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Enhancing Concrete Building Sustainability through Innovative Reinforcement: A Review of Fiber Reinforced Concrete Studies

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ABSTRACT

A lot of study has been done on the use of fibers in concrete composites to improve the characteristics of concrete in different ways. The results of many research studies examining the impact of various fiber kinds on concrete are summarized in this article. This review covers a broad range of fibers and their properties, providing insight into how they affect concrete composites. This thorough investigation leads to the conclusion that adding fibers to concrete has a number of advantages. Compared to regular concrete, fiber-reinforced concrete notably shows improved strength, durability, waste utilization, and cost-effectiveness. According to the study, adding fibers of any kind increases the strength of the concrete in the compressive, split-tensile, and flexural domains. It also mentions that adding fiber causes the slump value to decline, which calls for adding extra superplasticizer to keep the mixture pumpable. Notwithstanding this limitation, the overall advantages show that fibers were successfully incorporated into concrete, opening the door for their extensive use in building applications.

Keywords: *Infrastructure /Construction, Concrete building, Strength, Reinforced Fiber Concrete, Durability.*

1.0 Introduction

Concrete, which is now the most widely used building material in the field of civil engineering construction, has room for development in terms of both the strength and the durability of its properties. Concrete is the name given to a material that does not exhibit ductile behaviour and is a collection of materials that each have their own unique qualities. Rebar is added to concrete to increase its tensile properties since it is known that the material is stronger during its compression phase than during its tension phase (weak phase). This is because the mode of failure determines which phase the concrete is in when it fails. These integrated reinforcements have a lower propensity to stop fractures that form as a result of an increase in stress. Therefore, strengthening concrete and making it capable of resisting cracking to a greater extent or at a level of higher pressures is required in order to improve concrete's performance and make it more attractive and acceptable. As a result, the employment of fibre in the modern building of concrete is regarded as the method that is both the best and the most acceptable. Fiber Reinforced Concrete is a term used to describe concrete that contains fibres that are both randomly and evenly aligned (FRP).

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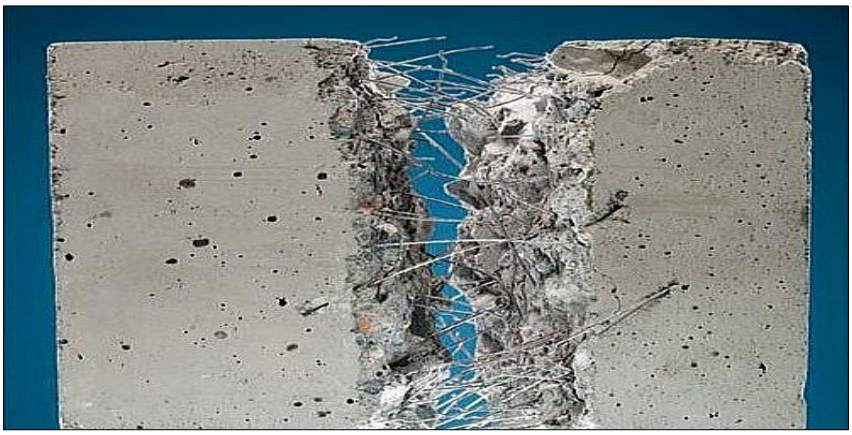
The preceding research on fibres serves as a foundation for this study, which is why it is a requirement. Fibers have been used as a form of reinforcement in concrete for a number of decades now due to the fact that in harsh environments, they have a higher level of durability than other materials. Natural fibres, metallic fibres, and mineral fibres are the three categories into which fibres that are utilised to improve the properties of concrete may be placed. In a more general sense, we may categorise them as steel fibres, glass fibres, coir fibres, jute fibres, wool fibres, wood fibres, polypropylene fibres, asbestos fibres, and many more types of fibres.

Figure 1: Fiber Reinforced Concrete



2.0 Material Reviewed

2.1 Metallic fiber

Materials such as metal and plastic are used in the production of fibres like steel fibre, which may be further subdivided into carbon steel fibre and stainless steel fibre.

Figure 2: Carbon Steel Fiber

Metal with a coating. Using steel fibre in traditional concrete is an easy way to get rid of problems. These problems may be prevented in the first place by using steel. When compared to the usage of steel rebar in concrete, the use of steel fibre is seen as being superior in terms of durability, cost effectiveness, and efficiency of time spent in harsh environmental circumstances. In prior studies, it was shown that the load-carrying capability of ground slabs increased dramatically when between 0 and 30 kg/m3 of steel wire was inserted into the slabs. The slabs' strengths were between 30 and 40 MPa.

Figure 3: Chopped Carbon Fiber

Figure 4: Carbon-Structural Fiber

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Figure 5: Chopped Glass Fiber

2.2 Mineral fiber

Mineral-Fiber is the name given to fibres that may be readily removed using an electro-thermal process. It was discovered that the addition of glass fibre to concrete causes a significant reduction in ductility when the material is subjected to the natural conditions and elements of the environment (Shah, Ludirdja, Daniel, & Mobasher, 1988).

2.3 Natural fiber

The phrase "natural fibre" refers to a kind of fibre that has a high tensile strength but a low modulus of elasticity (TORGAL & JALALI, 2011). Natural fibers have several advantages beyond their use as reinforcement for concrete. These include their renewable nature, low cost, lack of abrasiveness, and lack of negative health and safety consequences throughout the production and handling phases (Reis, 2006). (Ramakrishna & Sundararajan, 2005) state that the concrete was able to overcome the inert inadequacies created by the cementing element because of the potential of natural fiber as reinforcement. The following are the several categories of natural fibres:

Figure 6: Coir Fiber

Figure 7: Wood Fiber

Figure 8: Sisal Fiber

Figure 9: Jute Fiber

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Table 1: Literature Review

Reference	Fiber Category	Reviewed Conclusion
(Al-Oraimi & Seibi, 1995)	Natural Fiber	The investigation was carried out on concrete containing varying amounts of glass fibre and natural fiber. The author arrived at the conclusion that the incorporation of fibre led to an improvement in both the impact resistance and the toughness of the concrete. The author explained in the introduction that thinking about high-strength concrete came first in the investigation before anything else was done. There is a possibility that the presence of fibre in normal concrete will not improve the pre-cracking behaviour of the concrete but will significantly improve the post-cracking behavior.
(Aziz, Paramasivam, & Lee, 1981)	Natural Fiber	Although adding fibre to concrete makes the concrete stronger, there are specific aspects that alter the qualities of the fibre and, in turn, how the fibre affects the concrete. The author comes to the conclusion in his work that some of the parameters. The inclusion of fibre into concrete results in a reduction in the fresh concrete's workability. This reduction is related to the surface area of the fibre as well as the characteristics of the fibre. It has been observed that natural fibre is used in pre-cast goods in order to lessen the effect of unintentional damages. This is done in order to meet the requirements of the American National Standards Institute.
(Sethunarayan An, Chockalingam, & Ramanathan, 1989)	Natural Fiber	The usage of NFRC, which is suggested by many researchers due to the ease with which natural fibres may be obtained and the fact that many of these natural fibres can be found locally in underdeveloped nations, is recommended. There have only been a few studies that have documented the long-term effects of fibre in concrete beams, and from those studies, the researchers came to the conclusion that an increase in the amount of cycle loads led to an increase in the lifetime of such beams. In their most basic form, natural fibres may be divided into two categories: those of vegetable and animal origin.
(Song & Hwang, 2004)	Steel Fiber	The author conducted research on the performance of high-strength concrete that included the addition of fibre. According to the following percentage breakdown, hooked-end steel fiber made up 1.51 percent of the composite. On the other hand, a little reduction in strength was seen at the 2.01 percent fraction; nonetheless, this remained more than that of non-fibrous concrete. Ultimately, the study concludes that strength was enhanced by the fiber addition.
(Nataraja, Dhang, & Gupta, 1999)	Steel Fiber	Because of an increase in the production of steel fibre across a variety of sectors, there has been an uptick in the usage of steel fibre in concrete over the course of the last quarter century. At this time, steel fibres are most often used in concrete constructions including highways, airport pavements, hydraulic systems, and tunnel linings, amongst many other applications. According to the findings of a number of studies conducted in the past, the addition of steel fibre to concrete improves a variety of its properties. Researchers also found that the addition of steel fibre increased sapling. The following observation was made about the experimental investigation: The properties of concrete, such as its toughness and

		compressive strength, were significantly improved, and the improvement in both was directly related to the reinforcing index.
(Banthia & Sappakittipakorn, 2007)	Steel Fiber	During the course of this study, experimental and analytical work was carried out using steel fibres of several sizes, such as 0.8 mm, 0.45 mm, and 0.4 mm. The design called for M-335 Grade concrete to be used.
(Ali, Liu, Sou, & Chouw, 2012)	Coir Fiber	To keep the cost of concrete low, coir fiber—which has the best endurance of all natural fibers—should be used especially as reinforcement, according to the author's abstract. The best place for this application is somewhere where there are frequent tropical earthquakes. The amount of fibre that was mixed in with the concrete ranged from one percent to two percent, three percent to five percent of the total mass of the cement. According to him, the coir fibre that is available on the market may be purchased in one of three different forms. Taking into mind the findings of a physical evaluation of the study, it was hypothesised that the flexural toughness of CFRC (Coir Fiber Reinforced Concrete) rises significantly for all estimated proportions.
(Asasutjarit, Hirunlabh, Khedari, Charoenvai, Zeghmati, & Shin, 2007)	Coir Fiber	According to the findings of the study, the name "coir" refers to the fibre that is extracted from the thick mesocarp of coconuts. The boiling and rinsing of the fibre produces a cementing agent called lignin, and this lignin is what binds the cellulose fibres together. Lignin is found in fibres and serves as a cementing agent. Coir fibre is made more durable and rigid by the processes of boiling and washing. The purpose of this study is to investigate the possibility of producing lightweight cement board that contains coir made from coconut husks. In the course of this study, the fibre is subjected to a 24-hour boil followed by a washing in water with a pH of 7. After conducting the experiments and analysing the results, it was determined that the mechanical and physical properties of coir fibre could be improved by subjecting it to pretreatments such as washing and boiling.
(Silva, Mobasher, & Filho, 2009)	Sisal Fiber	Sisal is a fibre that is harvested from the sisal plant, and the sisal fibre that was harvested for this study came from a sisal plant that was located in the city of Valente in Brazil. The leaf of the sisal plant is made up of three distinct fibres that are called structural fibre, xylem fibre, and arch fibre, as seen in the image below. When sisal fibre was added to regular concrete, the resulting composite became visible. high modulus; it exhibits a variety of fracture characteristics under bending and tension pressures. The investigation also found that sisal fiber enhanced the mechanical properties and energy-absorbing capability of concrete. Additionally, it demonstrated how actively sisal fiber bridged and halted fissures in the material throughout the stress phase.
(Silva, Filho, Filho, & Fairbairn, 2010)	Sisal Fiber	Sisal fibre was collected from the sisal plant using a semi-automatic decorticator in this study. Sisal leaves weighed 100 kilogrammes and yielded 3.5 kilogrammes of sisal fibre. according to the author of the study on both materials. For the PC composite and CH-free composite, the Modulus of Rupture was measured at 21Mpa and 23Mpa, respectively.

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(Kundu, Chakraborty, Roy, Adhikari, & Majumder, 2012)	Jute Fiber	The study centred on developing jute-reinforced concrete by chemically changing existing concrete, with the goal of using the material in NP3 concrete pipe construction. In order to chemically alter jute fibre, the author made use of two different chemicals. Following the application of these chemicals to the jute fibre, the fibre was baked at 105 degrees Celsius in a laboratory oven for twenty-four hours. In the article's conclusion, the author explained the point of the chemical modification, and he made the observation that making the fibre surface hydrophobic is necessary in order to ensure that the fibres are evenly dispersed throughout the concrete mixture. Jute, which is a fibre, needs more water than other materials.
(Dharan & Lal, 2016)	Polypropylene Fiber	The study investigated the possibility of including various diameters of polypropylene fibre into the concrete mixture. It is a form of synthetic fibre known as polypropylene fibre, and it is a waste product that is produced by the textile industry. Studies conducted on concrete of grades M30 and M40 showed that, although CS and STS both achieved higher values at a fiber incorporation rate of 1.5 percent, the slump value tended to decrease with increasing fiber content. The research was carried out on both grades.

3.0 Conclusion

Without a doubt, the infrastructure and construction sector has become a vital driving force behind our nation's explosive growth. With the benefit of strength recovery and retrofitting, Concrete Building is the most efficient and long-lasting building option available. Concrete and its component parts have been the subject of much research aimed at improving the material's performance and value. A paste that gradually solidifies into firm concrete is created by mixing several components with different qualities to create concrete, a material used in construction. In addition to reducing environmental pollution, the use of valuable waste materials in the creation of eco-friendly concrete has improved the final product's strength and longevity. Pozzolana and fiber waste have been the subject of several research over the years, demonstrating the possibility of developing durable and sustainable building solutions. The importance of fiber-reinforced concrete (FRC) has been clarified by this publication's thorough analysis of earlier studies on the material.

Fiber Reinforced Concrete (FRC) offers a viable path for innovation in construction as it combines varied characteristics and orientations of fibers with concrete reinforcement. The research supports the use of fibers including organic, metallic, and natural fibers in concrete mixtures by emphasizing how they improve structural performance and integrity. In conclusion, the addition of fibers to concrete mixes and the production of environmentally friendly concrete from valuable waste materials are noteworthy developments in the building sector. In addition to addressing environmental issues, these initiatives help build robust and sustainable infrastructure, opening the door for more growth and prosperity in the development of our nation.

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