Experimental Investigation on Energy Dispersive Analysis of Fiber Reinforced Concrete

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Abstract- *Concrete structures are usually subjected to both static as a long term and dynamic as a short term loads. The impact resistance of plain concrete is low and that's mainly due to a fairly low energy dissipating features and inadequate tensile strength. To compensate for the weak tensile properties of the concrete the reinforced concrete is used and it has a better potential as a practicable structural material for such application under extreme loads such as impact. However, concrete is a developing material and the relevant studies towards the change and development of concrete which researchers have carried out to date reveals that the developed concrete improves the behavior of structural member more when compared to conventional concrete. Fiber Reinforced Concrete (FRC) material is a developed concrete that has been proposed to improve the tensile behavior of the concrete using fibers in the concrete mix. Synthetic Fiber Reinforced Concrete (SFRC) is popular FRC material that is being studied to improve the structural behavior of members under different load conditions. This study attempts is to use Synthetic fibers in the structure of concrete to obtain a composite with high tensile strength and ductility. However, a thorough understanding of the mechanical behavior of fiber-reinforced concrete requires knowledge of fiber cement interfaces at the nano scale. Scanning electron micros- copy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analysis are used to obtain a better understanding of the C-S-H fiber (in cement chemistry notation, C = CaO, S SiO2, and H H2O) interfaces.*

Keywords- SFRC, Investigation, Structure, SEM

I. INTRODUCTION

Concrete is a very strong and versatile moldable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

Concrete is the second most widely used substance after water and over six milliard tons of concrete is produced each year. Concrete is specified to different applications like a new construction, repair, rehabilitation and retrofitting. Concrete building components in different sizes and shapes include wall panels, doorsills, beams, pillars and more. Post tensioned slabs are a preferred method for industrial, commercial and residential floor slab construction. It makes sense to classify the uses of concrete on the basis of where and how it is produced, together with its method of application, since these have different requirements and properties.

The fiber Reinforced concrete is the concrete made with the hydraulic cement, containing fine, coarse aggregate and discontinuous fiber or concrete incorporating relatively short, discrete and discontinuous fibers

Among characteristic of fibers that has influence on the response of the composite are type of fiber, length of fiber, the volume fraction of fiber and the bond of the fiber with the matrix. We enlist the proven steps to publish the research paper in a journal.

II. IDENTIFY,RESEARCHANDCOLLECT IDEA

A commercial Synthetic fiber was used as a reinforcing material to produce SFRC structures. The detailed chemical and morphological characterization of Synthetic fibers was performed by using SEM-EDX analysis.

To obtain high performance SFRC advanced-structures, the compositional designing studies were carried out based on the combined use of chemical (CA) and Synthetic fiber (CGF) additives. Here, the Auramix-400was chosen as CA. The composite concrete samples were fabricated by separately doping with CA and CGF in the compositions of 450 g cement + 1350 g SiO_2 sand + 6.75 g Auramix-400(1.5 wt. %of cement) and 0.3, 0.5, 0.8, 1 and 2 wt. % of total weight, respectively. As a preference, CA was simultaneously added to concrete structure with water. Direct doping of CA in cement leads to a variety of undesired problems. Please also note that we do not use any CA in the system different than Auramix-400. Moreover, un-mixing of

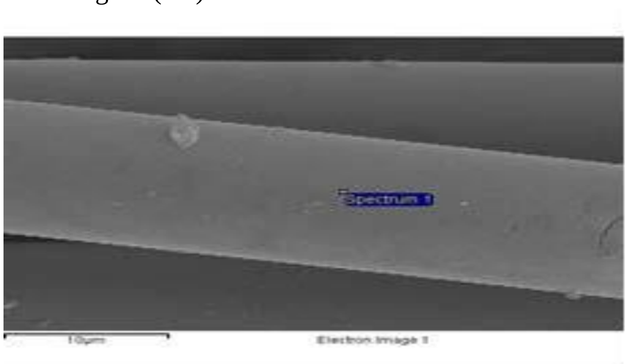
CA with the other components of concrete during batch preparation protects the chemical stability of CA and further improves its function in the mixture.

The micro-structural examinations of SFRC samples produced with addition of CFG, which includes a polymeric-based coating material, silane, on the surface as well as its removed form through applying a heat treatment process and combination of CA to CFG were performed by using high-SEM attached with EDX.

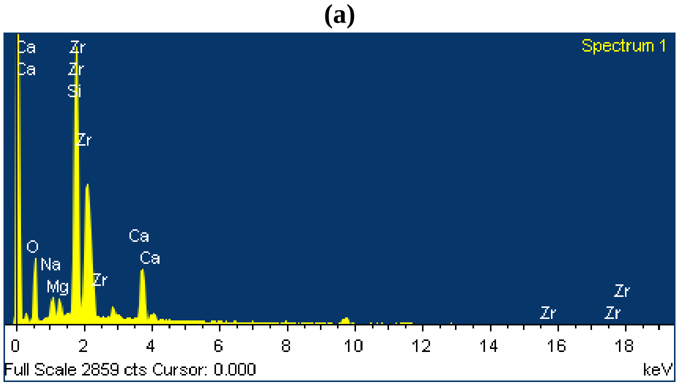
Three point bending test and compressive experiments of the concrete structures with CFG doping in different weight percentages and without adding any CFG at the end of 2, 7 and 28 days cure were carried out.

III. RESULTS AND DISCUSSIONS

The SEM-EDX analysis results performed with the aim of determination glass fibers' chemical composition were given in Figs. 1 (a-b).



(a)



(b)

Figure1.(a)The secondary electron (SE) SEM image indicating a place where EDX point analysis on Synthetic fiber was acquired from, (b) The EDX spectrum data coming from marked region in Fig. 1(a).

The commercial Synthetic fibers, as a reinforced-material, coated with a polymeric component (silane) on their surface were incorporated into the concrete structure in proportions of 0.5, 0.8 and 1 wt. %. As a result, the SFRC materials were successfully fabricated. The three point bending test and compressive experiments on the concrete structures with CFG doping and without adding any CFG, namely as- received samples at the end of 2, 7 and 28 days cure were comparatively presented in Table 1.

Table.1 The three-point bending and compressive test results obtained from the SFRC samples produced with the commercial synthetic fibers addition in the proportion of 0.5, 0.8 and 1 wt. %.

FiberAdditive	7 Days		28 Days	
	ThreePointBendingTest	Compressive Test	ThreePointBending Test	Compressive Test
Standard	6.0	12.6	7	39
0.5%	5.7	13.1	6.8	40.9
0.8%	5.3	13.5	6.4	41.2
1%	5.9	13.7	5.4	41.4

Based on the data of Table 1, as a result of synthetic fibers incorporation into the concrete structures, it is clearly observed that the mechanical properties of SFRC samples were negatively affected when compared to those of as-received sample. Therefore, it was thought that the reasons of this negativity could be related to the polymeric coating material's properties on the fiber surface, dispersion and bonding characteristics with matrix phases of commercial synthetic fibers within the concrete structure. At this point, for the sake of theclarity why the mechanical properties were affected in a negative way in the case of fiber doping into the concrete structure, the micro-structural and analytical observations taken from SFRC sample resulting with the addition of 0.5 wt. % synthetic fiber after 7 days cure were conducted with SEM-EDX combination under VP conditions without any coating and the obtained examinations' results were presented in Figs. 2 (a-d).

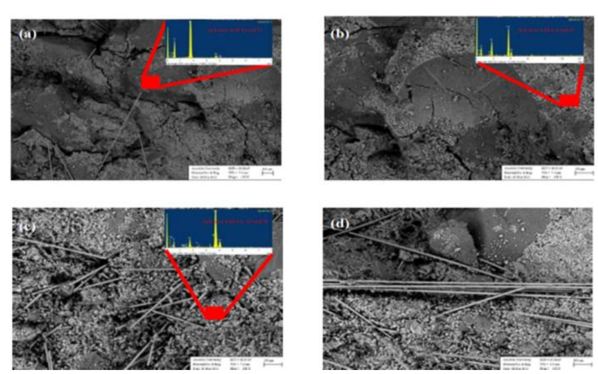


Figure 2. (a) The SEM image acquired from SFRC sample containing 0.5 wt. % commercial synthetic fiber addition.

Considering the SEM-

EDX imaging and chemical analysis results given in Figs.2 (a-d)together, it was clearly observed that the polymer-coated synthetic fibers used as reinforcement material were no thomogenously dispersed in matrix and aggregate structures of SFRC. Furthermore, it was determined that the fibers did not properly contact with the matrix and aggregate components. Therefore, this result implies that the polymeric–based coating material existing on the fiber's surface might be in hydrophobic character. As a result of this fiber nature, it can be said that synthetic fibers do not entirely hold on the matrix and aggregate components.

In the light of such results, the silane coating on the fibers surface was cleaned by means of a chemical reaction occurring between acetone and fiber.

Afterwards, different SFRC samples were produced by using the addition of 0.5, 0.7,and 0.8wt.%uncoated (no silane on the fibers' surface)short fibers and 0.8 wt. % long ones. In Figs. 3 (a-d), the SEM images of SFRC samples that reinforced with uncoated short and long synthetic fibers in different proportions (maximum 0.8 wt.%) were given.

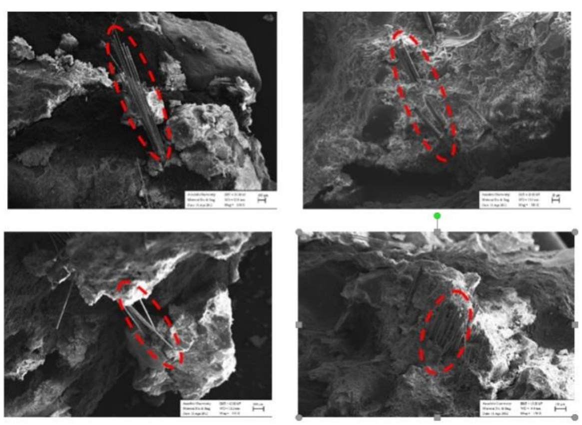


Figure3.(a-b)The SEM images of SFRC samples with the addition of uncoated short commercial synthetic fibers in 0.5 and 0.7 wt. %, respectively, (c-d) The SEM images of SFRC samples with the addition of uncoated short and long commercial glass fibers in 0.8wt. %.

Considering the findings observed in Fig.3 (a-d), it was seen that the commercial synthetic fibers, surfaces of which were treated with acetone were not homogenously distributed in SFRC matrix structure. Furthermore, the agglomerated groups can be clearly discerned in the special regions that labeled with dashed red lines. The acquired results clearly reveal that not only controlling the fibers surface characteristics is sufficient, but also additional chemical doping agents are required to homogenously disperse the commercial synthetic fibers and to prevent the clusters' formation in concrete matrix structure during the SFRC process. Therefore, it was decided to use a chemical additive to obtain the homogeneity in the distribution of glass fibers within SFRC.

Here, new SFRC samples produced by mixing of Admixture, used as a CA, and commercial synthetic fibers in the proportions of 0.3, 0.5, 0.8 and 1 wt. % are given. Thus, the values of three point bending and compressive tests of resulting new SFRC samples taking from the end of the 2, 7 and 28 days cure are comparatively shown in Table 2.

Amounts (% Weight)	7 Days		28 Days	
	Three Point Bending Test	Compressive Test	Three point bending test	Compressive Test
Standard	6.0	32.3	7	43
Standard	9.6	56.6	8.0	57.75
0.3 % (CA+CSF)	6.9	41.4	7.2	47.3
0.5 % (CA+CSF)	7.2	42.8	7.2	52.5
0.8 % (CA+CSF)	4.5	24.9	5.7	38.4
1 % (CA+CSF)	5.7	27.3	5.9	39.8
2 % (CA+CSF)	5.1	43.2	-	-

Table.2. The three-point bending and compressive tests' results of SFRC samples consisted of no including chemical additive (CA) and commercial synthetic fiber (CSF), called as standard concrete samples, as well as those containing CA and CSF in proportions to 0.3, 0.5, 0.8, 1 and 2 wt. % together.

According to Table 2, the significant data for the improvement of mechanical properties by means of glass fiber incorporation and chemical additive usage within the SFRC structures were obtained from the recipe with CA+CSF as 0.5 wt. %. Here, it can be observed that three point bending and compressive strengths of resulting SFRC advanced- materials at the end of 2, 7 and 28 days cure considerably increase when compared to both standard samples shown in Fig. 8.4. However, in the cases of the recipe with CA+CSF over 0.5 wt. %, it was observed that the strength values reduced due to the possible formation of voids in the structure.

The micro-structural evolutions of SFRC samples acquired from the recipe with CA+CSF as 0.5 wt. % at the end of 7 and 28 days cure were presented in the Fig.4 (a-b) and Fig.5 (a-b).

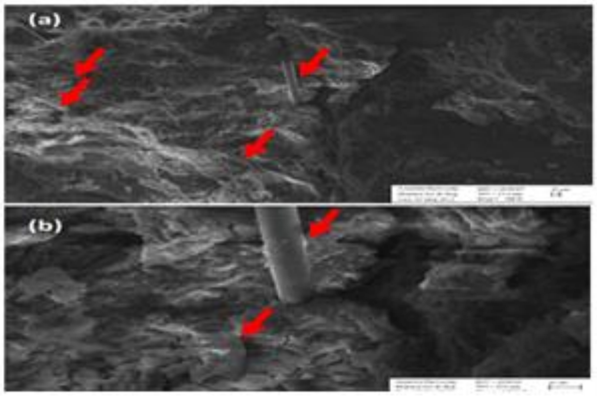


Figure.4.(a-b) The SEM images in different magnification taken from the SFRC sample with CA+CSF as 0.5 wt. at the end of 7 days cure.

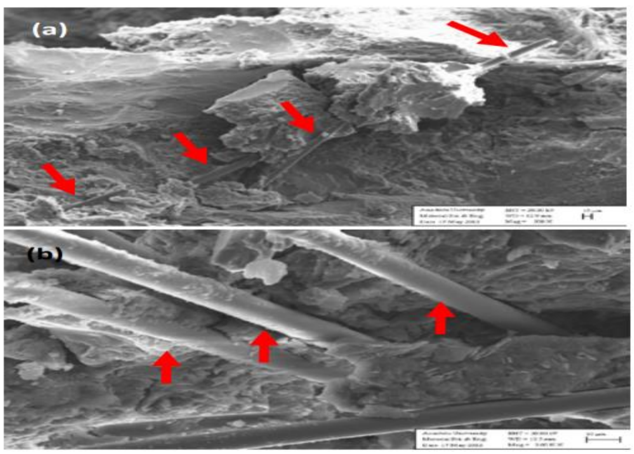


Figure.5. (a-b) The SEM images in different values taken from the SFRC sample with CA+CSF as 0.5 wt. % at the end of 28 days cure.

Looking at the Figs.4 (a-b) and 5 (a-b), it could easily be noticed that the synthetic fibers were homogeneously dispersed in SFRC structure wherein especially special regions marked with red arrows. Additionally, no cluster-type formation was detected in SFRC material. Furthermore, it was concluded that Synthetic fibers showed good bonding behavior with matrix phases, which also means that they play a role as load-carrying constituents in SFRC matrix. Moreover, based on the evolved micro-structural designs in Figs.4 (a-b) and 5 (a-b), it can be explained that the addition of Admixture the homogenous distribution of Synthetic fibers in SFRC structures easier and hence leads to the enhancement of the mechanical properties of resulting composites.

IV. CONCLUSION

In the present study, the commercial synthetic fibers incorporation into concrete structures for making a new type of advanced composite material generally called as synthetic fiber reinforced concrete/composite (SFRC) is reported. Firstly, the effects of polymeric-based coating material-saline-were investigated on the resulting SFRC structure. Here, using scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) spectroscopy facilities, the cluster-type formation of synthetic fibers in SFRC matrix further revealed the inhomogeneous distributions of fibers in SFRC was clearly observed. In the light of such an observation, secondly, the surfaces of commercial synthetic fibers were heat-treated to remove the polymer coating. However, even if heat-treated commercial fibers were added into SFRC structure, the formation of fiber clusters was not unfortunately prevented. Therefore, the mechanical properties, i.e., three point bending and compressive strengths were deteriorated in both coated and heat-treated commercial fibers doped SFRC samples with respect to the standard concrete. To overcome this undesired result, an extra chemical additive, Auramix 400, during the SFRC's production step was used. Finally, by the combination of chemical (CA) and synthetic glass fibers (SGF) in the proportion of 0.5 wt. % CA+CSF, the obtained samples' mechanical properties after 2, 7, and 28 days cure were considerably increased when compared to those of standard samples. Considering the micro-structural evolutions of SFRC composites with CA+CSF as 0.5 wt. %, it was seen that the commercial synthetic fibers were well-dispersed in the SFRC matrixes, further explaining that why such enhanced mechanical properties were obtained.

Consequently, the study on the relationship between micro-structure and mechanical properties in SFRC advanced-materials was carried out. It is anticipated that successfully controlling the synthetic fibers' micro-structural behavior will pave the way for the production of SFRC advanced-composites in constructional applications.

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