XRD AND SEM ANALYSIS OF BIOFIBER REINFORCED CONCRETE

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1. Abstract

Biofiber in concrete has opened up a new window for the green technology and helped with an increased tension, compression strength and reduced sudden failure of concrete but with little disadvantage of bonding between a concrete matrix and biofiber and durability of concrete. The present paper mainly concentrate on bonding between concrete complex and sida cordifolia biofiber and material characteristics of biofiber reinforced concrete, have been analyzed by the XRD & SEM. X – Ray diffraction analysis had been done on both plain concrete and biofibers reinforced concrete to know how the biofiber act with concrete complex during the whole hydration process and gain the bonding and extra ductility. Comparative study on plain concrete and biofiber reinforced concrete done for identification of phases present in the plain concrete as well as in biofiber reinforced concrete. This analysis reveals that bonding and tensile nature of concrete increases by incorporating biofibers. During investigation minerals found are calcite ($CaCO_3$), quartz or silica (SiO_2), sucrose and fluorite (CaF_2). The bonding between concrete and fiber, morphology of the structure is studied using scanning electron microscope and it shows the optimum length is available for proper bonding between the concrete matrix and fiber and it also reveals that biofibers can be used as homogeneous reinforcement in a concrete matrix.

Key Words: Biofibers, Sida Cordifolia, SEM, XRD and Natural fibers

2. Introduction

The introduction of natural fiber as reinforcement in the concrete complex has received attention by both academic as well as industrial sector. The Industrial application and research on natural fiber is growing rapidly because of renewable, recyclable, cheap and biodegradable property and environment friendly.

First time author tried to find mechanical properties of concrete homogeneously reinforced with Sida cordifolia plant biofibers. The optimum content of fiber to be used is determined by conducting an experimental study. The performance of this biofiber reinforced concrete is evaluated by conducting strength tests like compressive, flexural strength tests and split tensile in accordance with Indian standards [1]. Mechanical strength properties of synthetic fibers with different volume fractions and different aspect ratios were evaluated [6]. Earlier research were mainly concerned with the mechanical and physical properties of fibers. Bonding between Sida Cordifolia fibers and concrete matrix and durability are untouched area. Researcher worked on the durability of the sisal fiber cement mortar laminates by determining the effects of accelerated aging on the micro structure and flexural behavior of the composites [3]. The cellulose fiber-matrix interfacial bond, reflected in the changed mode of cellulose fiber failure at the composite fracture surface, varies with environment. The bond of the cellulose fiber to the cementations matrix is frictional and chemical in nature, quantified by frictional bond and chemical debonding energy. Loss of cellulose and cement toughness with aging are attributed to the increase of interfacial bonding of the cellulose fiber to the cement matrix, which causes an increased fiber rupture. Polymeric fibers have the unique characteristics of poor interfacial bond strength with the cementations matrix and weak lateral strength resulting in surface abrasion during fiber pullout from the matrix. The poor bonding characteristic is a severe limitation to the effective use of polymeric fibers in high performance cementations composites [9]. The cellulose fibers are sensitive to alkali solution [8]. Fiber rupture has been associated with fiber strength, optimum length, bond strength due to friction between concrete mix and fiber and orientation of the fiber and the crack surface [10].

Based on the issues mentioned above, the study aims to observe how the hydration process happening while sida cordifolia fiber added to concrete complex, due to which content degradation of fibers are happening. As taken, fibers are in sufficient amount & length to avoid the sudden failure nature of concrete.

3. Analysis & Results

3.1. XRD Analysis and results:

The XRD analysis is studied at room temperature using powder X – Ray diffraction with filtered 0.154 nm Cu, Kα radiation. Samples are scanned in a continuous mode from 10^0-80^0 with a scanning rate of 2^0 per minute.

The X-Ray powder diffraction gives the plot between the intensity of the X – Ray light which is scattered on the sample and angle difference of the deflected X – Rays. The X – Ray powder diffraction was done on four samples such as R_3, R_{28}, S_3, S_{28}. where, R_3 & R_{28} are indicated for plain concrete for 3 days & 28 days of curing respectively, and S_3 & S_{28} are indicated for biofiber reinforced concrete for 3 days & 28 days of curing respectively. The graphs were generated using the Origin pro8 software. Compounds present in the concrete is identified by using X – pert high score plus.

Fig. 3.1 (A) illustrated the XRD diffraction plots for investigating samples. XRD analysis indicates the predominance peaks of Fluorite (CaF_2) and Quartz or Silica (SiO_2) are observed. In the plot, no hydration compounds like C_3S, C_2S were observed because the hydration process of cement was not completed within 3 days.

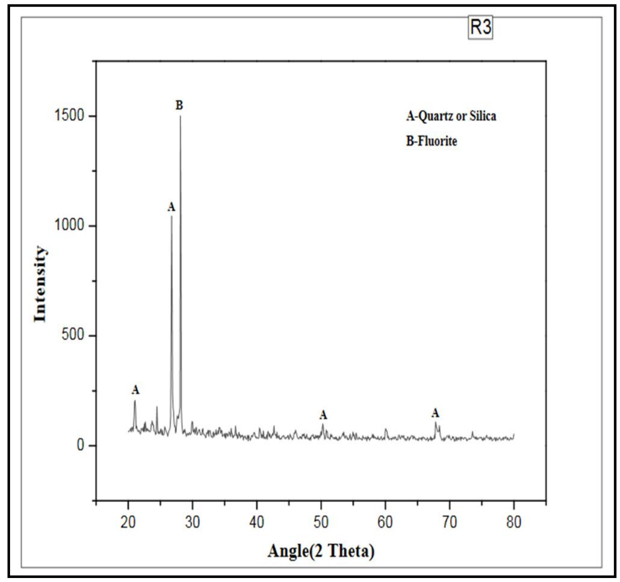

Fig. 3.1 (A) X – Ray diffraction of Plain concrete for 3 days

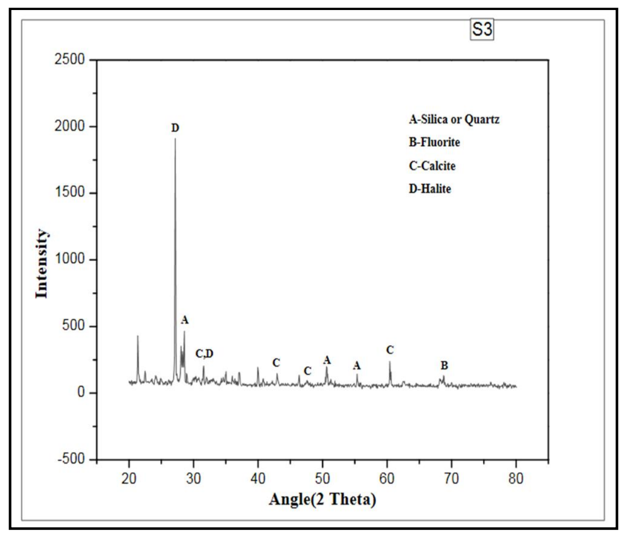

Fig. 3.1 (B) X – Ray diffraction of BFRC for 3 days

In Fig. 3.1 (B), XRD analysis indicates the predominance of Halite. While for calcite ($CaCO_3$), quartz or silica (SiO_2) and Fluorite (CaF_2) equal peaks are observed. Presence of calcite clearly indicates the hydration process of concrete is started and forms C – S – H gel. In the plot, large amount of halite indicates that concrete complex has reacted with biofiber chemically and reason for bio degradation of biofiber is due to alkali in nature.

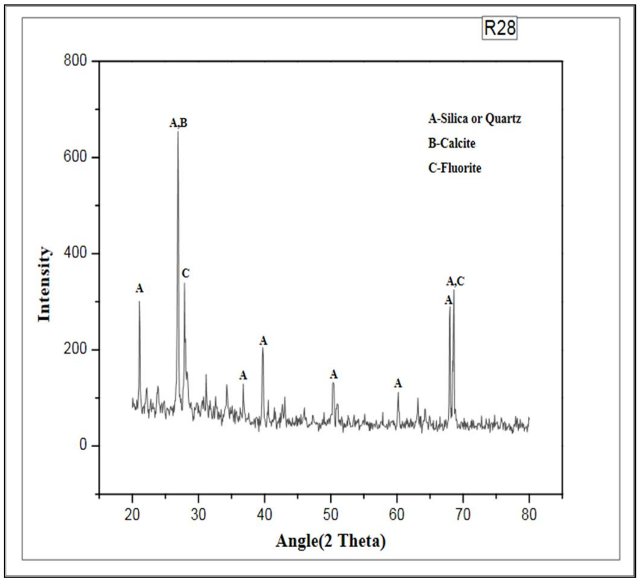

Fig. 3.1 (C) X-ray diffraction of Pain concrete for 28 days

XRD analysis indicates the predominance of calcite ($CaCO_3$), quartz or silica (SiO_2) and Fluorite (CaF_2) peaks are observed in Fig.3.1 (C). In the plot large amount of calcite indicates the hydration process of concrete was completed and the complex compound C – S – H gel was formed.

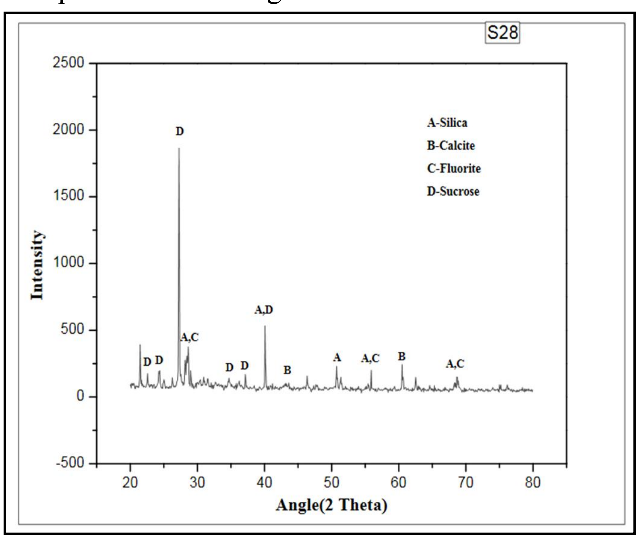

Fig. 3.1 (D) X-ray diffraction of BFRC for 28 days

In the Plot 3.1 (B) & 3.1 (D), it clearly indicates that hydration process is running at an equal rate between 3 day to 28 days and In the plot 3.1 (D), it was observed that chemically bio fiber releases sucrose that bacteria can use to form sticky polysaccharide, which build up a thick layer on a round. Streptococcus mutans bacteria available in an open area or water, metabolize any sucrose into lactic acid. The resulting lactic acid lowers the pH and the presence of Halite have the main role in degradation of biofiber and its indirectly affects the durability of concrete.

In plot 3.1 (A) & 3.1 (C), it clearly indicates that normal hydration process was happened and formed complex compound of C – S – H gel. Compared to it with plot 3.1 (B) & 3.1 (D) peaks of silica and calcite observed less due to building of thick layers around the concrete matrix.

3.2. Scanning Electron Microscopy Analysis and results:

Microstructure feature were studied using scanning electron microscope.

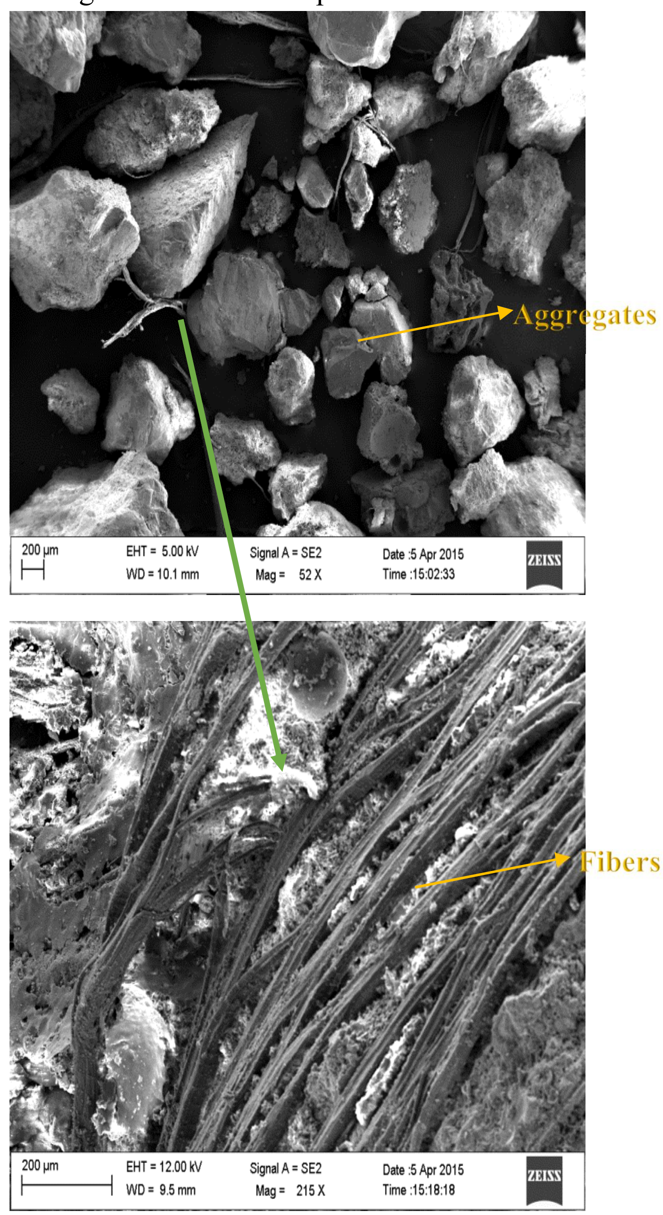

Fig. 3.2 (A) Arrangement of fiber in a cement matrix

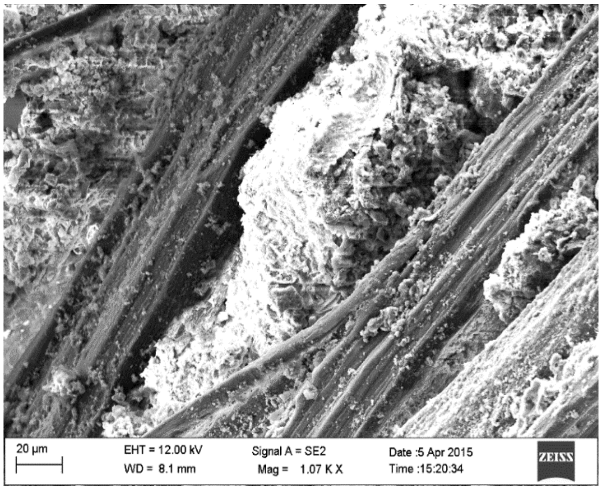

Fig. 3.2 (B) Fibers in a cement matrix

The SEM microstructure of a sample is shown in Fig. 3.2 (A) & 3.2 (B). Changes in the morphology of bio – degradable matrix surface were studied. It was observed in XRD result that the surfaces of matrix are undergoing biodegradation. Fig. 3.2 (B) shows the roughness of the composite. Here surface becomes very heterogeneous and rough. It was observed that the surfaces of the matrix are undergoing biodegradation which shows high roughness. Fig. 3.2 (B) shows the best reinforcement of fiber in the concrete mix. Here some concrete matrix has been found to be attached to the fiber and shows good adhesion of fiber with the matrix. Fig. 3.2 (B) shows the optimum length is available for proper bonding between the concrete matrix and fiber.

Fig. 3.2 (C) Cube specimen BFRC showing bridging of cracks by fiber

It may be the reason for good tensile strength as well as ductility compares with normal concrete mix. Due to this bonding property biofiber concrete shows ductile nature before going to fail can be observed in Fig. 3.2 (C).

4. Conclusion:

XRD results of the present investigation reveals that Halite and sucrose of fibers react with concrete complex and it is useful for proper bonding, but due to Streptococcus mutans bacteria may be developed in and around the fibers and react with sucrose and initiate the decomposition of fibers.

Adding the Sida Cardifolia biofiber to concrete mixtures shows the early hydration process, may result in increased compressive strength, which indicates the good response of fibers in concrete complex.

Moreover SEM results show proper generation of adhesion due to chemical activity happened inside the biofiber concrete complex. SEM result shows the optimum length is available for proper bonding between the concrete matrix and fiber, reason for good tensile strength as well as ductility compared to normal concrete mix. Results show that biofiber concrete has the ductile and bonding nature before going to fail and it completely depends on the presence of sucrose, optimum length and optimum quantity of sida cordifolia fiber.

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