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Study On Fresh And Hardened Properties For High Performance Concretes

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***Abstract*— Influence of condensed silica fume (CSF) addition as cement replacement material on the properties of cement-based solidification products was investigated. Final setting, unconfined compressive strength, and leachability of the synthetic lead and chromium hydroxides were determined. CSF was used at 0, 5, 10, and 20 wt.%. substitution for Portland cement. A water-to-solid ratio (w/s) of 0.45 was used for all mixes. Experimental results showed that the severe retardation effect on ordinary Portland cement (OPC) hydration caused by lead hydroxide has been minimized due to the pozzolanic effect and, as a result, the time to final setting has been significantly reduced.**

I. Introduction

The construction scenario is changing rapidly. Increase in the population and lack of sufficient land to house them is forcing cities to expand skywards. Bigger and heavier load carriers require stronger bridges to take them across rivers and other obstacles. Increase in the road transport requires more and tougher roads to cope with the traffic. All the above infrastructural applications require concrete. Conventional concrete is not sufficient to cater to all the current and future demands. Hence, the use of High Performance Concrete (HPC) has been on the rise in recent decades, driven mostly by a desire to extend the performance and service life of structures.

The CSF is a new pozzolanic material that has received a great amount of attention recently both at the research and application level in the production of HPC. Because of its extreme fineness and high silica content it is a highly effective pozzolanic material. The CSF reacts pozzolanically with the lime during the hydration of cement to form the stable cementitious compound calcium silicate hydrates (CSH).Concretes incorporating CSF are less permeable and decreases the number of coarse pores of the cement-CSF paste. There is an optimum CSF content for concrete and this depends upon W-B ratio, type of CSF and superplasticiser, properties of cement, mixing sequence and age of concrete. Increase in beyond optimum content may affect the properties adversely or the degree of improvement may not be significant. The usual range of CSF content in concrete is 5 to 15% by weight of binder content of concrete.

The typically higher number of constituents present in HPC mixes combined with lack of prescriptive limits presents a unique set of challenges to engineers developing mixture proportions for such materials. The traditional approach to select mixture proportions is a two-step process. The first step is the estimation of the starting quantities of individual components. The second step involves the production of a series of trial batches and performing necessary, trials until the mixture was optimized. Since changing the quantities of one of the components may have an undesirable influence on the overall performance of the mixture, all adjustments should be made in a well-controlled and systematic way. This may result in high number of trial batches and make the mixture selection process too expensive and time-consuming. This problem can be overcome by design of experiments using statistical techniques for optimizing HPC mix ingredients.

The interactions between the CSF and the cement particles can be classified as physical and chemical. The former, which are called the “micro filler effect”, consists of filling the spaces between the cement particles by the CSF. The later called the “pozzolonic effect”, follows from the reaction of the CSF with the portlandite produced by the hydration of the silicates giving the silicate hydrate gel (C-S-H).Regarding the influence on the hydration processes, several authors (Ramachandran, 1984 and Taylor, 1993) report an acceleration of the hydration of the anhydrous silicates of the cement in the presence of silica fume. The fine CSF particles appear to act as nucleation points, (Monteiro, et. al., 1986) leading to a finer porosity as well as denser and homogenous matrix. When silica fume is incorporated, the rate of cement hydration increases at the early hours due to the release of OH ions and alkalis in to the pore fluid (Larbi, et. al. 1990).

Bentz, et. al, (1991) demonstrated that both the size and the reactivity of the pozzolanic admixtures are important in producing a uniform microstructure of cement paste throughout the concrete. Highly reactive admixtures such as silica fume exhibits the greatest positive influence on the microstructure of the interfacial zone.

Kadri,, et. al, (2001) and Cohen, et. al, (1986) evaluated the influence of silica fume on the rate of heat liberation and the accumulated heat in high-performance concrete. Portland cement was replaced by silica fume in amounts from 10% to 30% in concrete with water-binder ratios varying between 0.25 to 0.4.

Pinto, et. al., (1999) investigated influence of silica fume and superplasticizer on the heat of hydration of mortar mixtures with low water - cementitious materials ratios. Superplasticizer and silica fume were both found to significantly affect the heat characteristics of the mixtures. Silica fume increased the early heat generation, whereas superplasticizer retarded early heat generation. Yogendran, et. al., (1987, 1991) studied the effect of CSF on high and low water-binder ratio with respect to hydration process of cement paste and concluded that the higher the water cement ratio, higher silica fume was required to consume all the Ca (OH)2 A large proportion of pozzolanic reaction takes place as early as 3 days. Although pozzolanic reaction was found to continue up to 180 days, amount taking place after 28 days is relatively small.

II. MATERIALS AND EXPERIMENTATION

Cement: In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used.

Sand: Locally available river sand zone II with specific gravity 2.58, water absorption 1% and conforming to I.S. – 383-1970.

Coarse aggregate: Crushed granite stones of 20 mm down size, having a specific gravity of 2.61 conforming to IS 383-1970

Water: Potable water was used for the experiment.

Pumice: Lightweight aggregates having density 624 kg/m3 and specific gravity 0.84.

Steel Fibers: - In this experimentation Flat Steel fibers were used, having length38mm and 2mm width. Tha aspect ratio of the steel fibre is 95.

III. EXPERIMENTAL RESULTS

Final setting of the solidified wastes

The effects of CSF on final setting of the cement metal waste mixes are shown in Fig. 1. The time to final set of control OPC was found to increase from 4 to 4.25 h when 5 wt.% of CSF was used, but it decreased to 4 and 3.75 h with 10 and 20 wt.%, respectively, substitution for Portland cement. A similar effect of CSF on the final setting time of OPC–Cr mixes was observed. It was noticed that theCSF did not cause a significant effect on the final setting time of the control OPC and OPC–Cr mix when compared to those of the OPC–Pb mix.

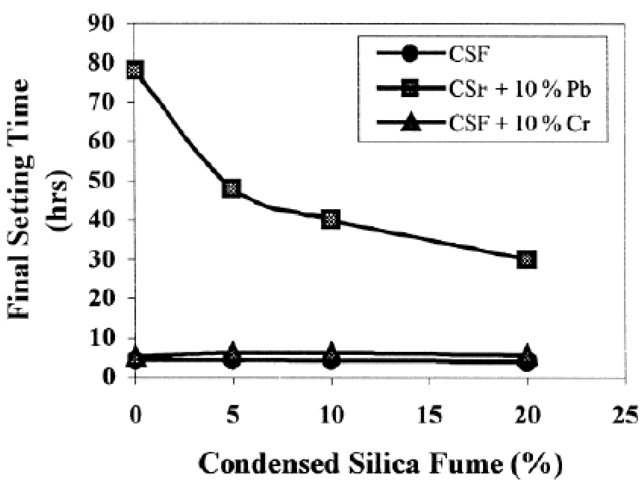

Fig. 1. Effect of CSF on final setting of cement-based solidified wastes.

Fig. 2a–c show the effect of 0, 5, 10, and 20 wt.% replacement of CSF for Portland cement on the compressive strength of the solidified wastes during the 1- to 91- day curing periods. The results clearly show no significant effect of CSF on compressive strength during the 1 to 3 days of curing (Fig. 2a). The hardened cement incorporating 5- and 10-wt.% substitution during the 3 to 91 days of curing had higher strength than that of the control. From this investigation, the highest strength was obtained at the replacement level of 10% with an increased strength of about 33%, 25%, and 22% gained at the curing ages of 8, 29, and 91 days, respectively. This was considered to be the beneficial effects of pozzolanic reactions on strength, which occurred mostly during these curing durations [20]. In addition, a reduction in strength of the specimens with 20% cement replacement by CSF was observed. It was possible that the CSF, an extremely fine particle, acted as filler and occupied the pore space. The reduced pore space in the OPC/CSF systems probably affected both the OPC hydration and the pozzolanic reactions.

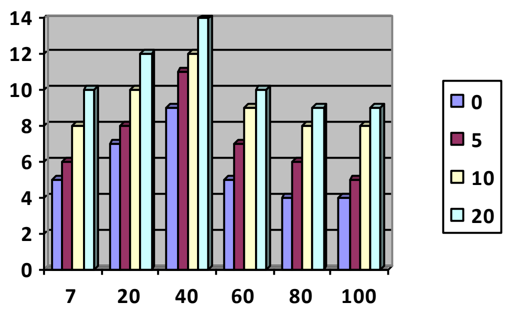

Fig. 2. Strength development of the solidified waste at different CSF content

CONCLUSIONS

CSF had a significant effect on final setting of the OPC/Pb samples. The final setting of OPC/Pb mixes decreased with increasing level of cement replacement from 0 to 20 wt.%. This is because the consumption of calcium hydroxide by CSF during pozzolanic reactions reduced the alkalinity of the OPC/Pb systems. As a result, the interfering effect on hydration retardation caused by lead hydroxide was reduced. It can be concluded that the flexural strength of self cured steel fibre reinforced concrete will be slightly affected.

The highest compressive strength was obtained at the 10% replacement of cement by CSF, but decreased at the 20% cement replacement. It was possible that the excess CSF occupied the pore spaces and reduced the available space for the hydration products and therefore limiting the extent of hydration.

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