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Fabrication of hybrid River sand –fly ash concrete with different admixture and its mechanical study

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Abstract
The mortar mixtures were prepared in various 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 prepared motor concrete subjected for structural study and mechanical property analysis. In FTIR spectra shows predominant peaks are observed the presence of admixture and fly ash in the concrete motor. The XRD spectra indicates the formation tetrahedrally arrangement of silicate and octahedrally arrangement of aluminate groups in fly ash mixed concrete. The surface morphology significantly improved upon adding of different admixture as examined in SEM image. The mechanical study revealed that the compressive strength increases with increase in clay percentages up to RFC (30 wt %) due to the strong adhesion because of mixture of water reduce and water repellent which makes better compact and reduce porosity. The addition of slump flow improved due to presence of polycarboxylate ether and the evident workability loss started after the resting time of 25 min.
Keywords: *Hybrid concrete, River sand, Flay ash, Mechanical study, Admixture*

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I. Introduction

The infrastructure development of our country is increasing everyday and with concrete is a main ingredient of construction material in an important portion of this infra-structural system, it is essential to enhance its characteristics by means of strength and durability [1]. It is also reasonable to compensate concrete in the form of using waste materials and saves in cost by the use of admixtures such as fly ash, silica fume, etc. as partial replacement of cement. Fly ash which is a byproduct of the thermal power plant poses a serious problem of its dumping to the environment [2]. Utilization of fly ash in concrete as partial replacement with cement not only solves the problems of dumping to some extent but also it is used as mineral admixture in concrete and helps to attain reduction in cost of concrete by saving cement [3]. This pozzolana is beneficially used to attain certain properties in concrete as lower water demand for similar workability, reduced bleeding and lower evolution of heat. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat of hydration and also helps in reducing cracking at early ages [4].

Plain concrete is fragile in tension and has limited ductility and little resistance to cracking. Microcracks are present in concrete and because of its poor tensile strength; the cracks propagate with the application of load, leading to brittle fracture of concrete. Microcracks in concrete are formed during its hardening stage [5, 6]. When the load is applied, microcracks start developing along the planes, which may experience relatively low tensile strains, at about 25-35% of the ultimate strength in compression. The low tensile strength of concrete is being compensated for in several ways, and this has been achieved by the use of reinforcing bars and also by applying pre-stressing method [7]. Though these methods provide tensile strength to concrete, they do not increase the inherent tensile strength of concrete itself. Further, conventionally reinforced concrete is not a two phase material in true sense. Conventionally the reinforced concrete in two phase material only after cracking when cracked matrix is held by the reinforcing bars [8]. Existence of one phase does not improve the basic strength characteristics of the other phase and consequently the overall performance of the traditional reinforced concrete composite is dictated by the individual performance of the concrete and steel phase separately [9].

The effect of fly ash on mechanical properties of high strength concrete is significant. In this different bar reinforcements of 2 numbers of 6mm and 12mm diameter and three types of fiber contents two straight with end hooks with different ultimate strength and one corrugated were used [10]. This experiments show that for all selected fiber contents a more ductile behavior and higher load levels in the post cracking range were obtained. They studied on the properties of concrete containing fly ash and steel fibers [11]. The reported results showed that the fiber addition, either into Portland cement concrete or fly ash concrete, improve the tensile strength properties, drying shrinkage and freeze–thaw resistance. However, it reduced workability and increase sorptivity coefficient [12]. Although fly ash replacement reduces strength properties, it improves workability, reduces drying shrinkage and increases freeze–thaw resistance of steel fiber reinforced concrete. It shows that the behavior of fly ash concrete is similar to that of Portland cement concrete when fly ash is added [13]. In this work, author has prepared the Series A, B and C, mixes are prepared using River sand as fine aggregate materials. In all series cement was replaced with fly ash with % replacement levels of 0, 10, 20, 30, 40, 50 and 60 by weight of cement keeping coarse aggregate proportion as constant.

II. Materials and Methods

2.1 Mix proportioning method

The basic mix proportions (control mix) are achieved based on soil compaction principles and ACI 211 3R-02 (2002) guidelines. The target flexural strength for the preparation mix was 5.0 MPa. The cement content of control mix is obtained as 295 kg/m^3. The Series A, B and C, mixes are prepared using River sand as fine aggregate materials. In all series cement was replaced with fly ash with % replacement levels of 0, 10, 20, 30, 40, 50 and 60 by weight of cement keeping coarse aggregate proportion as constant.

2.2 Casting, curing and testing of SCC

After performing the workability tests, the fresh concrete will be filled in the mould for determining compressive strength, split tensile strength and flexural strength. Compressive strength was performed on cube moulds of 150 x 150 x 150 mm as per IS: 516, Split tensile strength was performed on 150 x 300 mm cylindrical mould as per IS: 5816, whereas flexural strength will; be performed on beam mould of 150 x 150 x 700 mm as per IS: 516 [11, 13, 14]. The mix will be designed to study the effect of RHA and temperature variation on mechanical properties of SCC. The strength of each mix is measured at 3, 7 and 28 degree. After casting the specimens, specimens were kept along with moulds for temperature curing at 60 and 70 ºC for 24 h. One mix was kept for the ambient curing at room temperature. After 24 h of temperature curing and ambient curing, specimens were de-mould and kept at room temperature for 3, 7 and 28 degree [15].

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).

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. 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 test is in conformity with the International standard ASTM-C-143 for slump test. The equipment for the slump test includes a hollow frustum of a cone and a ruler as the measuring device. The height of the cone is 30 cm. The diameter of the top and bottom of the cone is 10 cm and 20 cm, respectively.

Table 1 shows that the composition of hybrid concrete

Samples	Polycarboxylates	SBR (Water repellent agent)	Silicon	Fly ash
RFC0	0	0	0	05 wt %
RFC1	1.6 wt %	1.5 % by w/c ratio	0.5 wt %	10 wt %
RFC2	1.6 wt %	1.5 % by w/c ratio	0.5 wt %	20 wt %

RFC3	1.6 wt %	1.5 % by w/c ratio	0.5 wt %	30 wt %
RFC4	1.6 wt %	1.5 % by w/c ratio	0.5 wt %	40 wt %
RFC5	1.6 wt %	1.5 % by w/c ratio	0.5 wt %	50 wt %

Note: RFC **–** River sand –fly ash concrete

IV. Results and Discussions

4.1 Fourier transform infrared spectroscopy (FTIR)

Figure 1 (a) show that the FTIR spectra of fly ash mixed concrete with 5 weight percentages. The important peaks observed at 410 cm^{-1} corresponding to Si – O out of plane deformation, 518 cm^{-1} due to the Al – O, CO_3 and Si = O rocking and stretching in plan of symmetry, 584 cm^{-1} for Si – OH stretching and bending, 624 cm^{-1} for C – C stretching, 812 cm^{-1} for CH_3 rocking, 1141 cm^{-1} for C – H wagging in plane, 1332 cm^{-1} for CH_2 symmetrical bending, 1495 cm^{-1} due to CH_3 symmetrical bending, 1573 cm^{-1} for C – O bending for flay ash and 2291 cm^{-1} for O – H bending of water molecules [13 – 17]. Figure 1(b) shows that the FTIR spectra of fly ash mixed concrete with different percentages of admixture and water repellent agent. The important peaks observed at 405.39 cm^{-1} corresponding to Si – O out of plane deformation, 606.72 cm^{-1} due to the Al – O, CO_3 and Si = O rocking and stretching in plan of symmetry, 684.51 cm^{-1} for Si – OH stretching and bending, 841.91 cm^{-1} for C – C stretching, 908.71 cm^{-1} for CH_3 rocking, 1233.58 cm^{-1} for C – H wagging in plane, 1223.26 cm^{-1} for CH_2 symmetrical bending, 1414.03 cm^{-1} due to CH_3 symmetrical bending, 1625.25 cm^{-1} for C – O bending, 2856.09 cm^{-1} for CH_3 asymmetry stretching, 3762.06 cm^{-1} for O – H bending. These important peaks indicates that the presence of polypropylene fibers, water repellent silicon in concrete mixture [16 – 18].

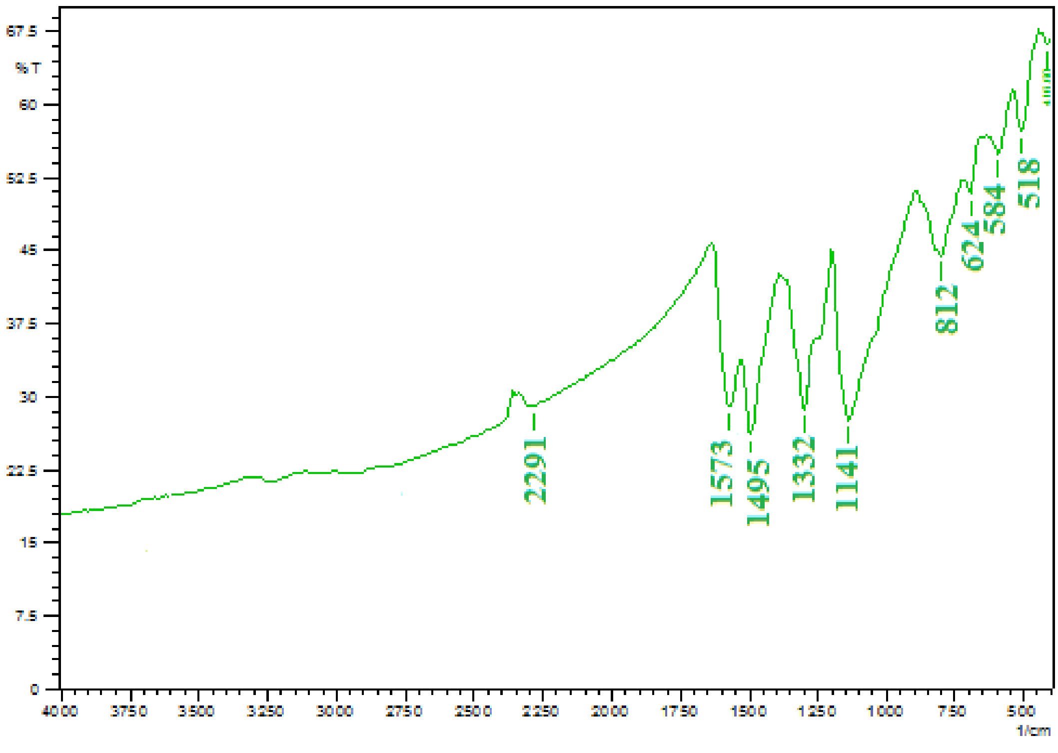

Figure 1(a) shows the FTIR spectra of revier sand concrete without fly ash (RFC0)

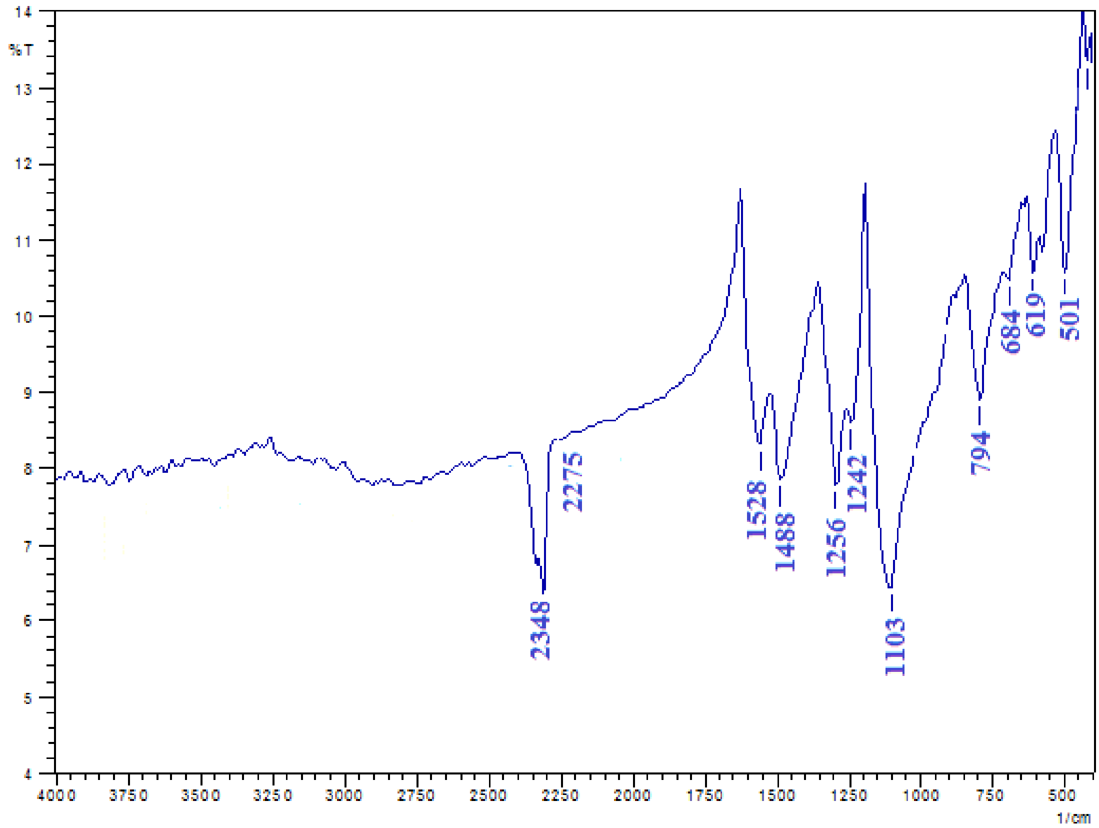

Figure 1(b) shows the FTIR spectra of revier sand concrete with fly ash (RFC3)

4.2 X-rays diffraction spectroscopy

Figure 2 shows the XRD spectra of the concrete with mixture of various weight percentages of admixtures and RFC (05, 10, 30 and 50 wt %) fly ash mixed concrete with mixture of various weight percentages of admixtures. It is observed that the angle 2θ value at 29.3Ǻ, 30.4 Ǻ, 35.8 Ǻ, 43.2 Ǻ, 52.6 Ǻ, 57.6 Ǻ, 63.1 Ǻ, 75.4 Ǻ and 42.6 Ǻ corresponds to (101), (110), (101), (111), (120), (102), (112), (221) and (202) are because of mainly tetrahedrally arranged silicate and octahedrally arrangement of aluminate groups in clay mixed concrete [19].

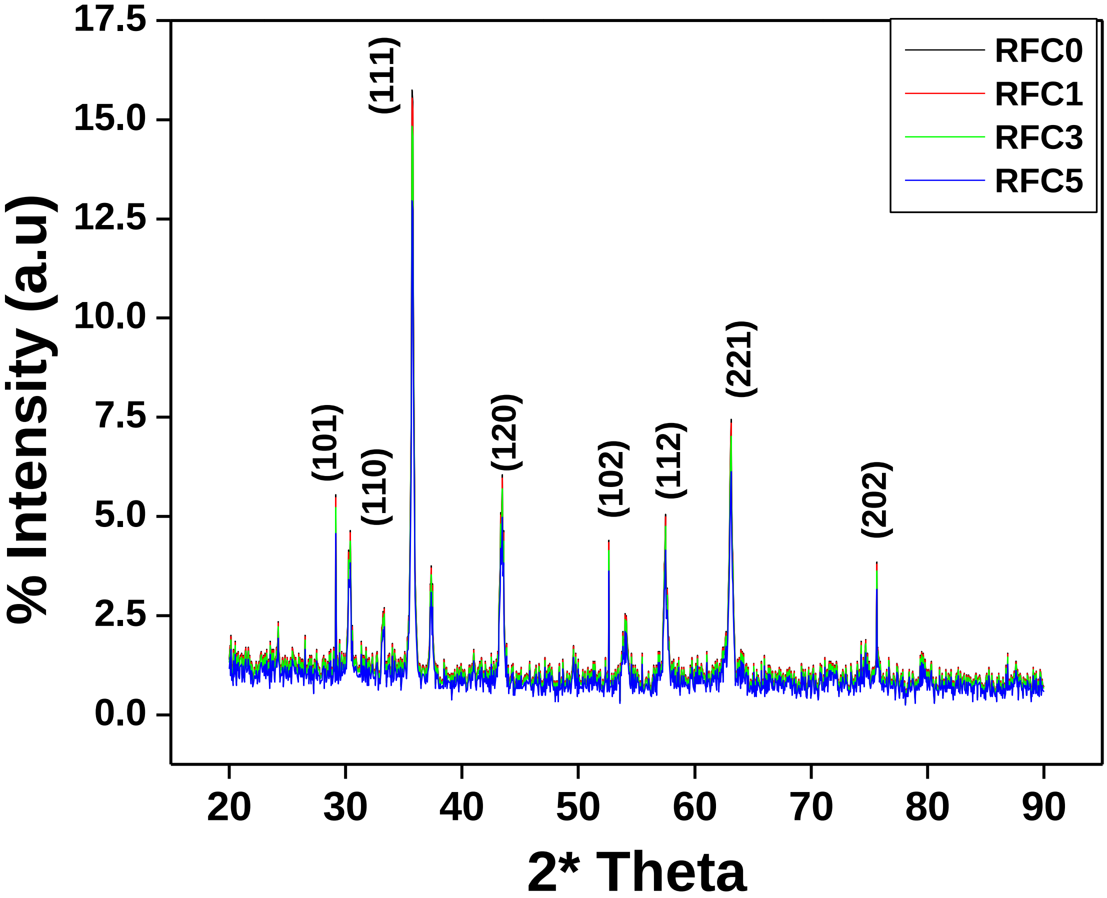

Figure 2 shows that the XRD spectra of RFC with 0, 1, 3 and 5 wt % of river sand with fly ash concrete

4.3 Scanning Electron Microscopy (SEM)

The scanning electron microscopic (SEM) image shows that the RFC with 05, 10, 30 and 50 wt % of fly ash concrete with different concentration. It is observed that the admixture significantly affect the boundary of the fly ash and cement concrete materials [20]. The image (a) indicates that the fly ash do not homogeneously mixed with concrete may be due to the indifference surface interaction with the cement materials. However, the presence of polycarboxylate ether and bonding agent SBR agent in the concrete influence the formation of proper mixing without any aggregate as shown in figure (b - d) [21].

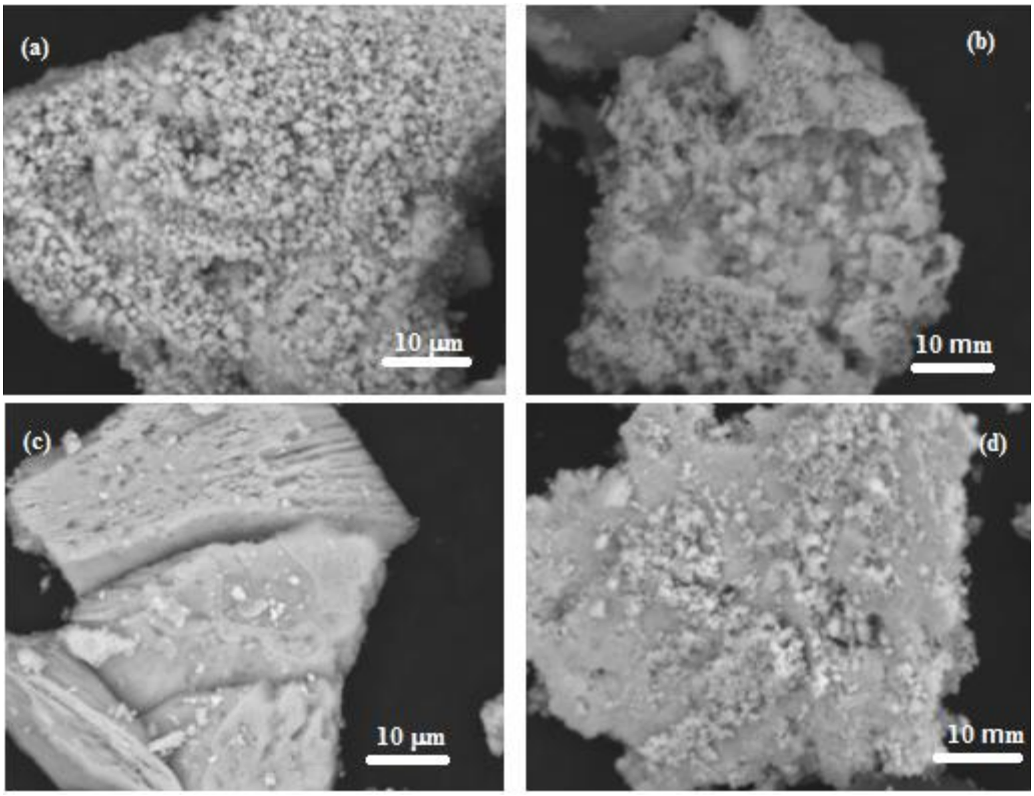

Figure 3 shows that SEM image of RFC with 05, 10, 30 and 50 wt % of fly ash concrete

V. Mechanical study

Figure 4 shows the variation of compressive strength against different weight percentage of river sand and fly ash along with polycarboxylates as superplasticizer and silicon oil for water repellent agent. It is observed that the mechanical strength of the concrete affected by the presence of fly ash and that can be overcome by adding bonding agents such as styrene-butadiene (SBR) copolymer. The compressive strength of the materials increases with increase in weight percentage of fly ash up to 30 wt % in presence of SBR bonding agent due to the lower porosity and good compactness without any surface crack results the higher strength. It is observed that the after 30 wt % of fly ash, the brittleness of the concrete significantly increases causes low compressive strength [22].

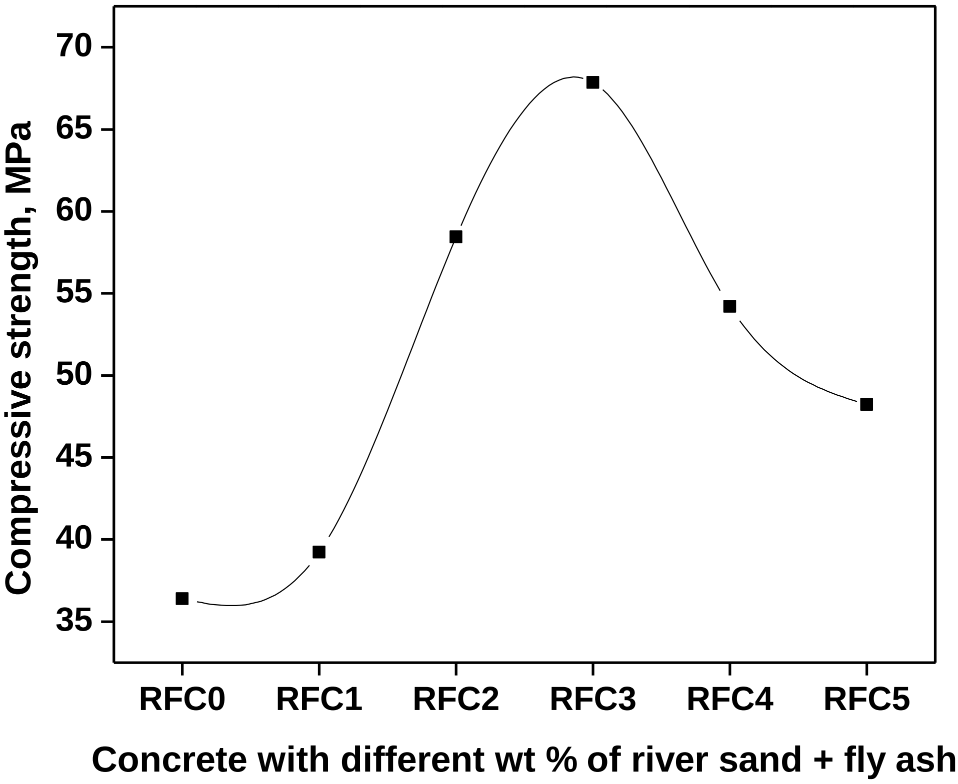

Figure 4 shows the variation of compressive strength against different weight percentage of river sand and fly ash

Figure 5 shows that the variation of retardation of concrete with different weight percentage of river sand and fly ash in required proportion along with the superplasticizer and bonding agent. It is observed that the retardation of the concrete increases with increase of fly ash in the concrete may be due to the presence of silicon oil and SBR agents which takes little longer time for drying because of hydrophilic nature of the copolymer. 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 [23]. However, the early stage compressive strengths indicated a very promising performance from the application point of view. Among all the composition, 30 wt % of concrete shows higher retardation time as the admixture disturbed properly in the concrete mixture. After 30 wt % of fly ash concrete, it is observed that the retardation time suddenly dropped may be due to the agglomeration of the fly ash and presence of silica in higher percentages in the river sand [24].

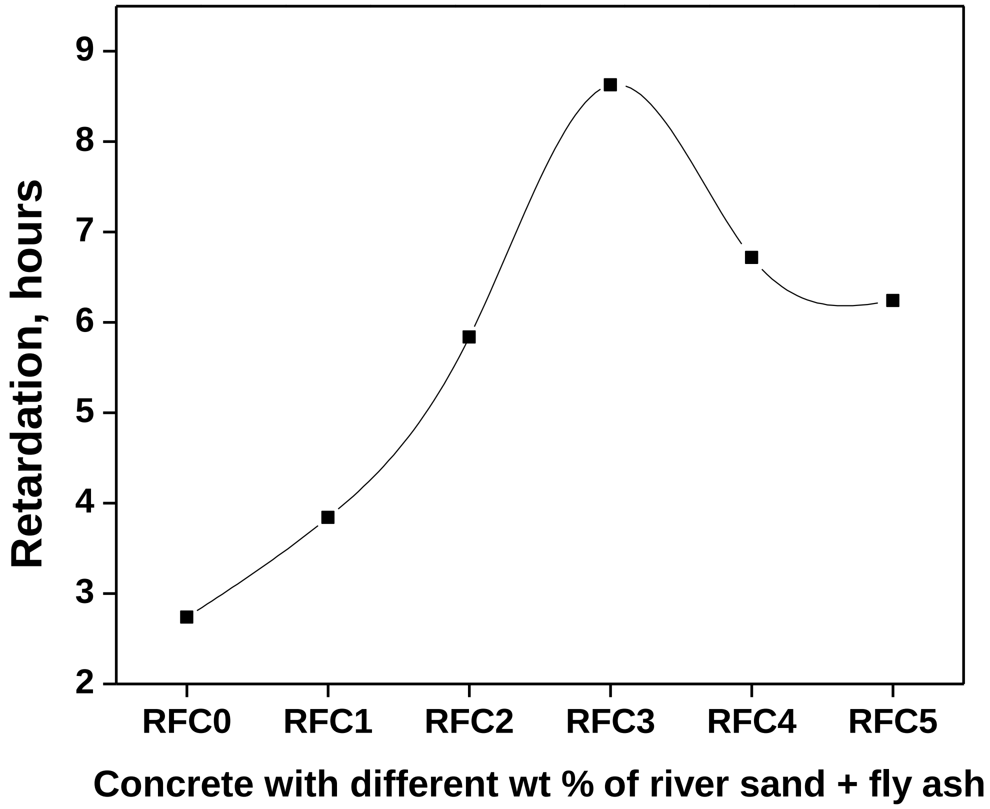

Figure 5 shows that the variation of retardation of concrete with different weight percentage of river sand and fly ash

Figure 6 shows the variation of tensile strength against concrete with different weight percentage of river sand and fly ash. It is found that the tensile strength increases with increase in different weight percentage of fly ash up to 30 wt %. This is may be due to the high compactness and reduction in porosity of the concrete block [25]. It is also important to note that the water reduce admixture such as polycarboxylates and silicon oil in required ratio's significantly effects on capillary threshold by reducing 12 % of water results higher density of the concrete [26].

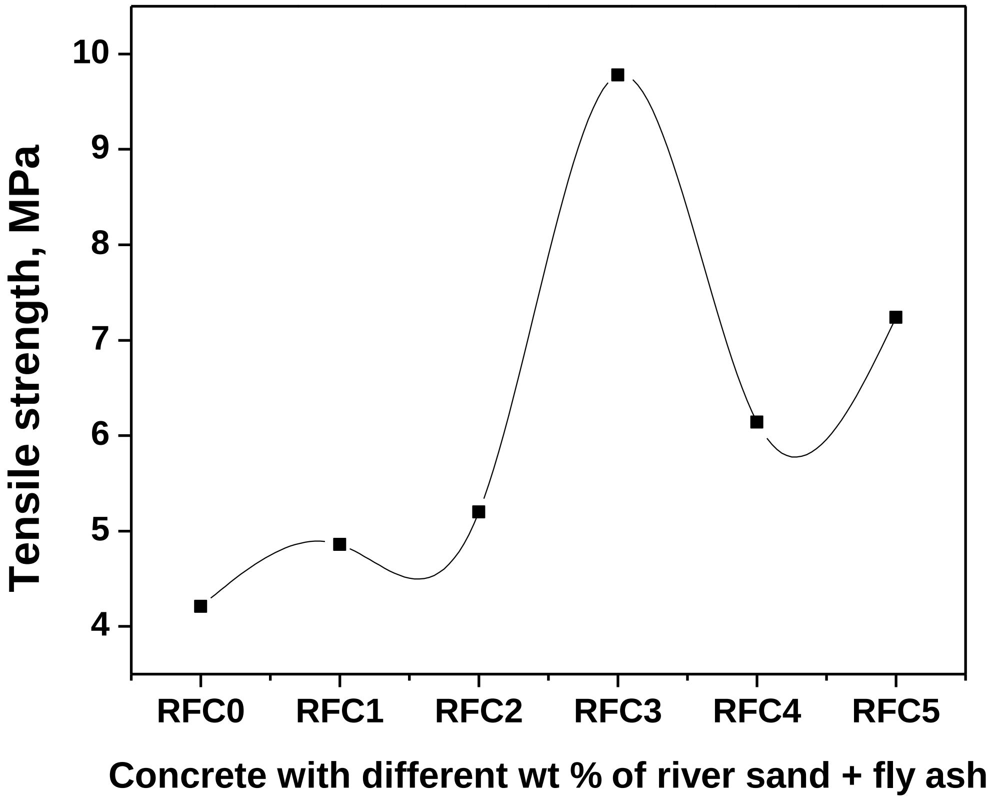

Figure 6 shows the variation of tensile strength against concrete with different weight percentage of river sand and fly ash

VI. Conclusion

The mortar mixtures have been prepared in various proportioned with cement to sand ratio of 1:3. The reinforced concretes were cast for the same flow level but different percentages of fly ash (05, 10, 20, 30, 40 & 50 wt %) dosage. The prepared motor concrete subjected for structural study and mechanical property analysis. In FTIR spectra shows predominant peaks are observed at 405.39 cm^{-1} corresponding to Si – O out of plane deformation, 606.72 cm^{-1} due to the Al – O, CO_3 and Si = O rocking and stretching in plan of symmetry, 684.51 cm^{-1} for Si – OH stretching and bending, 841.91 cm^{-1} for C – C stretching, 908.71 cm^{-1} for CH_3 rocking, 1233.58 cm^{-1} for C – H wagging in plane, 1223.26 cm^{-1} for CH_2 symmetrical bending, 1414.03 cm^{-1} due to CH_3 symmetrical bending, 1625.25 cm^{-1} for C – O bending, 2856.09 cm^{-1} for CH_3 asymmetry stretching, 3762.06 cm^{-1} for O – H bending. These important peaks indicate that the presence of polypropylene fibers, water repellent silicon in concrete mixture confirms the presence of admixture and fly ash in the concrete motor. The XRD spectra indicates the formation tetrahedrally arrangement of silicate and octahedrally arrangement of aluminate groups in clay mixed concrete. The surface morphology significantly improved upon adding of different admixture as examined in SEM image. It is found that the presence of polycarboxylate ether and bonding agent SBR agent in the concrete influence the formation of proper mixing without any aggregate. The mechanical study revealed that the compressive strength increases with increase in fly ash percentages up to RFC (30 wt %) due to the strong adhesion because of mixture of water reduce and water repellent which makes better compact and reduce porosity. The addition of slump flow improved due to presence of polycarboxylate ether and the evident workability loss started after the resting time of 25 min.

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