COMPRESSIVE STRENGTH OF MORTAR WITH HIGH AMOUNTS OF SUPER-PLASTICIZER

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ABSTRACT: Super-plasticizer has been available on construction market and used for improving the workability of normal concrete or producing self-compacting concrete. The effect of super-plasticizer on compressive strength has not been remarkably reported. In this paper, the manner how the strength is affected by super-plasticizer was investigated by using mortar mixes of different w/c ratios. The strength was tested on 7th and 28th day and studied with different sand contents. After the critical volume of sand was concluded, mores mixes were conducted with various dosages of super-plasticizer and mixing times. It was found that the maximum strength could be obtained with a 1.0% dosage of super-plasticizer.

KEYWORDS: strength, aggregate effect, mixing power, super-plasticizer effect.

1. INTRODUCTION

Since super-plasticizer was employed in construction, it was used for the main purpose of improving the flowability of concrete without losing the cohesion between components. Many researchers have been focused on using super-plasticizers in producing a good self-compacting concrete without considering the effect played by the super-plasticizers on strength which have been the important index of concrete. In this paper, compressive strength was the main concern.

2. MATERIALS AND METHODS

In this section, the materials used in the experiments including cement, sand and the manner how the experimental works were conducted were described.

2.1. CEMENT

Cement is a hydraulic product whose main components include C2S, C3S, C3A, C4AF and gypsum. Strength of cement is of first importance because its role is to bond all aggregates together to form a unique rock. The cement used was shown in Table 1.

Table 1: Cement compositions LH (Low heat)

Mineral types	C_3S	C_2S	C_3A	C_4AF	ρ_s in g/cm^3	SA cm^2/g
Value	28	53	3	10	3.24	3280

ρ_s: specific gravity and

SA: surface area

2.2. SAND

Sand is an inert component that may affect the mix property by its shape, fineness and its texture. Water content is a cause of variation of mix properties if it is not uniform. The variation of water content is due to its downward movement in case of water content higher than its absorption content. In order to keep uniform the water content of sand, sand needed to be kept with water content the same as SSD water content. (See Table 2)

Table 2: Mountain Sand properties

	ρ_b	ρ_a	Absorption	Fineness modulus
Property value	2.57 g/cm^3	2.64 g/cm^3	1.86 %	2.75

ρ_b: Bulk SSD specific gravity,

ρ_a: Apparent specific gravity

2.3. METHODS

All materials were prepared and kept in a room of the constant temperature 20°C with the relative humidity of 60%. Sand was prepared to have a water content similar to its absorption water content. Mortars were mixed with a pan mixer equipped of a central axe hanging three scraper-blades rotating. The mixing method was as follows: sand, powders were dry-mixed for 30sec after which water was poured in and mixed for 1 min; SP was finally added and the mixing process continued until the final desired time; the mixing time was measured from the introduction of water. After mixing, mortar was unloaded into a container then was sampled in plastic moulds 100x200 mm for strength test. The specimens were kept in a curing room, well controlled until a required test date. When the strength test was due, 3 specimens at an age (for one mix) were taken and the top and bottom surfaces were properly ground to have smooth surfaces avoiding the friction between the specimen end surfaces and machine platens. The testing machine was the Universal Testing Machine named SHIMADZU.

3. RESULTS AND INTERPRETATION

The results were gathered and charts were drawn in order to investigate the sand content effect, SP dosage effect and time mixing effect.

3.1. STRENGTH AND SAND CONTENT

Sand as well as coarse aggregate could affect strength if its content was increased. In this experimental works, mixes of different sand contents were made for a given SP dosage and a given w/c ratio. As can be shown on Figure 1, two parts were distinguished, the first part was for sand volume less than 0.38 where strength was found constant independent of sand content and another part was for sand volume more than 0.38 where strength was found increasing or decreasing dependent of sand contents and SP dosages. This suggests that for w/c=0.3, 0.38 was the critical volume (V_{cr}) fraction. That critical volume was found 0.52 for w/c=0.6 (see Figure 2). This behavior was conserved with both 7 and 28 day strength. In section 3.2, the high dispersion was obtained with SP dosage higher than 0.8%. Basing on the high and low dispersion criteria, the sand content effect was explained with the reason that at high SP dosage, the paste and sand were the strong parts in the mix however the interfacial zone of 15-50 μm (Scrivener, 1988) around aggregate constituted weak layers, so the increase of sand content (> V_{cr}) would increases the amount of weak zones then implied the decrease of strength. The contrary behavior at low SP dosage may be explained with the reason that when the paste was not yet dispersed, the paste was a weak part and the interfacial zones were also weak on the other hand, only sand was the strong part. So the increase of sand content would increase the strong parts in mix then strength increased

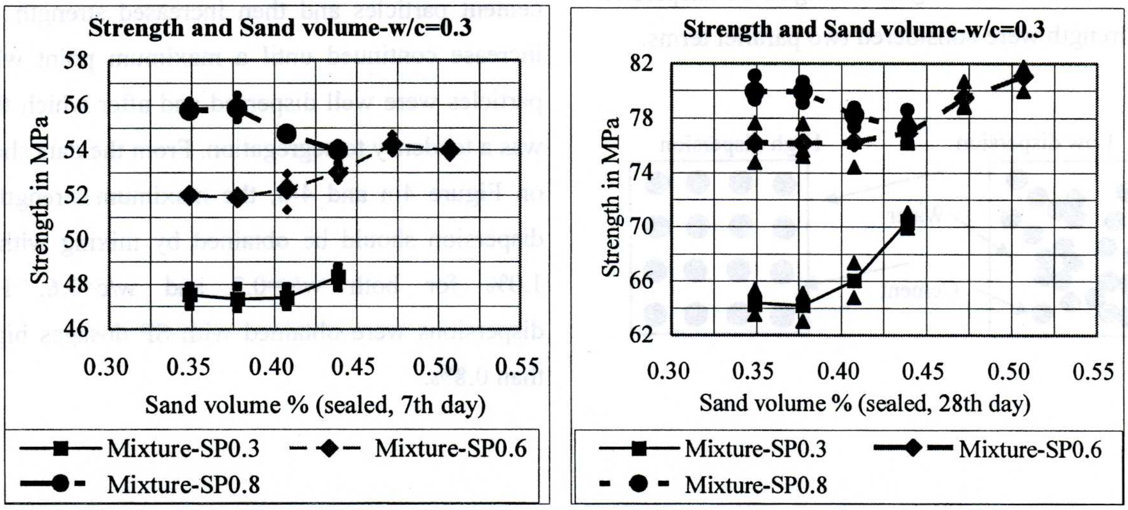

Fig 1: Strength behavior versus sand content at different dosage of SP

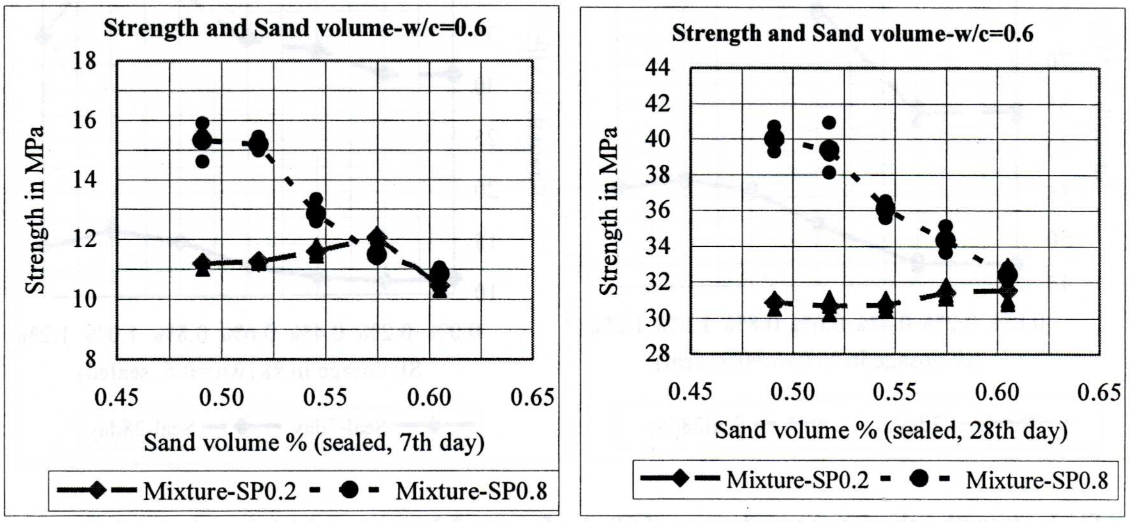

Fig 2: Strength behavior versus sand content at different dosage of SP

Mixes free of sand content effect could be obtained with the sand content less than or equal to 0.38 for w/c=0.3 and with the sand content less than or equal to 0.52 for w/c=0.6. In next sections, the mixes of w/c=0.3 would be mixed with the sand volume 0.38 and the mixes of w/c=0.6 would be mixed with the sand volume 0.52.

3.2. STRENGTH AND DOSAGE OF SP

The dispersion is defined as a status of well spaced particles of cement. This implied that higher dispersion (see Figure 3) would give higher hydration and then higher strength, so dispersion and strength were considered two parallel terms.

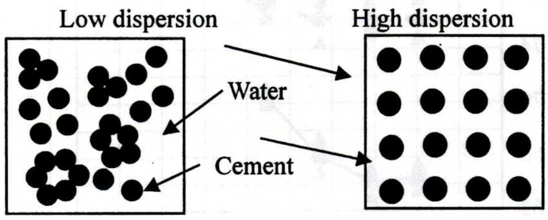

Fig 3: Low and high dispersion

As can be seen on Figure 4-a and 4-b, strength showed a particular relation with dosage of SP. There was an amount of SP (0.3%) which was absorbed by cement and it could not disperse cement. For the range of absorbed SP, strength did not increase. When SP was higher than the absorption amount, SP played a role in dispersing cement particles and then increased strength, this increase continued until a maximum point where particles were well dispersed and after which there was a tendency to segregation. From the data shown on Figure 4-a and 4-b, the maximum strength or dispersion should be obtained by mixing with SP 1.0% for both w/c=0.3 and w/c=0.6. High dispersions were obtained with SP dosages higher than 0.8%.

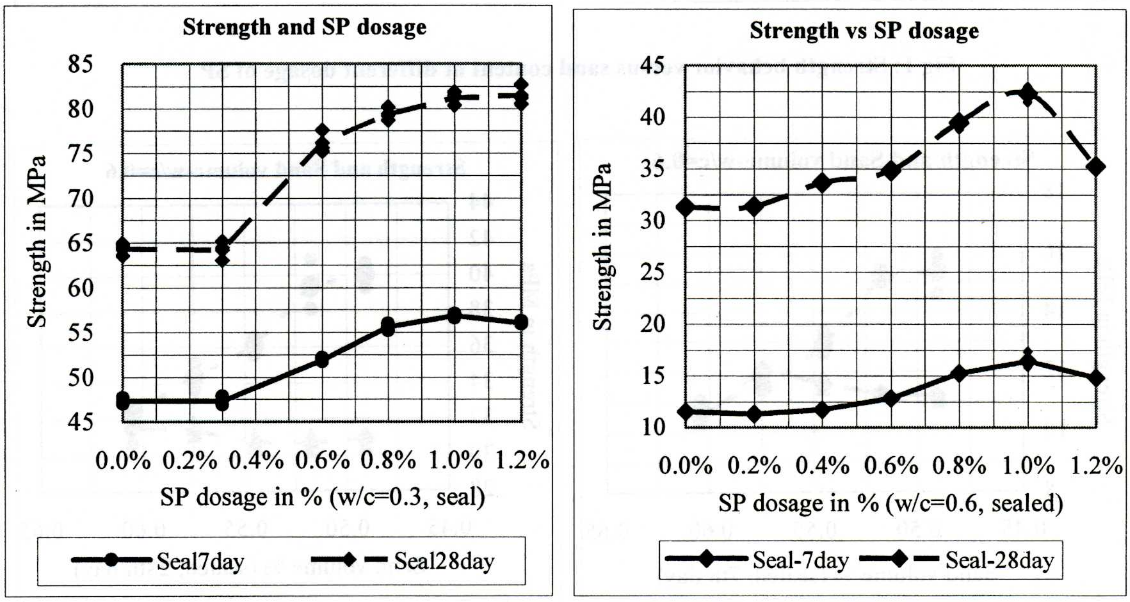

Fig 4: Strength behavior versus dosages of SP: 4-a for w/c=0.3 (right) and 4-b for w/c=0.6 (left)

3.3. STRENGTH AND MIXING TIMES

The mixing time is a mechanical mixing power however SP can dispersing cement particles by it chemical reaction. As can be shown on Figure 6-a and 6-b, strength attained it maximum at SP dosage of 1.0% for both low and high w/c. One different observation between w/c=0.3 and w/c=0.6 was that for a mixing time higher than 3 minutes, in case of w/c=0.3, strength were kept constant however for w/c=0.6, strength was decreased. This may be explained with Figure 5. At short mixing time, the bleeding was observed and made the mixing w/c lower which gave higher strength than at longer mixing time when bleeding was reduced and the w/c nearly reached the mixing w/c. In case of w/c=0.3, no bleeding was observed.

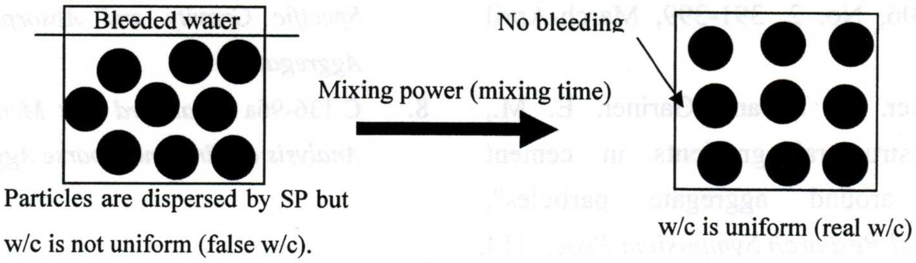

Fig 5: Status of cement particles when the mixing time is increased.

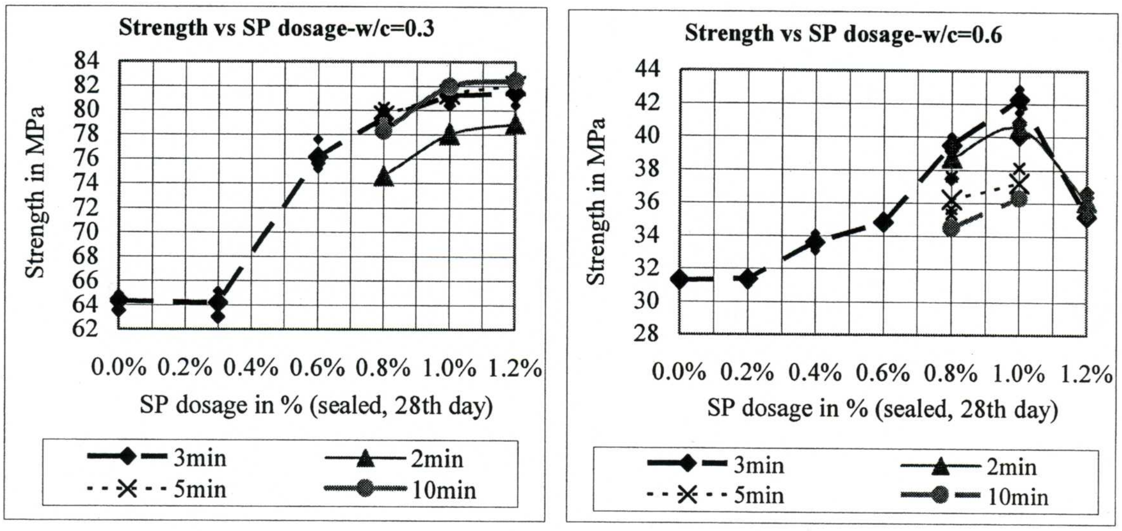

Fig 6 Strength behavior versus mixing time and dosage of SP: 6-a for w/c=0.3 (right), 6-b for w/c=0.6 (left)

4. CONCLUSIONS

According to the above discussion, the following conclusions were obtained.

- The increase of sand content would affect strength if it was higher than the critical volume. The critical volume was found 0.38 for w/c=0.3 and 0.52 for w/c=0.6.
- The effect of SP on strength was found remarkable, the maximum strength was provided with SP dosage of 1.0% for different w/c ratios.
- The increase of mixing time was found affecting strength. For different mixing times, the maximum strength was provided with SP=1.0%.

5. REFERENCES

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