Pak. J. Sci. Ind. Res. 2009 **52** (6) 293-295

Effect of Methylmethacrylate and Ethylenediamine on the Physicomechanical Properties of High Strength Portland Cement

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(received November 11, 2008; revised September 18, 2009; accepted September 30, 2009)

Abstract. In the study of the effect of methylmethacrylate ($C_5H_9O_2$) and ethylenediamine ($C_2N_2H_8$) on the physicomechanical properties of high strength Portland cement, addition of methylmethacrylate upto 5% strength showed negative effect on the bulk density, cold crushing strength and hydration of the cement; however, the negative effect was relatively less in case of lower concentrations ($\leq 2\%$). Addition of ethylenediamine upto 3% concentration showed remarkable increase in these properties.

Keywords: portland cement, additives, methylmethacrylate, ethylenediamine

Introduction

Different types of additives *viz*, lignosulphonates, carboxylic acids, hydroxyl carboxylic acids, hydroxides of alkali or alkaline earth metals, different types of amines, polymers etc. have been reported in the literature for improving the properties of Portland cement (Elert *et al.*, 2008; Zofia *et al.*, 2007; Saccani and Motori, 2006; Hewlett, 1998). These additives are commonly used as grinding aids, water-reducing admixtures, set-retarding admixtures, setting and/or hardening accelerators, air entraining admixtures, corrosion inhibitors, plasticizers and super-plasticizer admixtures (Schulze 1999; Ohama, 1998; 1997; Sakai and Sugita, 1995). Out of all known additives, the use of organic additives is more common in cement industry for keeping or improving the strength, adherence, thermal and acoustic insulation, ductility, fire performance and viscous dampening of the cement.

For improving the mechanical properties of concrete, resistance to environmental deterioration, chemical attack and moisture, usually polymeric concrete admixtures are used; their impact depends on the nature and concentration of the additive used (Niazi and Jalili, 2008; Xuli and Chung, 1996; Larbi and Bijin, 1990). Examples of some of the polymeric compounds are polymer latex, redispersible polymer powder, water-soluble polymer or liquid polymers. The change in the physical state of cement paste containing any of the above mentioned additives is accompanied by a change in the water content value and ionic concentration within the paste; this is reflected on a change in all other properties of the hardened cement paste.

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The objective of this work is to study the physicomechanical properties of high strength portland cement for its improvement under the influence of methylmethacrylate ($CH_2CHCH_3COOCH_3$) and ethylenediamine ($NH_2CH_2CH_2NH_2$)as additives.

Materials and Methods

High strength portland cement (Pakistan Standard Specification PS-232) was used in this study. Different concentrations (1, 2, 3, 4 and 5 % of dry cement weight) of two organic polymers namely methylmethacrylate and ethylenediamine were used as additives.

Several cement batches were used separately to prepare different cement pastes containing 0 % (blank), 1,2,3,4, and 5% of methylmethacrylate and ethylenediamine. Every time, the water of consistency was tested. The pastes were separately moulded in 5´15 cm cylindrical plastic moulds. The moulded cement pastes were kept for 24 h in a humid cupboard and then demoulded and kept in water tank until the time of study. Three representative samples were taken from each hardened cement batch at different curing times (3,7 and 28 days) and tested for their bulk density according to the international standard specifications. After testing, same samples were subjected to cold crushing strength test using a machine of maximum load of 20,000 kg. Load readings were divided by the surface area of the mould to obtain cold crushing strength per cm^2. Hydrated samples (28 days old) were investigated using IR spectroscopy.

Results and Discussion

Bulk density. Figures 1 and 2 show the results of bulk density at different curing time, using methylmethacrylate and ethylenediamine. It was found that the bulk density decreased with the use of methylmethacrylate; the decrease was relatively limited upto 2%, beyond which a great decrease in bulk density was observed (Fig. 1). In the case of ethylenediamine, a noticeable increase in bulk density was observed, more obvious up to 3%, beyond which (4 and 5 %) the increase in bulk density became less pronounced. On increasing the hydration with ethylenediamine additive, the hydrated products of cement formed according to the following equations, fill the pores, resulting in higher densities. With methylmethacrylate, relatively lower densities were correlated with the higher content of mixing water. On hardening, this water evaporates leaving a large number of pores, which decrease the density (Niazi and Jalili, 2008).

$C_2S + xH_2O$ ® $C_2S.xH_2O$
$C_3S + xH_2O$® $C_2S. (X\text{-}1)H_2O + Ca(OH)_2$
$C_4AF + xH_2O$® $C_3A.6H_2O + CF.(x\text{-}6)H_2O$

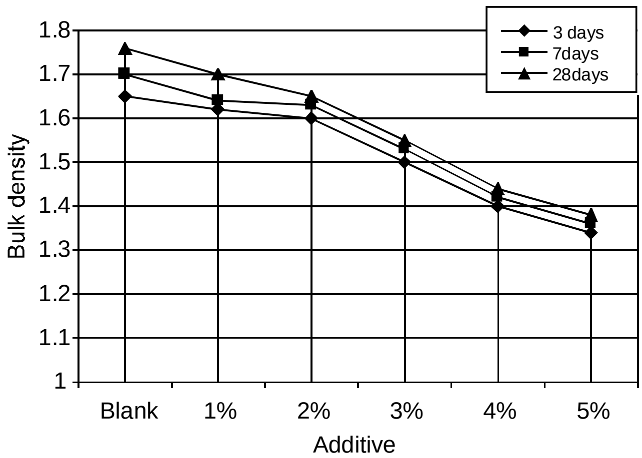

Fig. 1. Effect of methylmethacrylate on bulk density of high strength portland cement.

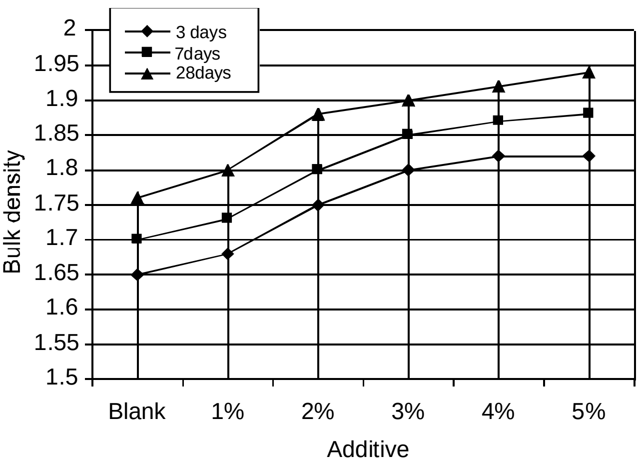

Fig. 2. Effect of ethylenediamine on bulk density of high strength portland cement.

Cold crushing strength. A slight decrease was observed in cold crushing strength of 28 days-cured cement paste prepared with methylmethacrylate upto 2%, above which a great deterioration in strength was observed (Fig. 3). In contrast to methylmethacrylate, the addition of ethylenediamine resulted in remarkable improvement in cold crushing strength upto 3% concentration, above which the improvement in strength was less pronounced (Fig. 4). Cold crushing strength was reflected in the hydration behaviour (combined water). The progress in hydration, using ethylenediamine resulted in considerable increase in the mechanical properties while the slow hydration in case of addition of ethylenediamine resulted in relatively lower cold crushing strength.

IR spectra of hydrated cement. Patterns of IR spectra of 28 days-hydrated cement, with and without addition of methylmethacrylate and ethylenediamine are shown, in Fig. 5 (a, b and c). It can be seen that the transmittance of IR spectral patterns of hydrated cement in the presence

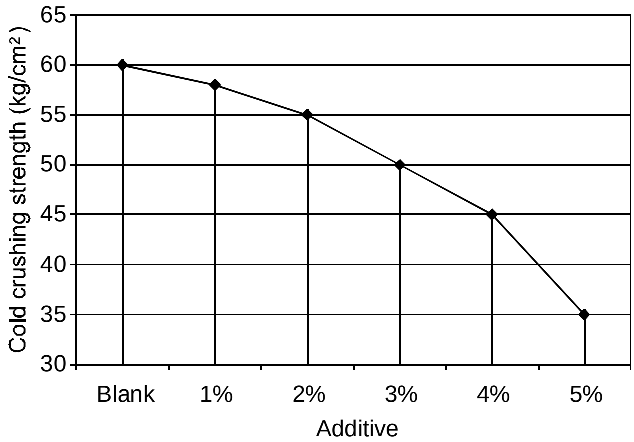

Fig. 3. Cold crushing strength of 28 days hydrated cement with methylmethacrylate.

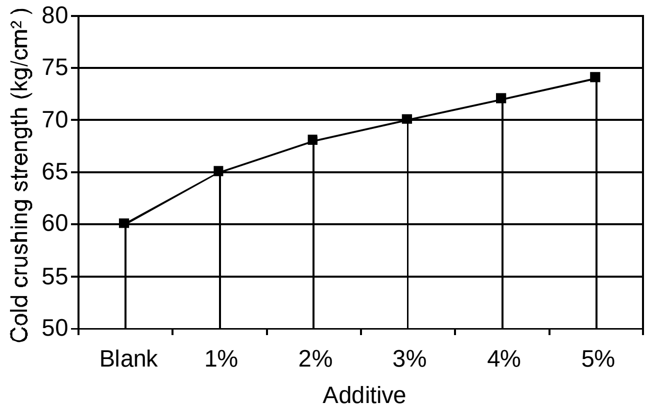

Fig. 4. Cold crushing strength of 28 days-hydrated cement with ethylenediamine.

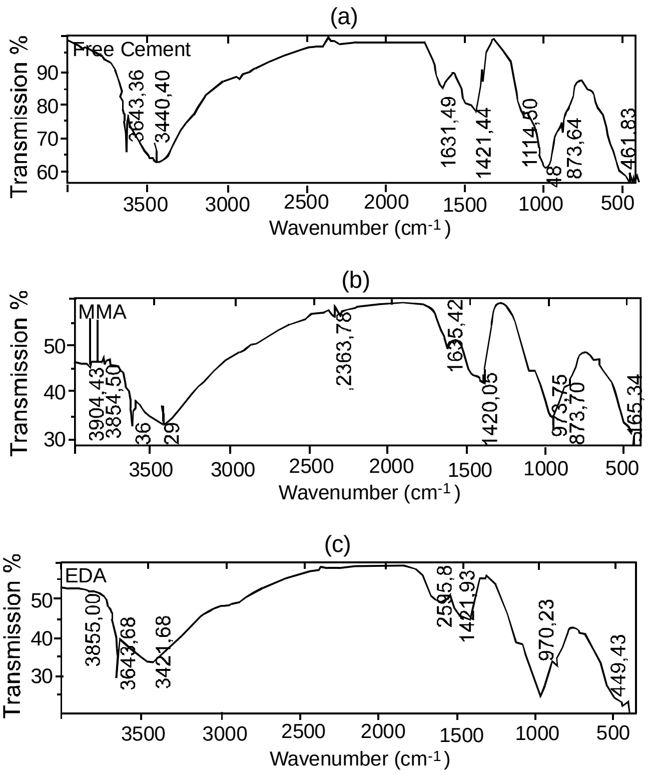

Fig. 5. Infrared spectra of 28 days-hydrated sample: (a) blank cement; (b) with methylmethacrylate additive; (c) with ethylenediamine additive.

of additive (either methylmethacrylate or ethylenediamine) decreased to about one half of the blank cement value. This means the active sinters (functional groups) of the cement are affected by the additive, which result in the retardation of hydration in case of methylmethacrylate. In case of ethylenediamine additive, better hydration behaviour may be due to the presence of lone pairs of free electrons on the two nitrogen atoms of the molecule that activate these sinters and hence the hydration is promoted.

Conclusion

Based on the above mentioned evaluations, it is concluded that methylmethacrylate has a negative effect on bulk density and mechanical strength of the cement. However, it can be used up to 2% concentration without any considerable negative effect. In contrast, the addition of ethylenediamine up to 3% concentration results in noticeable improvement of hydration, bulk density and mechanical strength of the Portland cement.

References

Elert, K., Sebastian, E., Valverde, I., Rodriguez-Navarro, C. 2008. Alkaline treatment of clay minerals from the Alhambra formation: Implications for the conservation of earthen architecture. *Applied Clay Science* **39:** 122-132.

Hewlett, P.C. (ed.) 1998. *Lea's Chemistry of Cement and Concrete*, 4th edition. Arnold Publishers, London, UK.

Larbi, J.A., Bijin, J.M. 1990. Interaction of polymer with Portland cement during hydration. *Cement and Concrete Research* **20:** 139-147.

Niazi, Y., Jalili, M. 2008. Effect of Portland cement and lime additives on properties of cold in-place recycled mixtures with asphalt emulsion *Construction and Building Materials* (available online, 16 September, 2008).

Ohama, Y. 1998. Polymer based admixtures. *Cement and Concrete Composites* **20:** 189-212.

Ohama, Y. 1997. Recent progress in concrete-polymer composites. *Advanced Cement Based Material* **5:** 31-40.

Saccani, A., Motori, A. 2006. The effect of polymer addition on alkali silica reactions in cementitious mortars. *Materials and Structures* **34:** 373-377.

Sakai, E., Sugita, J. 1995. Composite mechanism of polymer modified cement. *Cement and Concrete Research* **25:** 127-135.

Schulze, J. 1999. Influence of water-cement ratio and cement content on the properties of polymer modified cement. *Cement and Concrete Research* **29:** 909-915.

Xuli, F., Chung, D. 1996. Effect of polymer admixtures to cement on the bond strength and electrical contact resistivity between steel fibre and cement. *Cement and Concrete Research* **26:** 189-194.

Zofia, K., Jan, M., Wojciech, R., Andrzej, S. 2007. Production of expansive additive to Portland cement. *Journal of the European Ceramic Society* **27:** 605-609.