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SUPER PLASTICIZER:
CONCRETE

Use Of Various Superplasticizers In Nominal Concretes

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Superplasticizers are getting increasing popularity for use in concrete because of the benefits they provide in handling, placing, compaction and finishing of concrete alongwith other technical and economic advantages (1-10) and their desirable effects on cement particles (11-12). Though superplasticizers are being used in large quantities in developed countries, however, in the third world countries the use of superplasticizers is not so common. It is by now a well established fact that the superplasticized concrete is in many respects superior to normal concrete. The use of superplasticizers has been established mainly in the production of high strength concrete and prestressed concrete etc.. However, not much efforts have been made to popularise use of superplasticizers in nominal concretes of various grades which are generally used for huge construction works.

The purpose of the study reported in this paper has been mainly to find the behaviour of different grades of nominal concrete with the use of various superplasticizers. The results of the study on the 1:2:4, 1:1.5:3 and 1:1:2 grade of concrete with 7 commercial superplasticizers available in the Indian market and one developed at CBRI have been presented here.

Materials

Aggregate: Crushed stone aggregate passing 20 mm was used in the present study.

Sand : River sand of fineness modulus 2.65 was used.

Cement : Ordinary Portland Cement conforming to IS:8112/1989 (13).

Admixtures: Eight superplasticizers have been used for this study. These seven superplasticizers had been obtained from the Indian manufacturers and have been labelled as SP-1 to SP-7. SP-8 superplasticizer was developed during the studies. The chemical nature of these products as mentioned in the company catalogues is as follows:

SP-1: Brown liquid as per ASTM-C-494

SP-2: Napthalene sulphonated formaldehyde condensate

SP-3: Napthalene sulphonated formaldehyde condensate

SP-4: Melamine sulphonated formaldehyde condensate

SP-5: Melamine sulphonated formaldehyde condensate

SP-6: Brown liquid as per ASTM C-494

SP-7: Blend of specially organic polymers as per ASTM - C-494

SP-8: Superplasticizer based on cashew nut shell liquid developed during the studies.

Experimental Details

Two sets of experiments have been carried out with the concrete using the superplasticizers. In one case the slump of the concrete was fixed around 75 mm at the recommended dose of superplasticizer, the w/c ratio was adjusted; while in the second set of experiment the w/c ratio was kept same as that of control and the slump was measured.

The various ingredients, cement, sand and aggregate were hand-mixed thoroughly to prepare the concrete cubes. In one set the mix was prepared with cement 1, sand 2 and aggregate 4 (<20mm) parts. The other sets of 1:1.5:3 and 1:1:2 were prepared similarly. The materials for two 150 mm cubes were mixed thoroughly before adding water or water containing the superplasticizer. The slump of the concrete mix was measured as per IS:7320/1992 (14) and the values are given in Tables 1 to 3. The mixture was filled in the cube moulds in two instalments. Cubes were allowed to mature under water in a constant temperature room maintained at 27 + 2 deg. C. These were demoulded after 24 hrs and allowed to cure for various prestipulated periods in the constant temperature room.

The cubes were tested for compressive strength at 7, 28 and 180 days. The results of compressive strength test are given in Tables 1 to 3.

Results And Discussion

The use of water reducing superplasticizing admixtures allow a similar or better workability, slump

Tabel - 1 Compressive Strength (Kg/cm²) of M 15 (1:2:4) Grade Concrete of 150 mm Size Cubes

Sl. No.	System	Recommended Dose of SP.	W/c ratio	Slump (mm)	Compressive Strength (after days) 7	28	180
1.	Control	—	0.53	75	230	320	340
2.	SP-1	2%	0.53	Flowing	245	340	408
3.	SP-1	2%	0.49	75	260	420	480
4.	SP-2	0.5%	0.53	Flowing	230	342	408
5.	SP-2	0.5%	0.49	75	245	345	431
6.	SP-3	1 litre/100kg of cement	0.53	Flowing	248	330	404
7.	SP-3	- do -	0.49	75	275	430	482
8.	SP-4	0.5%	0.53	Flowing	200	315	428
9.	SP-4	0.5%	0.50	75	230	365	470
10.	SP-5	0.75%	0.53	Flowing	230	340	382
11.	SP-5	0.75%	0.49	75	245	350	424

etc., to be achieved by using less water than required for normal concrete. High workability or high slump are desired for better placement etc. But higher quantity of water if used for this purpose is highly undesirable. It is clear from the tables 1 to 3 that for nominal concrete 1:2:4, 1:1.5:3 and 1:1:2, the concrete with initial slump of 75 mm becomes flowing (which is not desirable for present work) with all the superplasticizers selected for the study at the dosage as recommended by the manufacturers. Therefore, calling for the use of less quantity (reduction) of water required for the designated slump. However, with incorporation of superplasticizers in the mix water, reduction of 10 to 15% water at same dosage level is achieved and there upon the slump of 75 mm and 100 mm had been achieved easily.

The compressive strength of 150 mm cubes of 1:2:4 concrete obtained at different periods (7, 28 and 180 days) indicates that at 7 days, except in case of SP-4, the compressive strength at constant w/c ratio is either equal or 5% more than the strength of the control cubes. The lower strength in case of SP-4 can be attributed to the retarding nature of the superplasticizer. However, this lowering of the strength is compensated when w/c ratio is lowered to have the same slump. There is 10-15% increase in the strength in case of other superplasticizers studied. Further, the results at 28 days indicate that the compressive strength is almost same at constant w/c ratio, though about 25% increased strength had been obtained in case of SP-1 and SP-3. At 180 days the compressive strength at same w/c ratio shows 30% increase in strength with SP-1 to SP-4 superplasticizers. The use of SP-5 has given about 10% increase in strength. However, at constant slump there is 25 to 40% increase in strength. Another important observation in case of SP-4 which had given almost same strength as in control at constant slump, results in an increase in strength of 40% indicating thereby that the lower strength due to retardation has been compensated at longer time interval of curing.

From Table 2 it is clear that the compressive strength of 1:1.5:3 concrete at constant w/c ratio is comparable to that of control at 7 and 28 days. However, at 180 days SP-3 and SP-4 superplasticizers have given 20% increase in strength. The same effect has been observed in the 1:2:4 nominal concrete of same slump. There is 25 to 30% increase in strength at 7 days. The 28 days strength shows 10 to 20% increase, whereas at 180 days this increase in strength is in the range of 15 to 25%.

Table - 2 Compressive Strength (Kg/cm²) Of M 20 (1:1.5:3) Grade Concrete of 150 mm Size Cubes.

Sl. No.	System	Recommended Dose of SP.	W/c ratio	Slump (mm)	Compressive Strength (after days) 7	28	180
1.	Control	—	0.48	75mm	250	375	425
2.	SP-1	2%	0.48	Flowing	255	375	430
3.	SP-1	2%	0.42	75mm	340	455	550
4.	SP-2	0.5%	0.48	Flowing	250	380	424
5.	SP-2	0.5%	0.42	75mm	308	450	550
6.	SP-3	1 litre/100kg of cement	0.48	Flowing	255	378	500
7.	SP-3	- do -	0.41	75 mm	335	440	515
8.	SP-4	0.5%	0.48	Flowing	255	390	502
9.	SP-4	0.5%	0.41	75mm	310	440	520
10.	SP-5	0.75%	0.48	Flowing	255	390	435
11.	SP-5	0.75%	0.42	75mm	360	405	480

Table 3 gives the compressive strength of 1:1:2 nominal concrete. The 7 day compressive strength at same w/c ratio had been found to be 5 to 10% higher with all the superplasticizers studied except SP-6, as compared to control. The gain in strength at 7 days is of the order of 25 to 35% when the w/c ratio is reduced to have the same slump. At 28 days and at constant w/c ratio the increase in strength over control has been about 30%, whereas at constant slump this is 30 to 50%. However, in case of 180 days curing this increased strength remains 10% at same w/c ratio and 10 to 20% at same slump. The studies are being continued further to study the effect of various superplasticizers on long periods of exposures.

A comparative analysis of the results for three grades of concrete studied, makes it apparent that at 180 days in case of the set at constant slump, the 1:2:4 concrete gives 24-40% increase in strength, 1:1.5:3 and 1:1:2 concrete show 15 to 25% and 10 to 20% increase in strength respectively when compared to control. Since all studies have been

Table - 3 Compressive Strength (Kg/cm²) Of M30 (1:1:2) Grade Concrete of 150 mm Size Cubes

Sl. No.	System	Recommended Dose Of SP.	W/c Ratio	Slump (mm)	Compressive Strength (after days) 7	28	180
1.	Control	-	0.43	100	305	345	500
2.	SP-3	2%	0.43	Flowing	365	475	565
3.	SP-3	2%	0.39	100	430	520	575
4.	SP-4	3%	0.43	120	350	410	510
5.	SP-4	3%	0.39	100	375	525	620
6.	SP-6	0.3%	0.43	160	310	417	505
7.	SP-7	0.3%	0.40	100	401	460	510
8.	SP-6	0.6%	0.43	Flowing	375	490	555
9.	SP-7	0.6%	0.39	100	425	530	560
10.	SP-8	0.6%	0.43	130	385	440	520
11.	SP-8	0.6%	0.40	100	405	480	535

done at constant slump the water reduction in case of 1:2:4 as expected has been found to be more than that obtained in case of 1:1.5:3 and 1:1:2 concretes.

Conclusions

It is evident from the studies carried out with various superplasticizers that it is possible to make the concrete of normal slump flowable using recommended dosages of superplasticizers. This will make the concrete more compact and will require less compaction efforts and result in easy and better placement. Due to increase in strength over the control concretes, it is possible to remove the shuttering at an early date and save on the cost of shuttering. Thus making the use of superplasticizers economical.

The additional cost of superplasticizers can be compensated with the saving of cement due to increase in compressive strength. However, this approach may be adopted in some cases but is not desirable as a general case. Though the strength is primarily governed by the requirement of structure only, but the other properties like reduced porosity, better durability of the structure etc. are also not less important and hence forbid the reduction of cement. These properties are further improved with the use of superplasticizers. The longevity to the life and less maintenance of structure compensate for the additional cost of the superplasticizer. The use of superplasticizer in the case of nominal concrete will be advantageous.

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