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Utilization of an Industrial Waste Product from Thermal Power Plants in Civil Construction

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Abstarct : *Use of fly ash, obtained primarily from coal combustion for power generation, in concrete is important from the point of view of checking environmental pollution, cost effectiveness. The pozzolanic properties of the ash, including its lime binding capacity, makes it useful for the manufacture of cement, building materials concrete and concrete-admixed products. Depending on their physical and chemical properties and the amount of replacements with cement, fly ashes may provide an economical production possibility in construction industry. This paper reviews considerations and state of art of utilization of fly ash in the civil construction sphere and presents results of its effects on performance of cement mortar in aggressive environments.*

Keywords*: Fly ash, industrial waste, construction, aggressive*

I. INTRODUCTION

Fly ash is an environmentally polluting waste product collected at various thermal power plants in great quantities. It has been used for many purposes such as in brick making, in land filling and in cement based composite materials such as cement mortar and cement concrete as a part replacement of cement or in addition to cement. The content of fly ash as a part replacement of cement in fly ash cement concrete mixes, excluding high volume fly ash concrete, has generally been in the range of 0% to 30% [1, 2, 3, 4; 5]. Effect of fly ash as a partial replacement of cement as well as sand on strength and sorption behaviour of concrete has been investigated [6]. The partial replacement of sand by fly ash is seen to be more effective in case of mixes of low cement content [6]. Ramyar and Inan [7] have presented equations to estimate sulphate expansion depending on mineral admixture substitution level among other parameters provided the admixture has satisfactory composition, fineness and pozzolanic activity.

Effects of utilization of fly ash on various properties of cement based composites have been investigated by many researchers. The pulverized fly ash makes a big contribution in concrete because of its pozzolanic properties and it is reflected in lower heat evolution [8]. Effects of use of fly ash on concrete workability have been investigated [2, 9, 10, 11, 12]. Compressive strength of fly ash concrete has been widely investigated [10, 13-20]. Modulus of elasticity of concrete made with the use of ash has been reported to depend on solution to ash ratio and paste to aggregate ratio [14, 21]. Drying shrinkage aspects connected with use of fly ash in concrete have been studied and it has been reported that the use of fly ash improves the performance of concrete [10, 14,16, 20]. Freeze-thaw behaviour, thermal expansion properties of cement based materials and self healing of shrinkage cracks have been investigated and beneficial effects of use of fly ash have been reported [9, 19, 21] Effect of fly ash on electrical resistivity of concrete has been investigated and it has compared well with the use of rice husk ash in concrete [22]. Fly ash concretes with 35% and 50% replacement of cement have been found to provide better resistance compared to normal concrete in marine environment [23].

II EXPERIMENTAL PROGRAMME

It was intended to observe the performance of fine fly ash blended cement mortar mixes in different concentrations of acidic environments and compare the performances. The experimental programme included the consideration of the effect of sulphuric acid environments of varying degrees on plain and fly ash blended cement mortar specimens. In the present investigation the water cement ratio was kept constant equal to 0.50. The ratios of cement and sand in mortar were 1:4 and 1:6 by weight. Abbreviations of some typical mortar mix designations are explained below in Table 1.

Mortar cube samples of 70 mm size were prepared as per standard procedure and immersed in two tanks of sulphuric acid of 0.1 N and 0.2 N concentrations respectively. The compressive strength and variation in weight of 5 samples were observed after 28, 90 and 180 days of curing. Variations of compressive strength and mass in specimens and microstructural changes were noted with time.

Table 1 – Explanation Of Some Mortar Mix Designations

Typical mix designation	Explanation
CM4W	**C**ement **M**ortar 1:**4** **W**ater cured
CM4N1	**C**ement **M**ortar 1:**4** **N**ormal 0.**1** acid environment cured
CM6F30N2	**C**ement **M**ortar 1:**6** blended with **F**ly ash **30**% **N**ormal 0.**2** acid environment cured

III RESULTS AND DISCUSSION

Compressive strength of plain and blended mortar specimens is shown in Table 2. Generally, the effect of sulphuric acid to degrade the mortar specimens with time and the degradation depends on many factors such as concentration of sulphuric acid, time of exposure to aggressive environment etc. It is observed in Table 2 that compressive strength of any mix increases with age. It is seen that the compressive strength of blended mixes with respect to their respective plain counterparts is more. The trend may be due to the presence of fly ash and the pozzolanic reactions in these mixes.

Table 2 – Compressive Strength Of Plain And Fly Ash Blended Cement Mortar Specimens

Mix Designation	Compressive strength (MPa) at the age			Mix Designation	Compressive strength (MPa) at the age		
	28 days	90 days	180 days		28 days	90 days	180 days
CM4W	26.00	31.20	34.32	CM4F30W	29.90	32.50	36.92
CM6W	20.80	24.70	29.90	CM6F30W	23.40	28.60	32.24
CM4N1	22.75	25.48	27.04	CM4F30N1	26.00	26.91	29.77
CM6N1	18.07	19.24	20.93	CM6F30N1	20.41	22.62	23.27
CM4N2	20.80	23.40	24.31	CM4F30N2	24.05	25.09	26.91
CM6N2	15.73	18.20	20.28	CM6F30N2	18.20	21.71	22.62

In the case of comparison of fly ash blended mixes with their plain cement mortar counterparts, it is seen in Figure 1 that percentage difference of their compressive strengths from those of plain mixes come down with age. It is indicated by the values of 15.00%, 4.17% and 7.58% at the ages of 28 days, 90 days and 180 days respectively for the mix CM4F30W. It indicates the beneficial effect of fly ash in acid aggressive environment due to pozzolanic reactions.

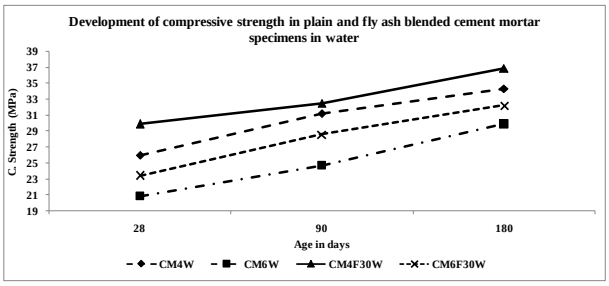

Figure 1 - Compressive strength of plain and fly ash blended cement mortar specimens cured in water

Incremental percentage changes in compressive strengths in various durations for plain and blended mortar specimens in water and acid environments with respect to respective control mixes have been presented in Figure 2.

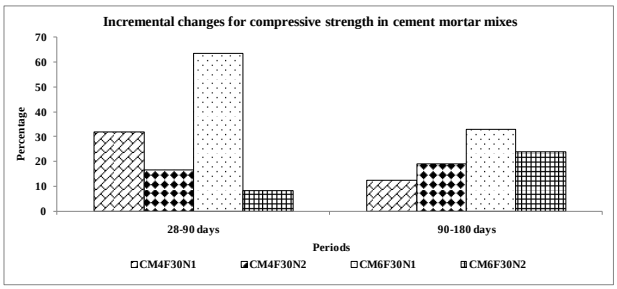

Figure 2 -Incremental changes for compressive strength in cement mortar mixes

It is seen that incremental changes in compressive strengths in the periods of 28-90 days and 90-180 days, as shown in Table 2, are encouraging in the case of blended mixes when exposed to aggressive environments. The incremental changes in both of these periods determine the rate of growth between growths of any mix compared to control mix at different stages. The incremental rates of growth for fly ash blended mixes in acidic environments were all positive indicating the beneficial effect of fly ash in cement mortar. It may also be suggested that incremental growth rates may provide a valuable insight in the analysis of the effect of a blend in a cement based mix.

IV CONCLUSIONS

Following conclusions may be drawn from this review study.

1. Appropriate remedies enable fly ash to be used in cement based materials for the satisfaction of particular requirements concerning strength and durability. It is suggested that causes in variability in characteristics of ash and its effects on the quality of the blended cement based on the variability of calcium and loss on ignition values should be investigated
2. Cement–superplasticizers compatibility can be altered by the physical and chemical characteristics of the mineral additions such as fly ash. It is to be

seen that if the ash contains high chloride content and high loss on ignition values, the ash should be suitably treated

3. Setting behaviour of cement mortar mixes is influenced with the blending of fly ash. This affects the microstructure of the cement mortar paste even after hardening of the paste has started.
4. Use of fly ash in cement mortar mixes has been reported to be beneficial. This is all the more beneficial in the case of exposure to aggressive environments.
5. Many aspects such as effect of variability of fly ash characteristics, such as fineness of fly ash, material characteristics etc should be further investigated.

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