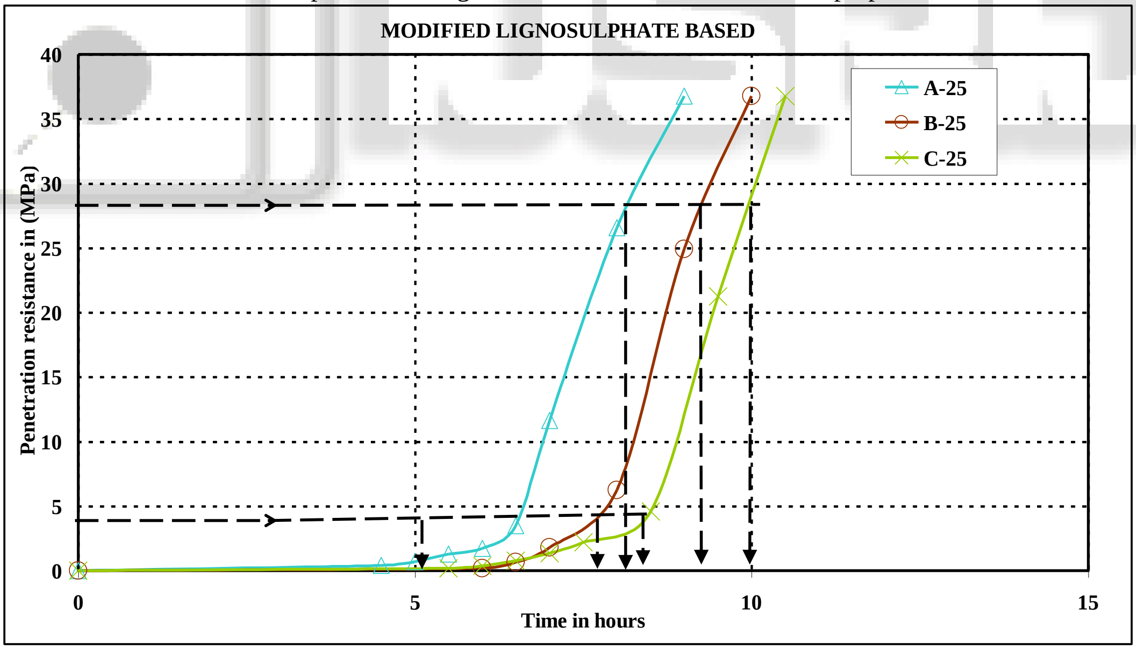
Table 1: Dosage of chemical admixture

Brand of cement	Design comp. strength (MPa)	Type of chemical admixture									
		SNF				Lignosulphonate & SNF		Modified lignosulphonate		Modified melamine & naphthalene polymer	
		BASF		FOSROC							
		IST (Hrs)	FST (Hrs)	IST (Hrs)	FST (Hrs)	IST (Hrs)	FST (Hrs)	IST (Hrs)	FST (Hrs)	IST (Hrs)	FST (Hrs)
A	25	6.5	7.8	6	6.4	8.4	9.7	6.5	8	5.1	7
	40	9.0	10.2	7.6	8.2	6.0	7.5	6.1	7.6	6.2	7.6
B	25	10.4	12.5	10.8	11.4	15.8	19.6	7.6	9.2	9.6	12.4
	40	18.2	20.5	12.4	13.2	20.4	23.5	8.6	10.6	10.5	14
C	25	7.5	10.5	8.4	12.2	11.3	13.4	8.4	9.9	9.2	12
	40	11.3	13.5	12.2	14.4	16.5	18.3	7.1	9.4	9.3	14.1

Table 2: Initial and final setting times of concrete.

Type of cement	Design compressive strength of concrete (MPa)	Predicted 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	
			BASF	FOSROC	BASF	FOSROC	BASF	FOSROC
A	25	36.58	18.34	18.91	25.64	27.65	36.20	37.63
	40	52.58	25.43	25.63	36.15	37.26	52.84	60.48
B	25	36.20	20.23	21.32	27.54	28.4	47.37	37.02
	40	52.34	22.73	29.82	35.06	37.64	49.64	58.54
C	25	34.05	19.65	16.97	27.44	21.25	41.78	32.74
	40	52.84	28.65	24.34	38.48	32.36	56.10	54.68

Table -3: Compressive strengths of concrete with SNF based superplasticizer



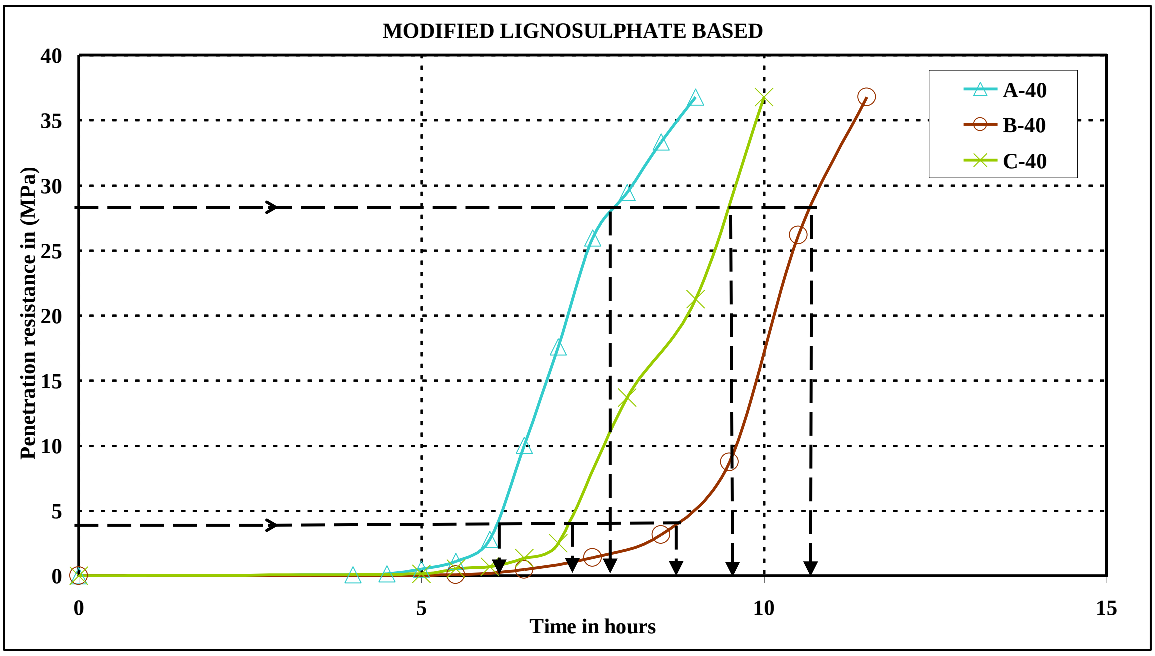


Fig. 1: Evaluation of Penetration Resistance for 25 and M40 MPa concrete made with modified lignosulphonate based superplasticiser