Review Paper on Use of Sisal Fiber and Polypropylene Fiber in Reinforced Concrete

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Abstract — With the introduction of fibers into concrete, a beneficial method that has evolved to increase the mechanical and durability features of concrete products has emerged. Between the many different types of fibers, Sisal fiber and Polypropylene (PP) fiber have garnered a substantial amount of interest owing to the distinctive qualities that they possess. Sisal fiber, which is a natural fiber that is produced from the Agave Sisalana plant, is biodegradable, lightweight, and cost-effective. Polypropylene fibers, on the other hand, are synthetic fibers that provide greater resistance to chemical assault and water absorption. In this study, a detailed assessment of the mechanical and durability characteristics of Sisal fiber reinforced concrete and PP fiber reinforced concrete (SFRC and PPFRC) is presented. Our primary emphasis is on the influence that the kind of fiber, its content, its length, and its orientation have on the performance of concrete. We investigate both laboratory research and actual applications. There is also a discussion of the durability elements, which include resistance to corrosion, freeze-thaw cycles, and abrasion. According to the results, both sisal and polypropylene fibers have the potential to considerably increase the mechanical qualities of concrete, including its toughness, compressive strength, and flexural strength, as well as its durability, characteristics that include resistance to water permeability, chemical assault, and other similar factors. Nevertheless, there are still areas that need more investigation, such as the issues of fiber dispersion and the optimal fiber dose.

Keywords: Workability, Fibers, Concrete, Hybrid Fiber Reinforced, Ductility

I. INTRODUCTION

One of the most extensively used building materials, concrete, has intrinsic limitations such as poor tensile strength and brittleness. Concrete is also one of the most widely used building materials. The incorporation of fibers into concrete is a tried-and-true approach that has emerged as a solution to address these deficiencies. In addition to boosting the mechanical strength, toughness, and durability of concrete, fibers may also improve the performance of concrete in a variety of other ways. Concrete often makes use of either natural or synthetic fibers, with Sisal fiber, which is a natural fiber, and Polypropylene (PP) fiber, which is a synthetic fiber, being two famous examples of the former.

It is regarded to be one of the most promising natural fibers in the construction industry owing to its high tensile strength and sustainability. Sisal fiber is derived from the Agave Sisalana plant. In addition to being biodegradable and renewable, it has a minimal influence on the environment, which is one of the reasons why it is so appealing.

Polypropylene Fiber, on the other hand, is a synthetic material that is well-known for its hydrophobic qualities, excellent chemical resistance, and significant capacity to enhance the structural integrity of concrete by minimizing shrinkage and cracking. Applications that need resistance to chemicals and moisture are among the most common uses for this material.

II. LITERATURE SURVEY & BACKGROUND

1) N Pannirselvam et al (2009) conducted the experimental strength behaviour of fibre reinforced polymer strengthened beam. They found that strengthening of structures using fibre reinforced polymer. The objective of their work is to determine the strength of structural behaviour of reinforced concrete beams. They observed that in the beam the deflection duclity values for beams showed increases over the corresponding the reference beams
2) Kolli.Ramujee (2013) The interest in the use of fibers for the reinforcement of composites has increased during the last several years. A combination of high strength, stiffness and thermal resistance favorably characterizes the fibers. In this study, the results of the Strength properties of Polypropylene fiber reinforced concrete have been presented. The compressive strength, splitting tensile strength of concrete samples made with different fibers amounts varies from 0%, 0.5%,1% 1.5% and 2.0% were studied. The samples with added Polypropylene fibers of 1.5 % showed better results in comparison with the others
3) Amit Rai, Dr. Y.P.Joshi (2014) conducted the experimental studies and application of fibers reinforced concrete. They study different types of fibers and their application. The improvement in concrete properties by polypropylene fibers, they analysed that compressive strength which is increased about 16%. The flexural strength of polypropylene fibers is improved about 30%
4) Milind V. Mohod (2015) This paper presents an experimental study on performance of polypropylene fiber reinforced concrete. In this study deals with the effects of addition of various proportions of polypropylene fibers on the properties of High strength concrete (M30and M40 mixes). An experimental program was carried out to explore its effects on compressive, tensile, flexural strength under different curing condition. The main aim of the investigation program is to study the effect of Polypropylene fiber mix by varying content such as 0% ,0.5%,1%,1.5% & 2% and finding the optimum Polypropylene fiber content. A notable increase in the compressive, tensile and flexural strength was observed. However, further investigations were highly recommended and should be carried out to understand more mechanical properties of fiber reinforced concrete.

5) Shirsath et al. (2017) investigated the performance of concrete which is thermally deteriorated with the presence of fibers and in the absence of fibers. They have attempted to enhance the mechanical properties performance at various temperatures with the use of steel and polypropylene fiber combinations. The concrete cubes of size 100 mm of various compositions of fibers were casted. They were cured in the water for 28 days and then exposed to the varying temperatures of either 200 C or 400 C or 600 C or 800 C with the retention period of 2 hours.
6) Hawileh et al. (2016) presented the results of an experimental program that studied the mechanical properties of Carbon (C), basalt (B) and their hybrid combinations of BC, CBC, CCB, BBC and BCB of multiple layers at elevated temperatures. Nearly 140 specimens were casted and tested after it has been exposed to the temperatures ranging from 25°C to 250°C. It was observed from the results that with the increase in the exposure to temperature, the elastic modulus and tensile strength of the C and B laminates degraded.
7) Chacko & Hema (2016) described the use of coconut fibres and banana fibres on the concrete matrix and its uses in enhancing the strength and applications of concrete. The fibres used in the production of concrete are natural and hence have excellent physical and mechanical properties which can be utilized effectively. The advantage of using the natural fibres in the concrete is that they are cost effective and have no artificially added chemicals. From the results,
8) Murugan & Kumaran (2016) focused mainly on the behaviour of flexural characteristics of the reinforced concrete beams. Glass fibres are used as reinforcements. The preliminary lab tests are conducted to assess the basic properties of the normal strength concrete. Also, the result of the flexural tests of the glass fiber reinforced beam under the static loading was compared with that of the conventional steel reinforcement beams. Six beams were casted in which three beams were made of conventional steel reinforcement and the three beams were made of glass fibres as reinforcement material.
9) Li et al. (2017) conducted a number of test programs to find the optimum mix proportion of fibers in the Hybrid Fiber Reinforced Concrete. The tests conducted were direct shear, four points flexure, uniaxial tensile test, uniaxial compression test and split tensile strength tests. Additionally, shear strength and toughness tests were conducted to identify the optimum unit weight of the hybrid fibers in the concrete. The flexure test, direct shear toughness and residual loads were also conducted to analyse the influence of fibers and its varying proportions on the effect of mechanical properties of HFRC.
10) Vijay Antony Raj et al. (2017) demonstrated that it can also be used as sand replacement material because of certain advantages like lower density, degree of permeability and manufacturing cost, better durability, strength to weight ratio and Strength to Energy Ratio, than those of conventional river sand-based cement concrete. An experimental study on the mechanical properties of concrete made of High-Volume Fly Ash Based Autoclaved Aerated (HVFAAC), reinforced with synthetic fibers was carried out in this research work. High volume fly ash was used instead of river sand with minimized cement content, in order to overcome environmental impact and cost related factors
11) Ronald Aseer et al. (2017) investigated the HFRC made of municipal solid waste and banana fiber composite as a function of total volume fraction of filler. The chemical modification and the MSW and banana fiber volume fraction were also investigated. The relative volume fraction of MSW and banana fiber was maintained as 50:50 in order to establish the total volume fraction (Vf) of the filler. As the filler ratio increased, the thermal conductivity of the composites decreases.
12) Xin et al. (2019) investigated various specimens such as plain concrete (PC), Polypropylene fiber reinforced concrete (PFRC) and steel reinforced concrete on scaled tunnel models in order to identify its seismic behavior. The research aimed to analyze the seismic performance of the Polypropylene fiber reinforced concrete as secondary lining in the tunnel structure. The analysis of plain concrete in the shaking table showed that the specimen is brittle in nature and possessed low tensile strength.
13) Eidan et al. (2019) presented the results of the mechanical properties obtained from the studies conducted experimentally which are exposed to elevated temperatures. Totally, six series of polypropylene fiber specimens were casted and one set of plain concrete specimens were casted and cured for 28 days. The specimens were tested for its mechanical properties such as compressive strength, tensile strength, modulus of elasticity and cracking models.
14) Zheng et al. (2020) investigated the effect of fibre dosages and the mechanical properties of the fibre reinforced concrete. The failure modes are also studied. The types of fibres used in the concrete specimens are polypropylene, glass and polyacrylonitrile. The different dosages of these fibres are 0% by weight, 0.4% by weight, 0.8% by weight and 1.2% by weight. The casted specimens were subjected to uniaxial testing. The temporal and spatial evolution of the internal micro cracks were analysed using the industrial computed tomography scanning. From the results it was found that the compressive strength of the concrete increased gradually and declined as the dosage of the fibre increases. It was also found that the peak stress of the concrete reinforced with the glass fibers was observed to be higher when compared to the other two fibre reinforced concretes.
15) Babaaie et al. (2020) investigated the influence of a number of fibre parameters such as the type of the fibre, content, hybridization on the strength of the polymer fibre reinforced concrete and steel fibre reinforced concrete. The fibre reinforced concrete was widely used in tunnelling practices as the primary shotcrete lining. The cubes and cylindrical specimens were casted and tested for its strength and durability. From the results obtained, it was found that the Steel fibre reinforced concrete performed better with respect to the strength

characteristics of the concrete than the polymer fibre reinforced concrete. However, according to European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC), at the fibre fraction of 4%, both the fibre reinforced concrete composites were found to have the same strength in terms of flexural characteristics. The results indicated that both the reinforced concrete composites have excellent bonding properties and the polymer fibres were more slender. In terms of tensile strength, SFRC was found to have higher value than the PFRC. The analysis has shown that the augmentation of fibre content affected the mechanical characteristics of FRC in almost all the cases

16) Afroughsabet & Teng (2020) evaluated the time dependent creep and shrinkage properties of HFRC through various experimental programs and compared it with the results of the common prediction models. For the production of HFRC, the fibers of different types such as single hooked and 17 double hooked end steel fibers and PVA fibers of different proportions were used. They adopted the total of 0%, 0.6% and 1.2% respectively.
17) Liu et al. (2020) experimentally studied the behaviour of HFRC containing steel fibers and PVA fibers as reinforcement material with the fly ash and slag powder concrete mix by performing series of direct tensile stress tests. They also captured the propagation and formation of cracks by the use of Digital Image Correlation (DIC) measurement. The hybrid ratios adopted were of 1:3 (Steel: Polyvinyl Alcohol) and 3:1 (Steel: Polyvinyl Alcohol) respectively and the fiber volume contents of 1% - 3% were investigated. The results obtained clearly indicated that there was an increase in the strength characteristics of the concrete with the increase in the steel fiber content and decrease of tensile strength with the increase in the PVA fibers content
18) Kha et al. (2020) examined the mechanical characteristics of the fiber reinforced concrete made of steel. It was found that by the addition of fibers in the concrete matrix, the mobility of the concrete in fresh state was influenced and acted as a barrier to the movement of coarse aggregate.
19) Fares et al. (2020) elucidated Fine Limestone Dust (FLSD) to produce the Hybrid Fiber Reinforced concrete with the combination of fibers such as steel and Poly Vinyl Alcohol (PVA) fibers. It was found from the results that the replacement level of 45% FLSD along with steel fibers of mix proportion 1% of the total volume has experienced a high dispersion of 0.35% PVA fibers.
20) Sujay et al. (2020) experimentally investigated the durability properties of composite hybrid fibre reinforced high performance concrete. The cement was replaced partially with the ultra-fine fly ash of about 15%. The nano silica was also used as the replacement of cement in less percentages such as 0%,1.5%, 3.0% and 4.5% by weight of cement respectively.
21) Alwesabi et al. (2020) evaluated the performance of HFRC made of Polypropylene and steel fibers. The improvements in the mechanical and impact resistance of the concrete was studied. This paper conducted the impact test using low-velocity drop hammer with an impact velocity of 2.8 m/s on FRC and Fiber Reinforced Rubberized Concrete specimens (FRCC). The prism specimens of size 100 x 100 x 500 mm were casted and cured for 28 days.
22) De Klerk et al. (2020) studied the degradation of sisal fibre reinforced concrete in an alkaline environment. The high alkaline environment reduced the strength of the concrete composite considerably. In order to tackle this situation, the sisal fibre reinforced concrete was treated with the alkaline and acetylation respectively along with the sodium hydroxide and acetic acid or acetic anhydride to improve the resistance of fibre alkaline attack.
23) Kuan Meng et al. (2021) investigated the mechanical properties of HFRC subjected to conventional triaxial cyclic compression. Nearly 48 HFRC cylindrical specimens with different fiber volume fraction, fiber aspect ratio and confining pressure were tested. It was observed from the results that the incorporation of two or more fibers together with the applying confinement improved the strength characteristics of the concrete with the transition of the failure pattern from a tensile failure to shear failure mode. A slight decrease in the compressive strength of the concrete was found due to the addition of PP fibers. However, there was an improvement in the plastic behavior of HFRC.
24) Aswin et al. (2021) experimented with the fibers so as to improve the mechanical properties and flexural behaviour of the conventional concrete. The behaviour of corbels with Hybrid Fiber Reinforced concrete was investigated experimentally. The fibers used in this experiment were steel fibers and polyvinyl alcohol (PVA) fibers respectively.
25) Sivakumar et al. (2021) experimented with the dispersed fibers as it acts as crack resistor and also helped in improving the properties of the concrete. The usage of fiber strands helped in strengthening the materials which were more vulnerable to strain than pressure. Steel fibers and Polypropylene fibers were used as cross over strands in various proportions such as 80:20, 70:30 and 60:40 individually. The mechanical properties of the cementitious mix were examined and the impact of the usage of steel fibers and polypropylene strands were observed for M60 in volume portion of 1.5%.
26) Yuan & Jia (2021) experimentally investigated the mechanical properties and micro structural properties of the Glass Fiber reinforced concrete (GF) and polypropylene fiber (PPF) reinforced concrete with the fiber content and water/binder ratio as its function. The different fiber content adopted in this study was 0.45%, 0.90% and 1.35% by volume fractions. The different water binder ratio adopted in this research was 0.30 and 0.35. The specimens were then casted and cured for 28 days.
27) Scorza et al. (2022) investigated the fracture properties Hybrid Fiber Roller Compacted Concrete to be used in the pavements. The fracture toughness was determined for the single fiber reinforced concrete and hybrid fiber reinforced concrete to be used effectively in the pavements. Plain concrete specimens were casted and tested to compare the performance with the fiber induced concrete specimens.

28) Hossain et al. (2023) investigated the hybrid fibers incorporation in the ordinary concrete in order to improve the mechanical and thermal properties of the HFRC to prevent the spalling damage of aircraft. The fibers induced in the concrete were micro steel fiber and polyvinyl alcohol fiber. Three fiber reinforced concrete samples were made with the fiber content being 0%, 0.3%, 0.5% and 0.7% by volume fraction. These samples were then exposed to high temperatures and aviation oils.
29) Chintan Patel et al studied the performance Evaluation of Polymer Fiber ìRECRON-3Sî in Pavement Quality Concreteî Road transportation is undoubtedly the lifeline of the nation and its development is a crucial concern. The traditional bituminous pavements and their needs for continuous maintenance and rehabilitation operations points towards the scope for cement concrete pavements. There are several advantages of cement concrete pavements over bituminous pavements. But, there are also some problems outcomes with concrete pavement like micro-shrinkage, cracking, and low water permeability. To overcome this kind of problems, the secondary construction material ìRecron-3Sî is preferable to add in concrete for making stronger and batter road pavement. Present paper focuses how the compressive and flexural strength of the Pavement Quality Concrete (PQC) increases using Recron-3S fiber with compression test of the concrete. The testing results of the prepared sample cube with Recron-3S has compared with other samples which is without the mixture of the Recron-3S

III. Conclusion

There is a significant improvement in the mechanical and durability properties of concrete that can be achieved by the addition of sisal and polypropylene fibers. Sisal fibers are an environmentally friendly choice that improves crack resistance and tensile strength. Polypropylene fibers, on the other hand, offer exceptional resistance to moisture, chemical assault, and freeze-thaw cycles. On the other hand, there is a need for additional research into the difficulties associated with fiber dispersion, binding strength, and the long-term influence on the environment. Both sisal and polypropylene fibers show a great deal of potential for the construction of concrete buildings that are more long-lasting and environmentally friendly. This may be accomplished by optimizing the use of the fibers and researching innovative approaches to improve their performance.

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