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Durability influence of water soluble Silane-Siloxane sealers for the partial replacement of cement by fly ash in concrete

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Abstract. We have fabricated two different concrete based on fly ash with three different percentage admixture and water repellent dosages. The mortar mixtures were proportioned with cement to sand ratio of 1:3 and 1:4. The important FTIR peaks indicates that the presence of fly ash, and water repellent silicon in concrete mixture. The XRD spectra confirmed that the angle 2θ value with corresponding planes are because of mainly tetrahedrally arranged silicate and octahedrally arrangement of aluminate groups in mixed concrete. The reinforced concretes were cast for the same flow level but different percentages of fly ash (0, 2.5, 5 & 7.5%) dosage. The mechanical study proves that the compressive strength and tensile strength of the concretes increases with increase in fly ash based concrete mixtures up to 5 wt %. However, it is also noted that the admixture significantly enhances the mechanical strength and decreases the early shrinkage of the concrete.
Key words: Fly ash, Concrete, Admixture, Tensile strength

I. INTRODUCTION

The researches have been directed towards the consumption of pozzolana materials. For the cement industry, the growth and use of fly ash blended cements become current studies in these days. Pozzolana from power plant residue as an example fly ash are getting more attention now since their utilizes publicly enhance the properties of the blended plaster real, the price tag and the reduction of negative environmental effects [1]. Fly ash enhances the properties of real or plaster paste because of the pozzolanic reaction and its part as a micro-filler. It's frequently of fly ash idea that the first operate is a very essential today. The essential implications of the partial replacement of plaster by fly ash in plaster paste and mortar are micro-structure improvement, pour filling execute and greater packing characteristics of the mix [2]. The workability of the blended mortar paste and mortar is greatly modified because of the incorporation of finer Pozzolana materials as an example fly ash, silica fume, etc. This addition depends both on the quality of fly ash and the stipulated provisions of force and durability. Now, fly ash and mortar contents in a mix are positive by laboratory trials. To determine upon the amount of to which fly ash might be utilized at the lowest conceivable water–cementitious-material ratios, distinct workability tests are carried out to optimize the proportion of fly ash [3-6].

The workability of the cementitious goods has already been attained by many compatible water reducing admixtures like super-plasticizers. Besides this, the mortar super-plasticizer compatibility is impacted by the after parameters narrated to the mortar: chemical and phase composition, mainly C_3A content material, alkali content material, quantum and write of calcium sulphate, mortar fineness and free lime content material. By considering the properties of a super-plasticizer, the after factors are of particular importance: its chemical nature and molecular weight, super-plasticizer amount of sulphonation, admixture dosage and addition system [7].

In this present study, authors have reported that preparation of water soluble Silane-Siloxane sealers for the partial replacement of cement by fly ash in concrete with super plasticizer. The prepared motor block subjected to FTIR, XRD for structural analysis and surface morphology by SEM image. The compressive and tensile strength for prepared motor blocks have studied by using Universal Testing Machine.

II. MATERIALS AND METHODS

2.1 Materials

The entire admixtures used for the concrete structural study were industrial grade. The fly ash were purchased from Dolphin Floats Pvt Ltd, India having density of 0.9 kg/m^3 with elongation of 19% and 6 mm in length. The Polycarboxylate Ether superplasticizer with purity 98% and density 1.1 g/ml supplied by Chemipol Pvt Ltd, Kothari Group of Industries, India. The bonding agent Styrene – butadiene rubber which has the strength from 500 – 3,000 PSI and elongation is about 635% and water soluble silane - siloxane compounds were procured from Mayfare Biotech Pvt Ltd, Mumbai, India.

2.2 Preparation of reinforced concrete

A total of 10 mortar road were cast for two different mix ratios and three different percentage fly ash dosages. The mortar mixtures were proportioned with cement to sand ratio of 1:3 and 1:4. The reinforced concretes were cast for the same flow level but different percentages of fly ash (0 (F0), 2.5 (F1), 5 (F2) & 7.5 (F3 wt %) dosage [10, 11]. Three mortar slabs for a mix ratio of 1:3 (Cement: sand) were exposed to direct heat from the sun and, four mortar slabs for each mix ratio of 1:3 and 1:4 (cement: sand) were kept away from direct heat. The shrinkage and cracks were measured using the aid of measuring scale and use of magnifying lens. The data's were recorded for plastic shrinkage at 5 hours and drying shrinkage at 3, 7, and 28 days [8-10].

2.3. Results and Discussions

Concrete code	Flay ash	Silicon	Polycarboxylates
F0	0	1.26 wt %	1.84 wt %
F1	2.5	1.26 wt %	1.84wt %
F2	5	1.26 wt %	1.84 wt %
F3	7.5	1.26 wt %	1.84 wt %

III. CHARACTERIZATION TECHNIQUE:

The different functional groups and chemical compositions of the films were investigated by using "Thermo-Nicolet 6700 FTIR (Japan) spectrophotometer". The XRD is used to determine the mineralogical composition of the raw material components as well as qualitative and quantitative phase analysis of multiphase mixtures. The occurrences of minerals in clay were identified by comparing 'd' values. The identification of powdered concrete was performed using X'Pert pro X-ray diffractometer with nickel filter. Diffraction data were obtained by exposing the samples to Cu-Ka X-rays, which has a characteristic wavelength of 1.5414 A˚.). The diffractograms were recorded in terms of 2u between 208 and 808 ranges. The two-wave-plate compensator (TWC) technique is introduced for single-point retardation measurements using Birefringence Measurement Systems, Hinds Instruments, India. The resolution of the TWC is shown to be 0.001 nm. TWC enables the measurement of sample retardation with as little as 0.13% errors and thus is more accurate than either the Brace–Köhler or the Sénarmont method. The morphology of the polypropylene polymer based reinforced concrete in the form of powder deposited on glass going to investigated using Philips XL 30 ESEM scanning electron microscope (SEM) [11].

The prepared concrete samples have been subjected for mechanical study using Universal Testing machine (UT – 2080) has loading accuracy well within ±1% with 1000 Kgf load capacity system provided by U-CAN DYNATEX INC, Taiwan Central Science Park, Taiwan.

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The test is in conformity with the International standard ASTM-C-426 for early shrinking. The equipment for the early shrinkage stages by measuring either decrease in the length or volume of a material resulting from change in moisture content or chemical composition. The height of the blocks is 30 cm and the diameter of the top and bottom of the cone is 10 cm and 20 cm, respectively.

IV. RESULTS AND DISCUSSION

4.1 Fourier-transform infrared (FTIR) spectroscopy

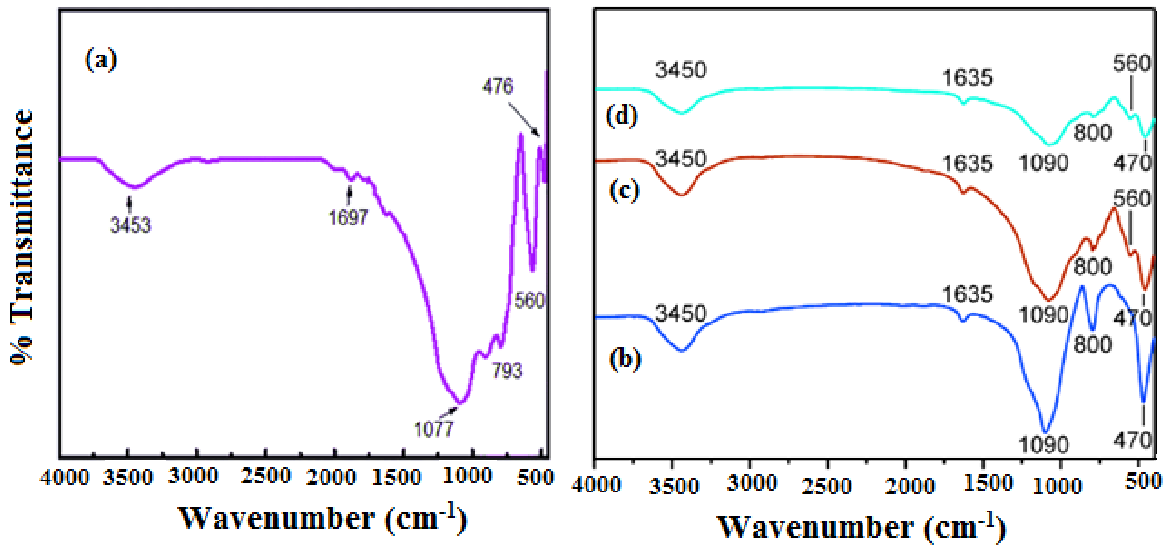

Figure 1 shows that the FTIR spectra of fly ash replaced cement concrete

Figure 1 shows that the FTIR spectra of fly ash doped concrete with different percentages. The important peaks observed for fly ash at 476 cm^{-1} corresponding to Si – O out of plane deformation, 560 cm^{-1} due to the Al – O, CO_3 and Si = O rocking and stretching in plan of symmetry, 793 cm^{-1} for Si – OH stretching and bending, 1077 cm^{-1} for C – C stretching, 1697 cm-1 for CH_3 rocking in asymmetry plane (figure 1(a)). Figure 1 (b –d) shows the important peaks at 470 cm^{-1} corresponding to Si – O out of plane deformation, 560 cm-1 due to the Al – O, CO_3 and Si = O rocking and stretching in plan of symmetry, 800 cm-1 for Si – OH stretching and bending, 1090 cm-1 for C – C stretching, 1635 cm-1 for CH_3 rocking in asymmetry plane and 3450 cm^{-1} for O – H bending. These important peaks indicates that the presence of fly ash, water repellent silicon in concrete mixture [13 -16].

4.2 X-ray powder diffraction (XRD) spectra

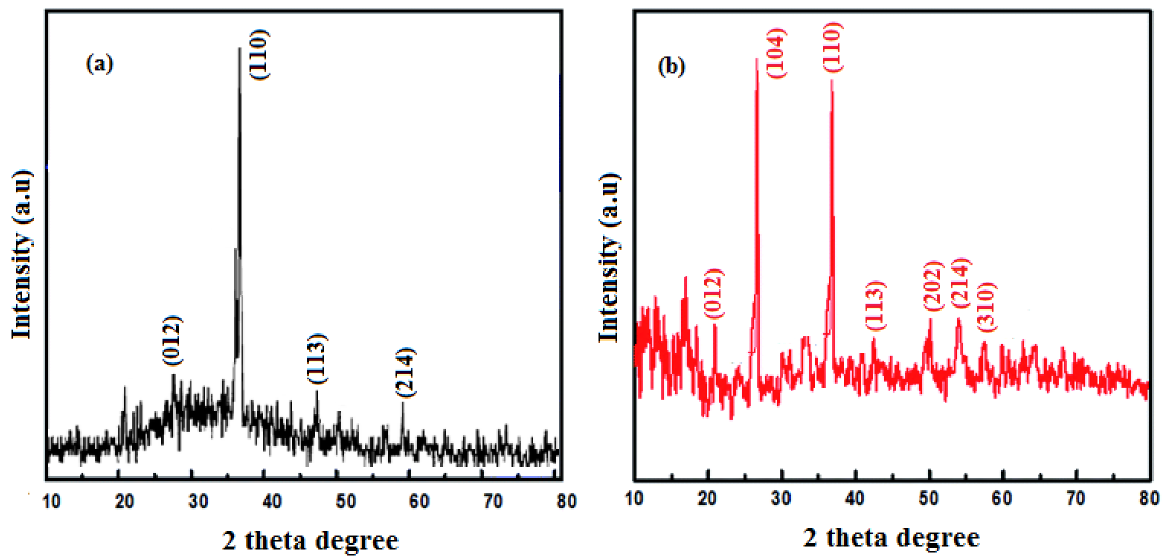

Figure 2 shows the XRD spectra of (a) fly ash and (b) F1, F2 and F3 mixed concrete with mixture of various weight percentages of admixtures

Figure 2 shows the XRD spectra of the concrete with mixture of various weight percentages of admixtures and F2 (5 wt %) mixed concrete with mixture of various weight percentages of admixtures. The fly ash shows numerous peaks particular to the essential chemical components oxides, as an example Q—quartz, C—corundum, M—mullite or H—hematite, but additionally other more complicated crystalline phases containing calcium, titanium, or magnesium, as an example A—anorthite, G—goethite, Al—albite, Ca—calcite, P—portlandite, Gb—gibbsite, magnesium hydroxide, etc. The peaks with the highest intensities particular to the quartz and corundum were positioned between 25° and 30°(2θ). It is observed that the angle 2θ value at 28.64Ǻ, 35.13 Ǻ, 45.6 Ǻ and 58.18 Ǻ corresponds to (012), (110), (113) and (214) are because of mainly semi crystalline nature. The F1, F2 and F3 composition indicates that the angle 2θ value at 22.44Ǻ, 26.63Ǻ, 35.13 Ǻ, 45.6 Ǻ, 42.32 Ǻ, 56.42 and 58.18 Ǻ corresponds to (012), (104), (110), (113), (202), (214) and (310) are because of mainly tetrahedral structure of cement motor [17 – 19].

4.3 Scanning electron microscopy (SEM) study

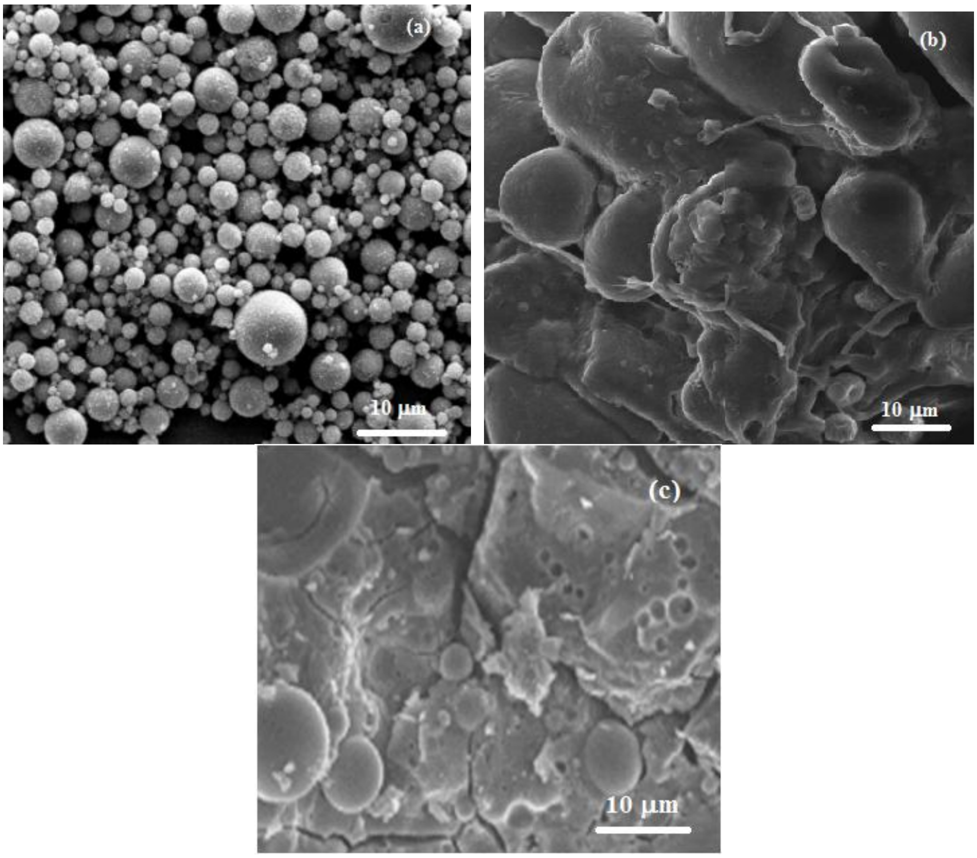

Figure 3 SEM image of (a) fly ash (b) F2 concrete motor and (c) F3 with concrete motor

Figure 3 shows that the SEM image of concrete with mixture of various weight percentages of admixtures and F2 (5 wt %) mixed concrete with mixture of admixtures. It is observed that the admixture significantly affect the boundary of the clay and cement concrete materials. The image (a) indicates that the clay do not homogeneously mixed with concrete may be due to the indifference surface interaction with the cement materials [20]. However, the presence of fly ash with silicon in the concrete influence the formation of proper mixing without any aggregate as shown in figure (b) [21].

V. Mechanical study

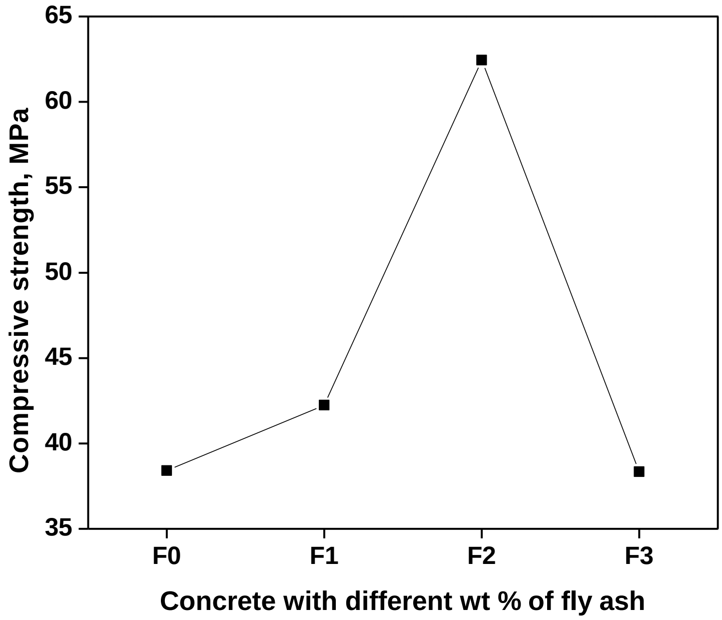

Figure 4 show that the variations of compressive strength against different weight percentages of fly ash. It is observed that the compressive strength of the concrete increases with increase in fly ash weight percentages up 5 wt % for required quantity of admixture added to it. The compressive strength of the concrete enhanced may be due to the capillary contraction and reduce the porosity of the concrete [22]. It is also important to note that the above 5 wt % of the fly ash increases the slump loss and causes cracks over the concrete surface. The addition of admixture and water repellent in concrete outcome synergetic effects on compactness and reduction of porosity results increase in compressive strength [23].

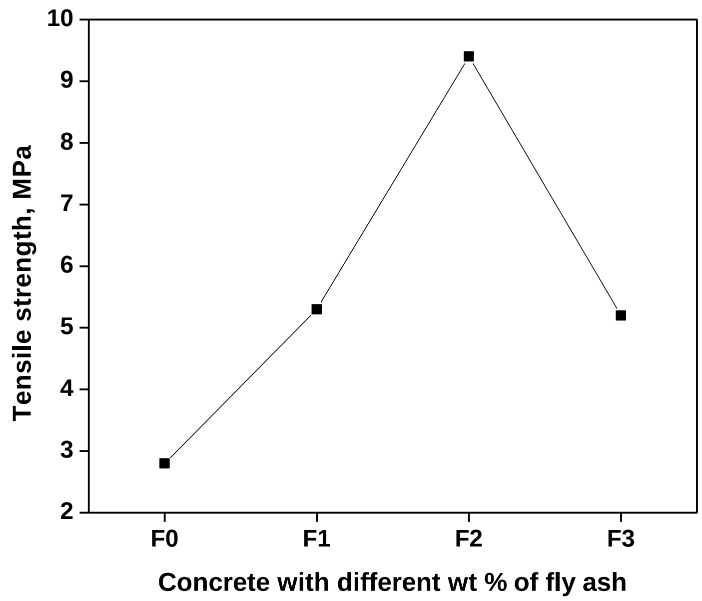

Figure 5 shows the tensile strength of the concrete block with different weight percentages of fly ash. It is found that the tensile strength of the fly ash loaded concrete increases with increase in fly ash for 10 wt %. In flexure tensile test, equal loads are applied at the distance of one – third from both of the beam supports. The loading on the block is increased such that the rate of increase in stress in the bottom lies within the range [24 -26]. It is observed that the concrete has ability to resist the elongation due to tension stress and therefore the concrete has weak in tension whereas strong in compression strength. Another reason to increase the tensile strength is due to the presence of polycarboxylate ether as super plasticizer and silicon oil as water repellent compound which helps in the reduction of capillary size and increase the compactness of the concrete results higher tensile strength [27 -29].

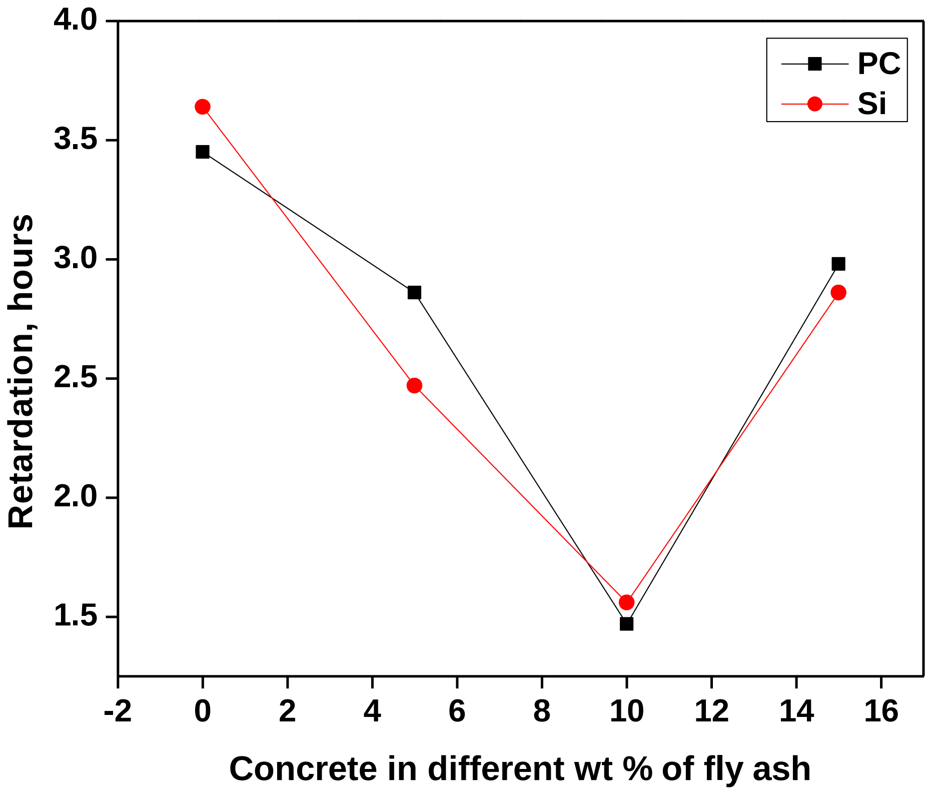

Figure 6 shows the variation of retardation of fly ash based concrete with different ratio of admixture and water repellent agent. It is observed that the retardation of the concrete decreases with increase in fly ash weight percentages up to 5 wt %. The differences in the water demand affected the hydration products and strength development in these systems [30 - 32]. Regarding the microstructure studies, it was revealed that C-S-H and C-A-S-H gels prevail in high calcium and silicon systems, whereas in silicon- and aluminum rich systems (N,C)-A-S-H and C-A-S-H gels predominated. However, the early stage compressive strengths indicated a very promising performance from the application point of view [33, 34].

VI. CONCLUSION

The water soluble silane – siloxane based concrete have been prepared with three different percentage admixture. The mortar mixtures were proportioned with cement to sand ratio of 1:3 and 1:4. The reinforced concretes were cast for the same flow level but different percentages of fly ash dosage. The important FTIR peaks indicates that the presence of fly ash, and water repellent silicon in concrete mixture. The XRD spectra confirmed that the angle 2θ value with corresponding planes are because of mainly tetrahedrally arranged silicate and octahedrally arrangement of aluminate groups in mixed concrete. The surface morphology study confirms that the presence of fly ash with silicon in the concrete influence the formation of proper mixing without any aggregate. The mechanical study proves that the compressive strength and tensile strength of the concretes increases with increase in polypropylene based concrete mixtures up to 5 wt %. However, it is also noted that the admixture significantly enhances the mechanical strength and decreases the early shrinkage of the concrete. The compressive strength of the concrete increases with increase in fly ash weight percentages up 5 wt % for required quantity of admixture added to it and concrete strength enhanced due to the capillary contraction and reduces the porosity of the concrete.

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