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Review Paper on Use Sisal Fiber used in the Concrete

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ABTRACT

Sisal fiber, derived from the Agave sisalana plant, is increasingly recognized as a valuable reinforcement material for concrete. This review paper provides an in-depth examination of the properties, benefits, challenges, and applications of sisal fiber in concrete, exploring its potential to enhance the mechanical performance and sustainability of concrete structures. The paper consolidates existing research on the impact of sisal fiber on concrete's physical, mechanical, and durability characteristics, aiming to contribute to the growing body of knowledge on sustainable construction materials.

Keyword- Natural fibres are, sisal fiber, green house, Ordinary Portland Cement ,(OPC). Geo Polymer Concrete (GPC).

1. Introduction

1.1 Sisal Fiber

The need for sustainable construction materials has driven the exploration of natural fibers as alternatives to conventional synthetic materials. Sisal fiber, a natural fiber obtained from the leaves of the Agave sisalana plant, is abundant, cost-effective, and biodegradable. When incorporated into concrete, it serves as an eco-friendly reinforcement material with potential benefits such as improving the mechanical properties, reducing the environmental footprint, and providing economic advantages.

Sisal fibers are traditionally used for making ropes, twines, and mats; however, their incorporation into concrete as an additive or reinforcement material has gained attention in recent years. Researchers have explored various aspects of sisal fiber in concrete, such as its effects on strength, workability, durability, and microstructure. This review aims to summarize the key findings, trends, and gaps in the research related to sisal fiber's use in concrete.

Composition and Properties of Sisal Fiber:

Sisal fibers are primarily composed of cellulose, hemicellulose, and lignin. The fiber's composition and structure play a critical role in determining its behavior when incorporated into concrete. Some key properties of sisal fiber include:

- **Tensile Strength:** Sisal fibers exhibit high tensile strength, typically in the range of 200–500 MPa, making them suitable for reinforcing concrete.
- **Length and Aspect Ratio:** The length and aspect ratio (fiber length to diameter ratio) of sisal fibers significantly influence the effectiveness of the reinforcement. Typically, longer fibers with higher aspect ratios lead to better mechanical performance.
- **Water Absorption:** Sisal fibers have a high water absorption capacity, which can affect the workability of concrete. Proper treatment or coating of fibers is often required to mitigate this issue.
- **Biodegradability:** Sisal fibers are biodegradable, contributing to the overall sustainability of the concrete. This property is crucial in reducing the environmental impact of construction materials.

2 Literature survey & background

2 .1 literature review on tensile strength of sisal fibre

The tensile characteristics of melt-mixing and solution-mixing composites were investigated by Joseph et al. (1999). The ideal parameters, mixing time, rotation speed, and temperature of the chamber unit are anticipated for the two composites, which are made from short sisal fiber reinforced concrete with polypropylene. The mechanical characteristics of the two mixing composites with varying rotational speeds, mixing times, and chamber temperatures are compared by the authors. It was contrasted with the two composites' ideal conditions.

The cross-sectional area and mechanical strength of natural fibers are described by Murali Mohan Rao et al. (2007). In order to create lightweight composites for load-bearing constructions, natural fibers are utilized as a filler. Tensile strength testing is done on lightweight composites. Experimental calculations are used to determine the cross-sectional shape of natural fibers, including sisal, vakka, coconut, banana, and palm fibers. The vakka fiber composite outperformed the other natural fibers in terms of tensile strength.

Flavio de Andrade Silva et al. (2008) investigated the behavior of composites under high-speed tension stress using sisal fibers as high-performance fibers. According to the author's research, natural fibers that are derived from plants in very small amounts are ideal for bonding with concrete.[75] Micro force testing was used to perform the tensile test. The author came to the conclusion that both strain rate sensitivity and tensile strength had significantly enhanced.

Boopalan et al. (2012) compare the mechanical characteristics of raw jute fiber and epoxy-reinforced sisal fiber using a combination of sisal fiber-reinforced epoxy composites and sodium hydroxide-treated jute.[77] The author examined the mechanical properties of the composites after treating epoxy-reinforcing sisal and jute fiber with 20% NaOH. The author noticed that jute and sisal fibers were treated by the NaOH. The tensile strength of epoxy-reinforced composites is superior to that of raw sisal and jute fiber composites.

The tensile and flexural strength characteristics of epoxy-coated sisal fiber reinforced composite were examined by Gupta and Srivastava (2014). 15%, 20%, 25%, and 30% by weight of sisal fibers were added to the epoxy matrix during the hand layup process to create this epoxy composite. Both unidirectional and mat-shaped fiber orientations are used. When compared to mat form, the unidirectional sisal fiber epoxy reinforced composite exhibits greater tensile and flexural strength characteristics.

M40 grade concrete's mechanical properties, including its modulus of rupture and compressive strength, were investigated by varying the dosage of fiber content from 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% by volume of cement with 35mm sisal fiber. In 2023, the quantity of fiber that HBRP Publication Page 8-12. All rights reserved. Page 9. The greatest improvement in compressive strength, as found in Journal of Advanced Cement & Concrete Technology Volume 6 Issue 1, is 0.3%. Athiappan and Vijaychandrakanth (2014).

It is being investigated how many natural fibers, such as jute, sisal, coir, etc., can be chemically altered to act as fiber reinforcing elements in composites. The benefits of natural fibers include their easy and safe use, biodegradability, and availability. (2016) S. Pavithra and L. Nagarajan.

The tensile and flexural strength characteristics of epoxy-coated sisal fiber reinforced composite were examined by Gupta and Srivastava (2014). 15%, 20%, 25%, and 30% by weight of sisal fibers were added to the epoxy matrix during the hand layup process to create this epoxy composite. Both unidirectional and mat-shaped fiber orientations are used. When compared to mat form, the unidirectional sisal fiber epoxy reinforced composite exhibits greater tensile and flexural strength characteristics.

The tensile strength and water absorption characteristics of sisal fiber reinforced composites with varying resin dosages were investigated by Li Yan et al. (2015). The author examined how resin penetration in the sisal fiber affected the composite's tensile strength and water absorption. Additionally, the author examined the failure process of composites and investigated the fracture mechanism utilizing various acoustic emission signals. The bonding qualities between sisal fiber and microfibrils are improved by the resin that is added to the fiber. In order to decrease the fracture modes, this composite enhanced its tensile strength.

Kalaiyarrasi, A. R. R., and Venkateshwaran, S. (2018)Through a partial cement substitution, this study aimed to investigate the effects of natural sisal fiber on concrete. In this case, sisal fiber is chemically treated for use in concrete. Among other mechanical properties, compressive strength, split tensile strength, The flexural strength of fiber-reinforced concrete with sisal fiber having an aspect ratio of 1:20 and 0.5%, 1%, and 1.5% of fiber replacing cement by volume fraction is compared to that of regular M25 concrete. The fiber substitutions of 0.5%, 1%, and 1.5% raised the compressive strength at 28 days by 13.8%, 21%, and 16.3%, respectively, compared to regular concrete. At 28 days, the split tensile strength increases by 24%, 56%, and 80%, while the first cracking load in flexure increases by 12.5%, 27.5%, and 20% for 0.5% and 1%.

K. Nirmalkumar2 and M.P. Iniya1 (2020) the reinforcing of a cement-supported matrix with sisal, a natural fiber with enhanced mechanical strength. The sisal fiber lengths in concrete with aspect ratio were 50 to 60 mm, and the percentage of sisal fiber utilized in the concrete varied from 0.1% to 2%. The inclusion of short fibers improves tensile strength, freeze-thaw resistance, impact resistance, and reduces brittleness in concrete. Fiber often does not increase the strength of concrete since it reduces the replacement moment in structural steel reinforcing. Environmental issues, restrictions on fiber content, and FRC—a new technology in civil engineering—are also covered in this study. Additionally covered in this review study are the tensile, flexural, and compressive strength tests, among others.

H.S. Suresh Chandra, R.M. Mahalinge Gowda, and Mr. Mithun K1 (2019). In this project, the impact of treating sisal fibers with Na2CO3 for five days on the strength metrics of regular concrete was investigated. For M30 grade concrete design, use IS10262-2009, 0.5%, 1%, 1.5%, and 2%. After they have finished curing, concrete cubes and cylinders are tested 7, 14, and 28 days later. According to experimental research, the optimal proportion of sisal fiber treated with Na2CO3 for M30 grade is 1%.

Y. Stalin Jose b, Biju C. Thomas a (2022) Since natural fiber is more accessible, it receives more focus in this study. The fiber used for reinforcement is called SISAL Fiber [SF], a substitute material in mount. The chemistry, physics, and structural properties of the fibers are investigated in detail. The sisal fiber reinforced composite has solid structural roots in both urban and rural buildings, according to the SF analysis. Since steel is poisonous to both people

and animals, this can be used as a substitute. The production of SF is compared to that of mineral asbestos and synthetic fibers. This sisal fiber is thought to be economical to manufacture and to provide social and economic benefits.
Thomas Biju and Stalin Y. Jose (2022) The survey being given to analyze the functioning of sisal fibers includes a number of articles. The sisal and concrete components included in the architectural marvel are also taken into consideration while evaluating the selected papers. There is also an example of sisal fiber that is not made of the same material as concrete. The compositional percentages and contributions to the tensile and compression strengths of the adopted papers are examined. Furthermore, a comprehensive examination of the development of the adopted products and their many applications is carried out.

2.2 REVIEW PAPER ON FLEXURE STRENGTH OF SISAL FIBRE

Swift and Smith (1979) used composite reinforced on cement-based natural fibers to create a model on flexure behavior. The flexural strength of composites increases significantly when the right amount of fibers, fiber length, and mix proportion are utilized. Tests on concrete beams reinforced with sisal fiber were conducted, and the results were consistent with the theoretical forecast. SiFRC beams have a flexural strength that is three times greater than that of CC beams.

Natural fiber-based plastic composite materials are frequently utilized for reinforcement, according to research by Fávaro et al. (2010). This study involves the preparation of composites, such as sisal fiber-reinforced high-density polyethylene (HDPE). Polyethelyne and sisal fibers were chemically altered to increase their compatibility. The hydrophilic and hydrophobic properties of HDPE and sisal fiber have increased as a result of this altered nature. Polyethylene was oxidized using KMnO4 solution, whereas sisal fiber was acetylated and mercerized using NaOH solution. Composites were created by having the percentage weight of fibers in changed and unmodified materials be roughly 5 or 10. The obtained material's morphology is assessed via SEM examination. Fiber chemical alteration improves matrix adherence, although HDPE oxidation had no discernible advantages. When compared to pure PE, the composites made with HDPE and modified sisal fibers have better mechanical qualities.
The flexural behavior of RC beams retrofitted with sheets of Sisal Fibre Reinforced Polymer Composites was described by Jeevan et al. (2013). In this study, the flexural zone of the beams was retrofitted with Natural Sisal Fibre Reinforced Polymer (NSIFRC) sheets. The outcomes and the control beams were contrasted. The ultimate load carrying capacity of the beams, the deflection that was produced, and the stiffness of the beams based on the load-deflection curves were used to draw the findings. Retrofitted RC beams showed improved deformation and load carrying performance compared to control beams.

Tara Sena and H.N. Jagannatha Reddy (2013) investigated the ductile and bending behavior of a Sisal fiber reinforced polymer composite. 5. Glass fibre reinforced polymer composite (GFRP) and carbon fibre reinforced polymer composite (CFRP) were used to examine the suitability of sisal fibre reinforced polymer composite (SFRPC). All of the fiber composites mentioned above were used to test the flexural behavior of reinforced cement (RC) shafts. The flexural strength of RC shafts increased significantly, according to SFRPC. Reinforced cement (RC) shafters were made and tested using the three fiber composites mentioned above in order to determine their flexural behavior.

Srisuwanet et al. (2014) conducted research using epoxy resin and sisal fiber. Blending is a procedure that modifies epoxy resin. Polymerized natural rubber (GNDR) and sisal fiber are combined with 1% by weight of either methyl methacrylate (MMA) or glycidyl methacrylate (GMA). The mix's impact strength was 63% more than that of regular epoxy resin. A 2% by weight NaOH solution was used to prepare alkaline woven sisal fiber. A mixture of alkaline fiber and γ-glycidoxy propyl trimethoxysilane (A-187) was used to create the saline fiber. The addition of salty sisal fiber raised the composite's flexure modulus. By adding saline sisal fiber, the composite's flexural strength increased by 230%.

The tensile characteristics, morphological characteristics, water absorption, and thermal treatment of sisal fiber (SF)/polypropylene (PP) composites with sisal fiber content materials of 10, 20, and 30% by weight were investigated by Sulawan Kaewkuk et al. (2013). MAPP (maleic anhydride polypropylene) is added as a compatibilizer to test the mechanical properties of the PP composites, and the results of treating sisal fiber with heat and alkalization are examined. The PP composites' mechanical qualities, water resistance, and cellulose decomposition temperature all improved as a result of the addition of sisal fiber and compatibilizer (MAPP). By employing SEM analysis to locate the fiber and PP matrix micrographs, the author also explains the interfacial change of sisal fiber and PP matrix. The author came to the conclusion that adding compatibilizer (MAPP) improved the PP composites' mechanical characteristics and modulus while decreasing their elongation and impact strength and increasing their fiber content.

According to Ramesh et al. (2013), the use of glass fiber in conjunction with natural and synthetic fibers, including sisal, has grown in numerous engineering and technological fields. Here, hybrid glass fiber reinforced epoxy composites were used to evaluate the mechanical qualities of sisal fiber, including its flexural and tensile capabilities. The internal structure of cracked surfaces, material failure morphology, and interfacial properties of materials were all examined under a microscope using a scanning electron microscope (SEM). The findings showed that adding sisal fibers to jute fiber reinforced (JFR) composites improved their tensile and flexural characteristics.

2.3 REVIEW PAPER ON SISAL FIBRE COMPOSITE CRACKING BEHAVIOR

In order to examine the composite's flexural cracking behavior, Flavio de Andrade Silva et al. (2009) investigated the usage of the cast hand layup technique for the fabrication of fiber reinforced composite laminated with sisal fiber. The 11 authors used an image-capturing technique to study the fracture creation in the bending test from the composites, and they used image analysis to quantify the crack spacing. This study discusses the sample's cracking system in terms of loading commencement, dispersion, opening, and localization. A strain gauge is used to quantify the impact of flexural cracking during the bending test. The sisal fiber-containing composites demonstrated excellent mechanical performance and energy absorption capacity, according to microstructural investigation.

Reis (2012) investigated the fracture characteristics of sisal fiber polymer composite mortar and sisal fiber polymer composite mortar supplemented with acetic acid and NaOH. To control surface fracturing, a 10% NaOH mixture is added to sisal fiber polymer mortar. The mechanical characteristics of treated and untreated sisal polymer mortar were contrasted by the author. According to the findings, untreated sisal fiber polymer mortar had more fractures than treated sisal fiber polymer mortar.

2.4 DURABILITY OF SISAL FIBRE REINFORCED CONCRETE

Romildo Dias Tolêdo Filho et al. (1999) investigated how to improve the engineering qualities of fiber-reinforced concrete, including impact, sapling, and thermal stress. Numerous fibers, including as sisal, jute, coconut, wood, and bamboo, have been studied for their physical characteristics and cement-based durability matrices. The general characteristics of the composites, including their fiber composition, length, strength, and stiffness, have been covered by the author. The findings demonstrate that sisal fiber-reinforced composites can be used in civil and rural construction for the creation of structural elements. Apart from the economic, social, and ecological advantages, sisal fiber production uses less energy than other mineral fibers.

The creation of sisal fiber with unidirectional aligned fiber reinforcement was examined by Flávio de Andrade Silva et al. (2009), and the author elaborates on the mechanical and physical behavior of the fibers. Corrugated and flat sheets were formed using a manual fiber arrangement technique in a self-compacted matrix cement, and they were crushed at a pressure of 3 MPa. Direct bending and tensile testing, as well as post-peak strength and toughness tests of the composites, were conducted to identify the initial crack. The capillary water absorption, watertight, and dry shrinkage tests were used to describe the composites' physical characteristics. The durability of the composite was guaranteed by consuming the calcium hydroxide produced during the Portland cement's hydration process with calcined waste crushed clay brick and metakaolin. The durability of the recently produced composites was assessed by using the hot water immersion test to speed up the aging process. When sisal fiber was used instead of regular concrete, the first fracture strength increased.

David et al. (2015) concentrate on using renewable resources and building materials to lower the amount of carbon dioxide (CO_2) released into the environment as a result of building material manufacturing, structure operation, and maintenance. One such substance is sisal fiber. Investigations into the durability of Sisal fiber reinforced cement-based composites 13 (SFRCC) were conducted. The composites underwent acetylation, alkaline treatment, and chemical treatments. Three-point bending (indirect), direct tensile, and compression tests were conducted to ascertain the matrix's strength. The chemical treatment and the addition of additional cementitious material to Sisal fiber reinforced cement-based composites (SFRCC) improved the specimens' durability.

2.5 LITERATURE REVIEW SUMMARY

According to the literature review, numerous researchers have focused on the usage of fiber and conducted a variety of studies on steel fibers and steel fiber reinforced concrete during the past year. The sisal fiber reinforced concrete (SiFRC) received minimal attention. Therefore, the endurance, flexural, and torsional behavior of SiFRC are the main topics of this study. Additionally, the impact of radiation, thermal aging, and the rebound resilience of SiFRC are the main topics of this study. Additionally, studies are conducted to enhance SiFRC's chemical characteristics. Additionally, studies are being conducted to improve sisal fiber's adherence to various concrete components.

3. Conclusion

Sisal fibers show great promise as an eco-friendly and sustainable reinforcement material for concrete. The addition of sisal fibers can significantly improve the mechanical properties of concrete, such as tensile, compressive, and flexural strength, while also enhancing durability. However, challenges related to fiber dispersion, water absorption, and long-term durability remain. Ongoing research into improving the treatment methods for sisal fibers and optimizing their use in concrete will likely lead to more widespread adoption in the construction industry.

Future research should focus on refining the processing techniques, exploring hybrid fiber systems (e.g., combining sisal with other natural fibers or synthetic materials), and assessing the environmental impact of sisal fiber-reinforced concrete in real-world applications. By addressing these challenges, sisal fiber can play a key role in the development of sustainable and resilient concrete for the future.

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