ENHANCING OF POLYCARBOXYLATE ETHER AND LIGNOSULPHATE BASED SUPERPLASTICIZER IN CONCRETE

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Abstract:

Admixtures are attach to concrete at the time of mixing. It has been erect that the use of admixtures is very important since low quantity may result in loss of fluidity and over quantity could lead to segregation, bleeding etc in concrete. Hence it is necessary to find optimum dosage of superplasticizer for good strength and workability. The paper deals with the quantity requirements of superplasticizer in concrete to get good workability. In this work for preparing concrete 2 brands of easily available Portland Pozzolana Cement and superplasticizer associating to 2 different groups namely polycarboxylate ether (PCE) and lignosulphate (LS) are used. Workability study on concrete with cement to sand ratio 1:1.5 and water cement ratio 0.38 was done using slump cone and flow table test. Compressive strength study on concrete cube were done on concrete mixes with a superplasticizer dosage and a comparative study were done to analyse the recovery in the compressive strength with addition of superplasticizer(PCE & LS).

Keywords: Polycarboxylate ether, lignosulphate, superplasticizers and concrete.

Introduction:

Polycarboxylate ether superplasticizers have been one of the most magnificent evolution in concrete technology over the past few decades, they are added to concrete mixes to improve the rheology and other important properties, such as strength and workability. Workability improvement by the superplsticizer in the concrete is mainly by increase in the surface potential force, the solid-liquid affinity, and the steric hindrance mainly in PCE based superplasticizer.

This way strength and workability of the hardened cement matrix will be improved. Because of the slow reaction of the pozzolanic material, the problem due to thermal cracking can also be escaped. It is commonly noted that the addition of mineral admixtures reduces the workability due to the higher surface area and consequently increase the water and superplasticizer requirement. Unexpected and abominable tendencies like bleeding, increased setting time and low cost effectiveness were experienced by the usage inconsistant cement and superplasticizer. Microstructure of the massively and reasonably superplasticized concrete were studied by Sidney Diamond (2006) to determine the modification in patched microstructure of the base Ordinary Portlant Cement (OPC) concrete with superplasticizer (PCE) addition. From the study it is observed that patched structure is present in both reasonaly and massively superplasticized concrete also but the porous patches are appeared to be relatively fewer in number and generally smaller in size in massively superplasticized concrete.

In this work to arrange concrete two brands of PPC namely C1 and C2 and two groups of SP's namely Polycarboxylate Ether (PCE) and Lignosulphate (LS) are used. Marsh cone test and flow table tests were achieved to determine the flow behavior of PPC concrete and to find dosage of superplasticizer in cement mortar with cement to sand proportion 1:1.5. Polycarboxylate superplasticizer (PCE), observed as a kind of high-efficiency water-reducing agent, are used to efficiently plasticize cement paste for achieving high fluidity of cement-based materials by using less mass of water.

Main specification which affect the concrete flow behavior are paste rheology, aggregate volume fraction and aggregate particle size distribution. So consequences of aggregates and the aggregate-paste attachment need to be studied to interact the paste results with concrete. Hence for the study on the flow behavior, concrete mixture of same cement to sand proportion as that of mortar was prepared using two brands of cement and two groups of superplasticizer and flow table test and slump cone tests were performed. Saturation dosage of superplasticizer in concrete was determined from the test result and an attempt is made to interact the flow behaviour of cement mortar with that of concrete. All the tests were carried out at a water-cement ratio of 0.38.

Material Specification:

1.Cement:

Physical properties of the cement tested according to the codal specifications are listed in table 1.

Table1. Physical proper of cement

Tests	C1	C2
Fineness(%)	1.08	1.93
Specific gravity	2.86	2.90
Consistency	37	36
Initial setting time(min)	177	125
Final setting time(min)	212	205

2.Aggregate:

Properties of the coarse aggregate and fine aggregate tested according to the codal provision is tabulated in table 2 and table 3 respectively. The results were compared with the specification given in the IS code and found suitable for use.

Table 2. Properties of coarse aggregate

Tests	Results
Maximum size of aggregate(mm)	20
Fineness modulus(%)	7.2
Specific gravity	2.753
Bulk Density(kg/m3)	1535
Percentage voids(%)	85.2
Water Absorption(%)	0.07

Table 3. Properties of fine aggregates

Tests	Results
Maximum size of the aggregate(mm)	4.75
Fineness Modulus (%)	2.89
Grading zone	II
Specific gravity	2.524
Bulk Density(kg/m3)	1720
Percentage Voids (%)	56.21
Maximum Percentage of Bulking (%)	18.6
Corresponding Moisture Content (%)	2
Water Absorption (%)	2.17

3.Superplasticizers:

Solid content of superplasticizers was determined according to IS 9103:2004 - Annex E. The density of superplasticizers obtained from the data sheet provided by the respective manufacturer is also tabulated along with the solid content in table 4.

Table 4. Properties of superplasticizers

Classification	Density (kg/litre)	Solid conten(%)
PCE-1	1.08	37.98
PCE-2	1.08	34.50
LS-1	1.17	31.18
LS-2	1.18	32.96

4. Concrete Mix Details:

Mortar of cement to sand proportion 1:1.5 and water to cement ratio 0.38 is used for this study. Concrete mixes were prepared for a characteristic compressive strength of 35MPa using the codal provision IS 10262 and adjustment were done in the ingredient quantity for making the cement/sand proportion as 1:1.5. The concrete mixture details used for this study are given in the table 5. Water correction for the aggregate moisture was done by considering water absorption of aggregate.

Table 5. Mix proportion of concrete

Ingredients of concrete	Quantity (kg/m^3)
Cement	445
Fine aggregate	650
Coarse aggregate	1080
Water	178

Test Details:

Concrete:

In this work, the flow behavior of cement Concrete was studied using flow table test and slump cone test. For preparing the concrete mix, the material were dry mixed followed by the mixing sequence adopted in an earlier study. The total mixing time was 5 minutes.

a) Flow Table Test

Workability test on concrete was performed by conducting flow table test using flow table and mould of dimensions specified in the IS code. In that test the concrete was filled in two layers and the mould was lifted vertically upwards and jolted 15 times in 15 seconds. The spread diameter was measured in six directions and the average was noted. The test gives the fluidity of concrete in terms of the spread diameter; higher the spread diameter, higher is the fluidity of concrete. The saturation point is the dosage beyond which further addition of SP does not increase spread diameter but can produce segregation; the saturation dosage can taken as the optimum dosage for given concrete mixture.

b) Slump Test

Workability was also measured by conducting slump test on concrete mixtures at the saturation dosages (as obtained in flow table test) according to the procedure given in the IS code using a slump cone of dimension specified in IS code. The concrete was placed in slump cone in four layers and sufficient tamping was given to each layer. The slump value was measured as the subsidence of concrete on removal of mould.

Results and Discussion:

A) Fresh stage properties of concrete:

Flow table spread of concrete for different dosages of SP are taken. Results of flow table test corresponding to the saturation dosage of superplasticizers are tabulated in table 6. Slump test results at the above saturation dosages are also presented.

Table 6: Spread diameters and slump values at saturation dosage of SP in concrete

SP	Cement	Saturation dosage of SP in concrete(%)	Average spread diameters (cm)	Slump value(cm)
PCE-1	C1	0.4	50.85	19.65
	C2	0.6	54.04	0
PCE-2	C1	0.5	66.12	0.2
	C2	0.6	57.45	0.2
LS-1	C1	0.7	56.76	0
	C2	1.2	55.12	0
LS-2	C1	0.6	54	18.25
	C2	0.6	41.55	0

B) Saturation dosage of Concrete:

Saturation dosage of superplasticizer in concrete. It is found that the performance of the PCE based superplasticizer are better than other groups of SPs in concrete. This is mainly due to the steric hindrance between the cement particles in addition to electrostatic repulsive force. But it is observed that not only SPs of different basic groups behave differently, but even the SP within the same basic group also behaves differently. Similar trends were observed in an earlier study also. This change in behavior is mainly due to difference in their synthesis process . The cement concrete saturation dosages of SP are observed to be at a higher range than that of cement mortar. Similar observations were mentioned in another study on OPC-SP combination properties. This has been aspected to the adsorption of superplasticizer on the fines in the crushed coarse aggregate and the subsequent reduction in the amount of superplasticiser availability for the cement paste.

C) Hardened state properties of concrete:

Cubes of 100 mm size for testing compressive strength were cast for the concrete mixtures made with superplasticizer corresponding to the saturation dosage. Water curing was given for concrete cubes and tested for 7th and 28th day compressive strength, which are tabulated in the table 7.

Table 7:Compressive strength of concrete

Cement	Superplasticizer	7th day compressive Strength(MPa)	28th day compressive Strength(MPa)
C1	PCE-1	28	43
	PCE-2	28	44
	LS-1	18.5	40.5
	LS-2	18.9	40
C2	PCE-1	30	40
	PCE-2	31	41
	LS-1	24	39
	LS-2	31.3	40

Superplasticised PPC concrete mixtures had higher compressive strength than those of control mixtures. This observation is consistent with the observation of other researchers. Improvement in the compressive strength of the superplasticized concrete mixtures is mainly due the improved compaction obtained in the concrete by the addition of superplasticizer and also due to the improvement in the pore structure.

Conclusions:

From this study, the following conclusion can be summarized:

1. The addition of superplasticizers improves the flowability of concrete. However, there is an optimum dosage for each water content.

2. Excessive use of superplasticizers causes bleeding and segregation.

3. Saturation dosages of superplasticizer in cement concrete are observed to be at a higher range than that of cement mortar. This is due to the adsorption of superplasticizer on the fines in the crushed coarse aggregate and consequently, the superplasticiser amount available in the cement paste decreases and more amount of superplasticizer is required to maintain the workability.

4. Each SP groups has different behavior with regards to the optimum dosage, setting time, strength development and slump value. Hence, the use of different cement type need to be carefully considered.

5. Due to enhancement in workability, superplasticized concrete yielded higher compressive strength than the PPC control mixtures. Compressive strength variation is only marginal for concretes made using different families of superplasticisers, at their optimum dosages.

6. Optimizing the superplasticizer dosage using flow table test and temperature evolution measurement give satisfactory information on the different performance amongest various SP groups.

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