International Journal of Web of Multidisciplinary Studies
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
website: *https://ijwos.com* OPEN ACCESS E-ISSN : 3049-2424
Volume 03, Issue 10,October 2026 DOI: https://doi.org/10.71366/ijwos

Review Paper on strength properties of concrete with partial replacement of cement by Polypropylene fibre and Sisal fibre

Sanvatsarkar Omkar Nivrutti[1], Pushpendra Kumar Kushwaha[2]
[1] *Student, Rkdf College of Engineering Bhopal*
[2] *Assistant Professor, Civil Department, Rkdf College of Engineering, Bhopal (M. P.),402026 India*

Article Info

Article History:
Published: 31 Oct 2026

Publication Issue:
Volume 03, Issue 10
October 2026

Page Number:
615-619

Corresponding Author:
Sanvatsarkar Omkar Nivrutti

Abstract:
Concrete is one of the most widely used construction materials because of its high compressive strength, durability, availability, and relatively low cost. However, conventional concrete has limited tensile strength, poor resistance to crack propagation, and a tendency to develop microcracks under service and environmental loading. Fibre-reinforced concrete has emerged as an effective approach for improving these limitations. Among different synthetic and natural fibres, polypropylene fibre and sisal fibre have attracted considerable attention because of their ability to control cracking and improve post-cracking behaviour. Polypropylene fibre is a synthetic fibre characterized by low density, chemical resistance, hydrophobicity, and good resistance to alkalis, while sisal fibre is a renewable natural fibre obtained from Agave sisalana. This review examines the influence of polypropylene and sisal fibres on the strength properties of M30-grade concrete. The reviewed properties include workability, compressive strength, split tensile strength, flexural strength, crack resistance, toughness, and durability-related performance. Previous studies generally indicate that small and optimized fibre dosages can improve tensile and flexural performance and reduce crack development, while excessive fibre content may reduce workability and produce fibre agglomeration, voids, and reduced compressive strength. Sisal fibre offers environmental advantages because it is renewable and biodegradable, whereas polypropylene provides greater durability and consistency in aggressive concrete environments.

Keywords: - Polypropylene fibre , sisal fibre , M30-grade, concrete, Density, Chemical resistance

1. Introduction

Concrete plays a fundamental role in modern infrastructure, including residential buildings, bridges, highways, industrial structures, dams, and other civil engineering projects. Its widespread use is primarily associated with its high compressive strength, durability, ease of production, and ability to be moulded into different shapes. Despite these advantages, conventional concrete has certain limitations, including low tensile strength, brittleness, shrinkage cracking, and relatively limited resistance to impact and repeated loading.The development of fibre-reinforced concrete (FRC) provides an effective approach to addressing some of these limitations. Fibres distributed throughout the concrete matrix can bridge developing cracks, transfer stresses across crack surfaces, and improve post-cracking behaviour. The effectiveness of this mechanism depends on the type of fibre, its geometry, dosage, orientation, distribution, and bond with the cementitious matrix.

Polypropylene fibre is a synthetic fibre commonly incorporated into concrete to control cracking and improve toughness. Its chemical resistance and low density make it suitable for various concrete applications. Research indicates that polypropylene fibres can improve tensile-related properties and crack resistance, although improvements in compressive strength are not consistent across all mixtures and testing conditions ,Sisal fibre, obtained from the

Copyright © 2026 The Author(s) : This is an open access article under the CC BY license (http://creativecommons.org/licenses/by-nc/4.0/)

leaves of the *Agave sisalana* plant, is a natural lignocellulosic fibre. It has attracted attention because of its renewable origin, relatively low weight, and potential to improve the mechanical response of cement-based composites. However, its moisture absorption, dimensional changes, and durability in highly alkaline cementitious environments must be considered during concrete mix design.Acosta-Calderon et al. experimentally compared sisal fibre and polypropylene fibre in concrete. Their investigation demonstrated that the two fibres can influence fresh and hardened concrete properties differently. In particular, sisal fibre reduced workability, whereas polypropylene fibre produced comparatively little change in workability under the conditions investigated.Therefore, a systematic comparison of polypropylene fibre, sisal fibre, and their combined application is important for identifying suitable materials and developing concrete mixtures with improved strength, crack resistance, and durability

2. Literature survey & background

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

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.

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

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.

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.

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.

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.

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.

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.

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.

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%.

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.

Scorza et al. (2021) 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.

Hossain et al. (2021) 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.

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

Yanzhu Liu (2021) published a comprehensive review of the durability of polypropylene fibre-reinforced concrete. The review examined drying shrinkage, creep, water absorption, permeability, chloride penetration, sulfate resistance, freeze–thaw resistance, carbonation and fire resistance.

The study concluded that polypropylene fibres can reduce cracking and improve resistance to water and harmful-ion penetration. However, excessive fibre content can cause dispersion and workability problems. Weak fibre–matrix bonding is also identified as an important limitation. The review suggested that fibre modification and hybridization can be used to improve PPFRC performance.

Research reviewed by Gupta et al. (2022) on natural and synthetic fibre-reinforced concrete indicates that both fibre categories can enhance mechanical properties, but their mechanisms differ. Natural fibres provide renewable reinforcement and can contribute to tensile and flexural performance, whereas synthetic fibres such as polypropylene provide crack-control and durability benefits.

Vikrant Vairagade and Shrikrishna A. Dhale (2023) presented a state-of-the-art review of hybrid fibre reinforced concrete. Their study considered steel, polymeric and natural fibres and explained how hybrid fibres can control cracks at different scales.

The review indicated that hybridization can improve toughness, energy absorption, resistance to dynamic loading and post-cracking behaviour. Natural fibres such as sisal and jute can therefore be combined with synthetic fibres to develop multifunctional cementitious composites.

Ishika Mittal and Anupama Sharma (2023) examined the mechanical and durability behaviour of fibre-reinforced concrete containing different fibre types, including polypropylene and natural fibres. Their work emphasized the influence of fibre dosage on mixing, workability, strength and durability.The authors noted that natural fibres can improve concrete behaviour but that their compatibility with cement and long-term durability require attention. Polypropylene, meanwhile, benefits concrete through lightweight reinforcement and corrosion resistance but has relatively low modulus and weaker interfacial bonding.

Manar Ali, Mahmoud Elsayed and Bassam A. Tayeh (2024) investigated hybrid combinations of steel, polypropylene, polyvinyl alcohol and jute fibres in ultra-high-performance concrete exposed to elevated temperature. The research demonstrated the importance of fibre hybridization when concrete is subjected to severe thermal conditions.

Lanka Sasi Priyaanka, Prabhath Kumar Ranjan, Rahesh Hari, Yan Zhuge and K. M. Mini (2026) investigated coir–polypropylene hybrid fibre reinforced concrete. The study evaluated strength, ductility and durability using different proportions of coir and polypropylene. The authors reported that hybridization improved the overall strength and durability characteristics, with an appropriate combination providing a balance between strength, durability and ductility

Lili Lorensia Mallu, Chauvy Remi Nicolas, Marcelo Bernuy-Zumaeta and Tsung Chin Hou (2026) investigated sustainable hybrid coir–polypropylene fibre reinforced concrete. Their work considered mechanical properties, durability, electrochemical behaviour, microstructure and environmental performance. The study investigated partial replacement of polypropylene with coir at different proportions

Research Gap

Based on the reviewed literature, the following research gaps can be identified:

1. Limited research is available specifically on M30 concrete containing both polypropylene and sisal fibres.
2. Many studies investigate either synthetic or natural fibres individually rather than their combined effect.
3. The optimum PPF–sisal hybrid ratio requires further investigation.
4. The interaction between fibre dosage and workability requires systematic evaluation.
5. Long-term durability of sisal fibre in an alkaline concrete environment requires further study.

3. Conclusion

The present review was carried out to understand the effect of incorporating Polypropylene Fibre (PPF) and Sisal Fibre (SF) on the strength properties of concrete. The review considered the findings of previous researchers regarding the mechanical properties, workability, crack resistance, durability, and sustainability of fibre-reinforced concrete. Particular attention was given to the influence of fibre type, fibre content, aspect ratio, fibre dispersion, and interaction between fibres and the cementitious matrix.

- The incorporation of fibres into concrete has a significant influence on its mechanical behaviour. Both polypropylene and sisal fibres can improve the resistance of concrete to crack initiation and crack propagation when incorporated at an appropriate dosage.
- Polypropylene fibre is effective in controlling plastic shrinkage and micro-cracking in concrete. Due to its relatively good chemical resistance and ability to bridge developing cracks, it can improve the tensile behaviour

and post-cracking performance of concrete.

- Sisal fibre has considerable potential as a natural reinforcement material. Its fibrous structure and surface characteristics provide mechanical interlocking with the cement matrix and can contribute to improvements in tensile and flexural behaviour.
- The literature indicates that fibre addition generally produces a greater improvement in split tensile strength and flexural strength than in compressive strength. This is mainly because fibres restrict crack opening and transfer tensile stresses across developing cracks.
- The effect of fibres on compressive strength depends strongly on the percentage and dispersion of fibres. Small or optimum quantities can contribute to strength improvement by controlling internal cracking, whereas excessive fibre content may reduce strength because of poor workability, fibre balling, entrapped air, and inadequate compaction.

References

[1] A. Bentur and S. Mindess, Fibre Reinforced Cementitious Composites, 2nd ed. London, U.K.: Taylor & Francis, 2007.

[2] H. A. Toutanji, S. McNeil, and Z. Bayasi, "Chloride permeability and impact resistance of polypropylene-fiber-reinforced silica fume concrete," Cement and Concrete Research, vol. 28, no. 7, pp. 961–968, 1998.

[3] H. A. Toutanji, "Properties of polypropylene fiber reinforced silica fume expansive-cement concrete," Construction and Building Materials, vol. 13, no. 4, pp. 171–177, 1999.

[4] A. E. Richardson, "Freeze/thaw durability in concrete with fibre additions," Structural Survey, vol. 21, no. 5, pp. 225–233, 2003.

[5] J. A. Larbi and R. B. Polder, "Effects of polypropylene fibres in concrete: Microstructure after fire testing and chloride migration," HERON, vol. 52, no. 4, pp. 289–306, 2007.

[6] Z. Sun and Q. Xu, "Microscopic, physical and mechanical analysis of polypropylene fiber reinforced concrete," Materials Science and Engineering: A, vol. 527, pp. 198–204, 2009.

[7] A. Sadrmomtazi and A. Fasihi, "Influence of polypropylene fibers on the performance of nano-SiO_2-incorporated mortar," Iranian Journal of Science and Technology, Transaction B: Engineering, vol. 34, no. B4, pp. 385–395, 2010.

[8] A. Richardson and K. Coventry, "Early life freeze/thaw durability of polypropylene fibre and ground granulated blast furnace slag concrete," in Proc. 2nd Int. Conf. Sustainable Construction Materials and Technologies, Ancona, Italy, 2010.

[9] O. Karahan and C. D. Atiş, "The durability properties of polypropylene fiber reinforced fly ash concrete," Materials and Design, vol. 32, pp. 1044–1049, 2011.

[10] C. F. Wang and D. T. Niu, "Research on the durability of polypropylene fiber concrete," Advanced Materials Research, vols. 261–263, pp. 93–97, 2011.

[11] Z. Zongjin, Advanced Concrete Technology. Hoboken, NJ, USA: Wiley, 2011.

[12] G. H. D. Tonoli, H. Savastano Jr., S. F. Santos, C. M. R. Dias, V. M. John, and F. A. R. Lahr, "Hybrid reinforcement of sisal and polypropylene fibers in cement-based composites," Journal of Materials in Civil Engineering, 2011.

[13] S. Kakooei, H. M. Akil, M. Jamshidi, and J. Rouhi, "The effects of polypropylene fibers on the properties of reinforced concrete structures," Construction and Building Materials, vol. 27, no. 1, pp. 73–77, 2012.

[14] R. Bagherzadeh, A.-H. Sadeghi, and M. Latifi, "Utilizing polypropylene fibers to improve physical and mechanical properties of concrete," Textile Research Journal, vol. 82, no. 1, pp. 88–96, 2012.