Concrete Compressive Strength Development with Age under Different Dosages of PC-200 Superplasticizer

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ABSTRACT

This study investigates the behavior of ordinary concrete and modified mixes with Superplasticizer (SP)-PC in compressive strength with different ages of curing. Different SP-PC dosages were used, ranging between 1.0 and 1.8 L for 100 kg of cement, while a total of 288 cube-shaped samples were examined. The results showed that higher compressive strength was achieved after 3 and 7 days using 1.8% SP. The mixes modified with 1.8% SP obtained 64% maximum compressive strength in 3 days and about 82% maximum compressive strength in 28 days, in comparison with the reference mix.

Keywords-concrete; super-plasticizer; polycarboxylate; compressive strength; cement

I. INTRODUCTION

Superplasticizers (SPs) are liquid chemicals often used in concrete construction. They have the potential to reduce the water/cement ratio while increasing strength, as well as to decrease porosity and permeability, improve workability, and increase compressive, tensile, flexural, and elastic modulus [1-3]. They can also increase the durability of concrete and produce economic benefits [4]. They are also used to produce high strength, ultra-high strength, and reactive powder concrete.

Numerous researchers examined the impact of various SPs on the mechanical and durability qualities of concrete. In [5], it was demonstrated that CF-555 SP substantially increased the compressive strength, tensile strength, and flexibility of concrete. The impact of SP type SP dosage on concrete was examined in [2], and it was found that there was a 2% increase in compressive strength by cement weight. Authors in [6] studied the effect of Aura-max-400 SP on the mechanical properties of concrete, with dosages ranging from 0.0% to 1.1%. It was found that the optimum dosage was 0.8% by weight of cement. In [7], the SP dosages were investigated and it was discovered that concrete compressive strength increased to 0.8 L for every 100 kg of cement. Higher dosages can cause the compressive strength values to decrease. It was also revealed that the 0.8% dosage was used with a water/cement ratio of 0.55, as well as other dosages that exceeded 0.8%, such as 1% and 1.2% SP, with the same water/cement ratio. Authors

in [8] studied the effects of adding the right amount of Waste Tire Rubber (WTR) to Fiber-reinforced foamed Concrete (FC), modified with an SP, on the material's compressive strength, impact resistance, and damping ratio. Four FC types with a density of 1100 kg/m3 were created in this study: fiber-reinforced rubberized FC (including SP, PP, and WTR), polypropylene (PP) fiber-reinforced FC, modified FC with SP, and standard FC. However, compared to the traditional FC (without SP and PP), the fiber-reinforced rubberized FC mix with SP demonstrated enhancement of 79.5%, 3700%, and 21.45% in compressive strength, impact resistance, and damping ratio, respectively. The higher the rubberized FC density was, the higher the compressive strength and impact resistance were.

II. EXPERIMENTAL PROGRAM

In the current study, SP of type PC-200, orange in color, as depicted in Figure 1, was used in all mixes, in different ages, and in varying percentages (0.0%, 1.0%, 1.2%, 1.4%, 1.6%, and 1.8%). It is defined chemically as polycarboxylate liquid admixture, it conforms to ASTM standard [9], and it has specific gravity of 1.05 and mix proportions of 1:1:2 (cement: sand: gravel). The used cement was common cement with coarse and fine aggregate, as presented in Tables I and II, following the Indian standards [10]. Six specimens of each mix were cast in steel molds measuring 100 × 100 × 100 mm. The specimens were then subjected to compressive strength tests in a hydraulic compression machine, as depicted in Figure 2, with a maximum capacity of 2000 KN for 3, 7, 14, and 28 days. Table III presents details about the mixtures.

Fig. 1. SP PC-200.

TABLE I. GRAVEL SIEVE ANALYSIS

Size of sieve (mm)	% passing by weight	Indian limits (IS-383)
40	100	100
20	96.5	95 - 100
10	35.4	25 - 55
5	3.8	0 - 10

TABLE II. SAND SIEVE ANALYSIS

Size of sieve (mm)	% passing by weight	Indian limits (IS-383)
10	100	100
4.75	98.2	90-100
2.36	90.5	75-100
1.18	81.3	55-90
0.6	53.8	35-59
0.3	27.5	8-30
0.15	5.8	0-10

Fig. 2. Specimen under compression test.

TABLE III. MIX INGREDIENT DETAILS

Mix type	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (kg)	SP PC-200 (L/100 kg cement)
Reference M1	550	550	1100	231	0.0
M2	550	550	1100	193	1.0
M3	550	550	1100	176	1.2
M4	550	550	1100	165	1.4
M5	550	550	1100	149	1.6
M6	550	550	1100	138	1.8

III. RESULTS AND DISCUSSION

The compressive strength of concrete after 3, 7, 14, and 28 days, at varying dosages of the SP-PC was examined, as illustrated in Table IV. The reference mix exhibits a maximum compressive strength of 29.3 MPa after 28 days, which increases to 44.3 MPa when using 1.8 L/100 kg of cement. This increase in compressive strength can be ascribed to the activity of this particular SP kind, which lowers the water/cement ratio and rearranges the cement and sand particles.

The reference mix obtained13.2 MPa compressive strength in 3 days and 29.3 MPa in 28 days, which can be expressed as 45% of the maximum compressive strength. However, in concrete with 1.8 % SP, the development in compressive

strength was much higher, that is, 28.5 MPa in 3 days and 44.3 MPa in 28 days, which can be expressed as about 64 % of the maximum compressive strength achieved in 3 days.

TABLE IV. MIX COMPRESSIVE STRENGTH

Mix	SP dosage (L/100 kg cement)	Compressive strength (MPa)			
		3-days	7-days	14-days	28-days
Mix 1	0.0	13.25	20.28	23.77	29.34
Mix 2	1.0	19.68	27.45	30.92	37.08
Mix 3	1.2	22.79	29.09	33.02	39.31
Mix 4	1.4	24.13	30.66	34.71	40.92
Mix 5	1.6	25.65	32.40	38.41	42.64
Mix 6	1.8	28.50	36.29	40.37	44.30

In 7 days, the reference mix compressive strength was 20.28 MPa, about 69% of the maximum compressive strength, while for the SP concrete it was about 82%. So, the benefits of using this SP type can be summarized in two points, the first is the high increment in compressive strength achieved and the second is the high early strength values. The latter can increase this concrete type utilization in construction, where higher early strength is required compared to ordinary cement or roads constructed by concrete which needs repairs and need to open in few days. The results of the current study are comparable to those of [11], where a compressive strength improvement was observed in 28 days, that is, 34.3 MPa for 1% SP dosage, while the reference mix compressive strength was 30.68 MPa, meaning 11.8% improvement. In the present research, the corresponding percentage was 26.4%.

Figures 3-8 present the relationship between the compressive strength and the age of the concrete in days, for the mixes M1, M2, M3, M4, M5, and M6.

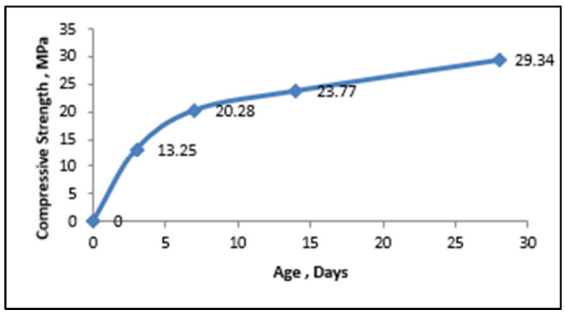

Fig. 3. Compressive strength and age relationship for M1.

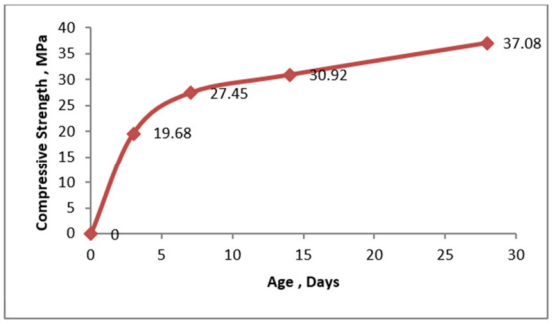

Fig. 4. Compressive strength and age relationship for M2.

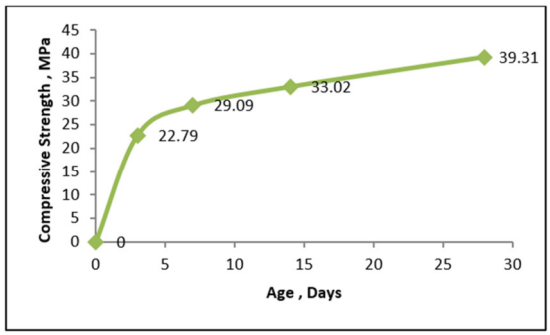

Fig. 5. Compressive strength and age relationship for M3.

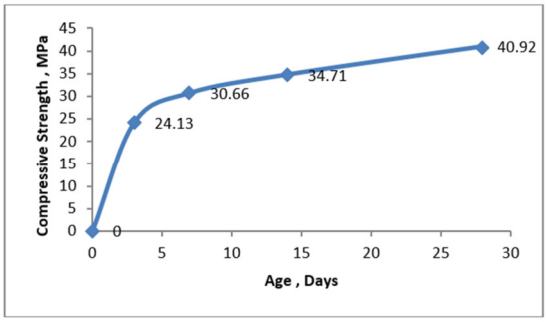

Fig. 6. Compressive strength and age relationship for M4.

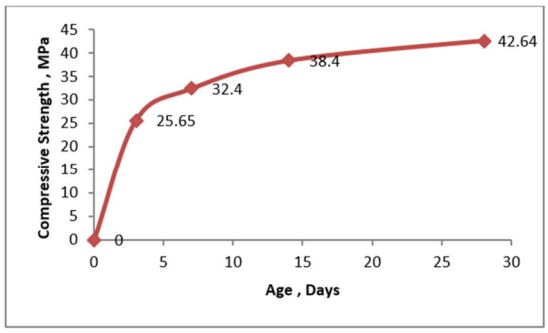

Fig. 7. Compressive strength and age relationship for M5.

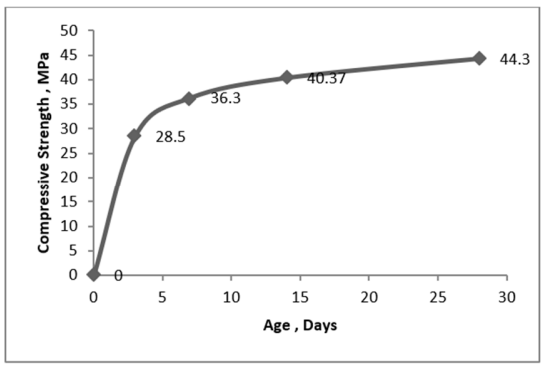

Fig. 8. Compressive strength and age relationship for M6.

The results show that the mix M6 has the optimum dosage of the SP PC, and the comparison with the reference mix M1 is presented in Figure 9.

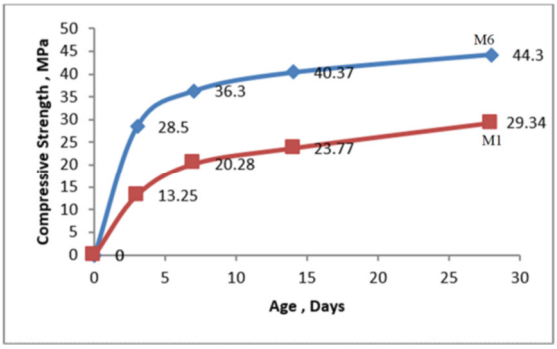

Fig. 9. M1 and M6 comparison.

Figure 10 illustrates the relationship between the PC-200 dosage and the compressive strength of concrete at different ages (3, 7, and 28 days).

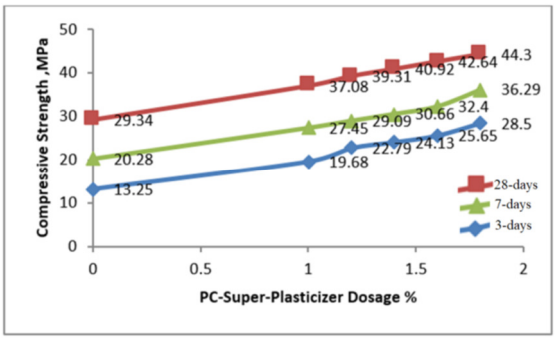

Fig. 10. PC-200 dosage and compressive strength relation.

IV. CONCLUSIONS

The compressive strength of normal concrete was enhanced by increasing the dose of PC-200 Superplasticizer (SP) and decreasing the water/cement ratio. The maximum early compressive strength achieved in this study by using SP-PC was 82% of the maximum compressive strength, and was achieved in in 7 days in concrete containing the maximum dosage of SP-PC. In the reference mix, though, the early maximum compressive strength was about 69% of the maximum value. In early-age specimens (3 days), the SP concrete's compressive strength was found to be 64% of the 28-day compressive strength, whereas the reference mix's compressive strength was found to be 45%. This difference can also be explained by the higher early strength achievement in concrete that contains SP-PC. There is high increment in compressive strength achieved by using the maximum dosage (1.8 L) in all ages, in that the compressive strength increased from 29.8 MPa to 44.3 MPa in 28 days and the increment percentage was 50.9%.

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