Comparative Study of the Impact of Different Additives on Cementing Properties of High Strength Portland Cement

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Summary: In this study Methylmethacrylate and Ethylenediammine have been used as additive in high strength Portland cement and its impact on the cementing properties (water of consistency, setting time and hydration behavior *i.e.*, combined water at different curing times; 3, 7 and 28 days) has been studied. Different doses (1, 2, 3, 4 and 5 %) of methylmethacrylate ($C_5H_9O_2$) and ethylenediammine ($C_2N_2H_8$) were added to high strength Portland. Results indicated that methylmethacrylate acts as a setting retarder with increasing water of consistency, it has a negative effect on hydration properties, however when present in limited content (not more than 2 %) its negative effect is relatively slight. On the other hand, ethylenediammine acts as a water reducing and setting accelerator agent, its addition up to 3 % results in a remarkable improvement in the above-mentioned properties.

Introduction

High strength Portland cement is recognized as the major construction material throughout the world [1-3]. The use of different types of additives in cement and concrete is an old passion, since long time for different purposes, which includes grinding aids, water-reducing admixtures, set-retarding admixtures, setting and/or hardening accelerators, air entraining admixtures, corrosion inhibitors, plasticizer and super plasticizer admixtures [4,5]. examples of some common additives are lignosulphonates, carboxylic acids, hydroxyl carboxylic acids, hydroxides of alkali or alkaline earth metals, different types of ammines, polymers *etc*. Out of all known additives, the use of organic additives is more common in cement chemistry with keeping or improving its strength, adherence, thermal and acoustical insulation, ductility, fire performance and viscous damping. For improving the mechanical properties of concrete, resistance to welds environment deterioration, chemical attack and moistures, polymeric concrete admixture are usually used [6], their impact depends on the nature and concentration of the used additives. The examples of some of the polymeric compounds are polymer latex, redispersible polymer powder, water-soluble polymer or liquid polymer. The change in the physical state of cement paste containing any of the above mentioned additives is accompanied by a change in water content value and ionic concentration within the paste; this is reflected on a change of all other properties of the hardened cement paste.

The objective of this work is to study the effect of different doses of methylmethacrylate and ethylenediammine on the cementing properties of high strength Portland cement to get better results.

Results and Discussion

Water of Consistency

The use of optimum amount of water to prepare the cement paste is required. Excess water results in higher porosity of the hardened cement which adversely affects its mechanical properties, while little amount causes poor workability of the prepared cement paste [7]. Fig. 1 and 2 shows water of consistency. It is clear from the figures that the percent of water suitable to prepare the cement paste without any foreign additives is 28 %. The Fig. 1 shows a considerable increase in water of consistency on using methylmethacrylate additives; it becomes larger as the additive doses increases. Fig. 2 shows a reverse effect of ethylenediammine additives, *i.e.*, using ethylenediammine additives results in a noticeable decrease in the water of consistency.

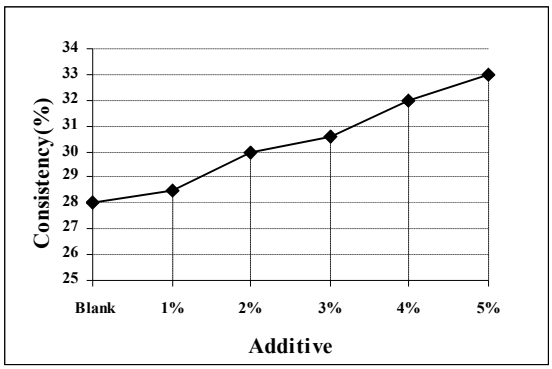

Fig. 1: Effect of Methylmethacrylate on Consistency of high Strength Portland Cement.

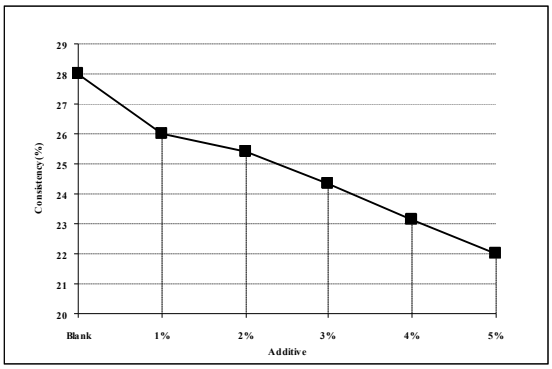

Fig. 2: Effect of Ethylenediammine on Consistency of High Strength Portland Cement.

This may be due to the fact that methylmethacylate network retain some water content preventing it to reach the cement powder while ethylenediammine act as superplasticizer which allow a well spreading and blending of water with the cement, so a consistence paste is obtained with lower amounts of water. These phenomena become more obvious with increasing the additive doses (Fig. 2).

Setting Time

The initial and final setting time of cement samples with methylmethacrylate and ethylenediammine is indicated in Figs. 3 and 4, respectively. Fig. 3 shows a noticeable increase in both initial and final setting times with using methylmethacrylate additives. As the additive dose is increased, the setting times become longer and longer. In contrast to methylmethacylate additives, the use of ethylenediammine additives results in a noticeable decrease in initial and final setting times, which become shorter and shorter as the additive doses increases (Fig. 4). The decrease in setting time with methylmethacrylate is due to the fact that it retains some of the added water. Ethylenediammine assists on well distribution and homogenization of water with the cement powder, which accelerates hydration and hence setting [8].

Combined Water

The combined water of the hardened cement pastes at 3, 7 and 28 days is indicated in Figs. 5 and 6 with methylmethacrylate and ethylenediammine respectively. It is obvious from Fig. 5, that a noticeable decrease in the percent of combined water occur on using methylmethacrylate additives. This decrease is observed at all curing times. However, it can be noticed that this decrease is relatively limited for doses up to 2 %, beyond which *i.e.*, 3 % or more the decrease in combined water content is more obvious. Ethylenediammine additives shows completely different behavior, *i.e.* it increases the combined water content especially with doses up to 3 %, beyond which (4 %and 5 %), the increase is less pronounced as shown in Fig. 6. The content of combined water reflects the hydration behavior, *i.e.*, the decrease in combined water content on using methylmethacrylate additives means slow hydration, while its increasing on using ethylenediammine means fast hydration [9].

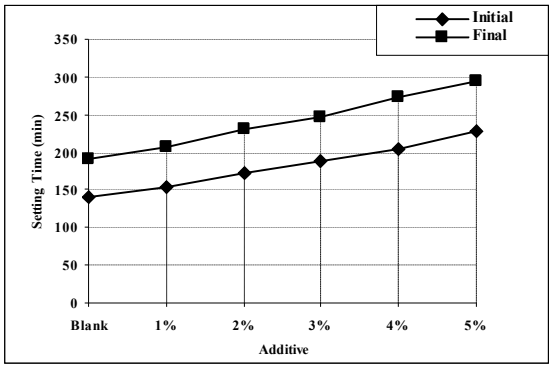

Fig. 3: Effect of Methylmethacrylate on the Setting times of High Strength Portland Cement.

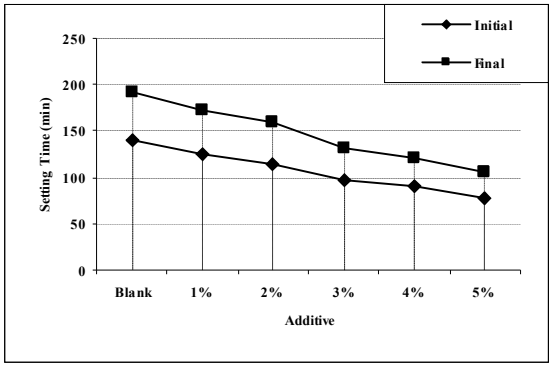

Fig. 4: Effect of Ethylenediammine on the Setting Times of High Strength Portland Cement.

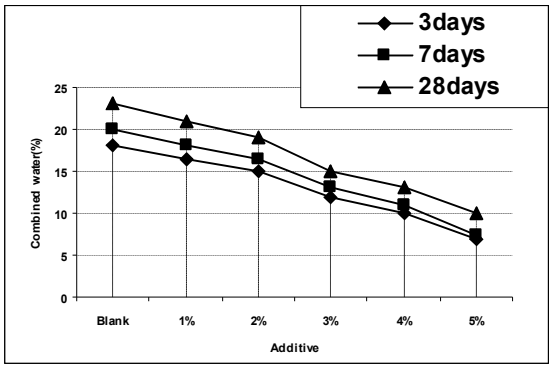

Fig. 5: Effect of Methylmethacrylate on Combined Water of High Strength Portland Cement.

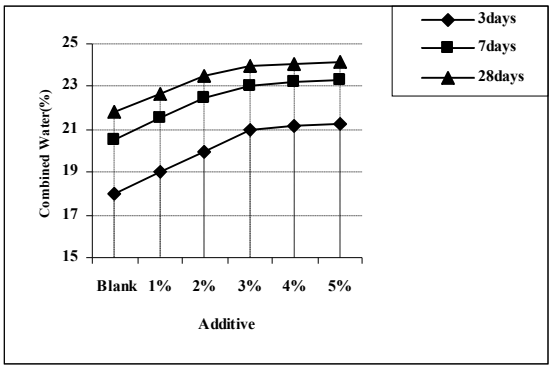

Fig. 6: Effect of Ethylenediammine on Combined Water of High strength Portland Cement.

Experimental

High strength Portland cement meeting Pakistan standard specification PS-232 [10-11] was used in this investigation. Different dosages of additive (1, 2, 3, 4 and 5 % of the dry cement weight) of two organic polymers namely, methylmethacrylate and ethylenediammine were used.

Several cement batches were used separately to prepare different cement pastes containing 0 % (blank), 1, 2, 3, 4 and 5 % of methylmethacrylate and ethylenediammine. In each time the water of consistency and setting time was tested using Vicat apparatus according to ASTM specifications. [12,13]. The same samples after setting time, were kept in a humidity cupboard for 24 hours. The samples were then demolded and kept in water tank. After 3, 7 and 28 days the samples were crushed and their hydration was stopped using 1:1 methyl alcohol and acetone mixture. 1.00 g of each sample was then subjected to firing at 850 $^{\circ}$C for 1 h. The combined water was calculated from the following equation:

$$\text{Combined water (\%)} = \frac{\text{Wt of Sample before firing - Wt of sample after firing}}{\text{Wt of sample before firing}} \text{X } 100$$

Conclusion

Based on the above mentioned evaluations it is concluded that methylmethacrylate is considered as setting time retarder with increasing water of consistency, it has a negative effect on hydration behavior, However it can be used with a dose up to 2 % without a great negative effect. On contrast, ethylenediammine is considered as setting accelerator and water reducing agent, its addition with a dose up to 3 % results in a noticeable improvement of hydration.

References

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