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Review on Enhance the Durability Properties of Polypropylene Fibre Concrete

Ram Ji Mishra [a], Vinay Kumar Singh Chandrakar [b]

[a] *M. Tech. Scholar, School of Civil Engineering, Faculty of Engineering and Technology, Madhyanchal Professional University Bhopal, M.P*
[b] *Assistant Professor, School of Civil Engineering, Faculty of Engineering and Technology, Madhyanchal Professional University Bhopal, M.P*

ABSTRACT

Polypropylene fibre (PPF) is a polymer material known for its light weight, high strength, and corrosion resistance, which enhances the crack resistance of concrete. By incorporating PPFs into concrete, the pore size distribution is optimized, significantly improving the material's durability by blocking the penetration of water and harmful ions. This paper summarizes the impact of PPF on various aspects of concrete durability, such as drying shrinkage, creep, water absorption, permeability resistance, chloride ion penetration resistance, sulfate corrosion resistance, freeze-thaw cycle resistance, carbonation resistance, and fire resistance. The study also analyzed the effects of various factors on these durability indexes, including fibre content, fibre diameter, and fibre hybrid ratio. It was found that combining PPFs with steel fibres can further enhance the durability properties of concrete. PPF in concrete faces challenges such as imperfect dispersion within the concrete mix and weak bonding with the cement matrix. To address these issues, methods like modifying fibres with nanoactive powder or chemical treatments are recommended. Lastly, the authors discuss future research prospects, emphasizing the need for continued development in PPF-concrete composites to overcome current limitations and enhance performance.

Keywords: Polypropylene fibre (PPF), Durability, Chemical treatments, permeability resistance, water absorption

Introduction

The integration of fibers into concrete is a notable technique to enhance its properties, with polypropylene fibers being a particularly advantageous option. These synthetic fibers are derived as a by-product from the textile industry and are accessible in various aspect ratios, making them cost-effective. Polypropylene fibers possess a low specific gravity and are inexpensive, allowing for the efficient and reliable utilization of the concrete's intrinsic tensile and flexural strength. Moreover, they significantly reduce plastic shrinkage cracking and minimize thermal cracking.

The inclusion of polypropylene fibers in concrete provides additional reinforcement, protecting the concrete structure from damage and preventing spelling during fires. The fibers are produced either by the pulling wire procedure, which results in a circular cross-section, or by extruding plastic film to form a rectangular cross-section. These fibers can be found in the form of fibrillated bundles or monofilament strands. Fibrillated polypropylene fibers are created by expanding a plastic film, which is then separated into strips and slit. The resulting fiber bundles are cut to specific lengths and fibrillated. Monofilament fibers, on the other hand, can be designed with buttons at their ends to increase the pull-out load, enhancing their reinforcing capabilities. In summary, the use of polypropylene fibers in concrete not only enhances the material's tensile and flexural strength but also reduces the occurrence of shrinkage and thermal cracking. Their manufacturing process, whether resulting in fibrillated bundles or monofilaments, ensures a versatile and effective reinforcement solution for concrete structures.

LITERATURE REVIEW

Yamuna Bhagwat et al (2023) the durability of self-compacting concrete (SCC) has become a significant area of interest due to its growing use in the construction industry for its ease of handling and placement. However, there is a notable gap in the literature regarding the durability of M-sand (manufactured sand) self-compacting concrete reinforced with polypropylene fibers. This study focuses on the comprehensive evaluation of SCC made with Portland pozzolana cement, natural sand, and M-sand, incorporating various volume fractions of polypropylene fibers (0%, 0.1%, 0.15%, and 0.2%). The investigation encompasses an array of properties, including fresh properties, hardened properties, drying shrinkage, water absorption, permeability, acid resistance, and the time to corrosion crack initiation. Additionally, Scanning Electron Microscopy (SEM) analysis was conducted to observe the microstructural effects of polypropylene fibers on the concrete.

Kanchan S et al (2022) this study investigates the effects of incorporating polypropylene fibres into concrete mixtures, aiming to enhance the material's tensile and flexural strength while reducing plastic shrinkage and thermal cracking. Polypropylene fibres were added to the concrete mix in varying dosages from 0.5% to 2.5% of the total weight of cement. An M-30 mix was used for the experiment, and the mechanical properties of the concrete were evaluated through Compression tests, Split Tensile tests, and Flexural Strength tests at 7 and 28 days, following standard procedures. The results were compared to those of conventional concrete, revealing that the optimal fibre dosage was 1.5% by weight, which provided the highest strength and reduced self-weight. Higher dosages led to a gradual decrease in strength. The study found that adding polypropylene fibres to concrete significantly affected its mechanical properties. At a dosage of 1.5% by weight, the concrete exhibited the highest strength in both tensile and flexural tests, along with a reduction in self-weight. This optimal dosage also minimized plastic shrinkage and thermal cracking. However, increasing the fibre content beyond 1.5% led to a decline in concrete strength, suggesting an optimal range for fibre addition.

Yanzhu Liu et al [2021] Polypropylene fiber (PPF) serves as a remarkable addition to concrete, bolstering its durability through several mechanisms. Firstly, PPF optimizes the pore size distribution within concrete, leading to enhanced crack resistance. This improvement is pivotal as it fortifies the concrete against structural weaknesses and prolongs its lifespan. Additionally, the incorporation of PPF mitigates drying shrinkage, minimizes creep, and curtails water absorption. These attributes collectively enhance the concrete's resilience to environmental factors and structural wear. Furthermore, PPF acts as a barrier, impeding the infiltration of water and harmful ions into the concrete matrix. This function is instrumental in safeguarding the concrete against degradation, thereby augmenting its longevity. The inclusion of PPF also bolsters the resistance of concrete to various forms of corrosion, including chloride ion penetration and sulfate corrosion. Moreover, it enhances the concrete's ability to withstand freeze-thaw cycles, carbonation, and fire, making it suitable for a wide array of applications in diverse environmental conditions. To optimize the benefits of PPF, researchers have delved into analyzing the impact of factors such as fiber content, diameter, and hybrid ratio on the durability of concrete. Additionally, combining PPF with steel fibers further enhances the durability properties of concrete, offering a synergistic effect. Despite its numerous advantages, challenges exist in the application of PPF in concrete. Imperfect dispersion within the concrete matrix and weak bonding with the cement matrix are notable drawbacks. To overcome these challenges, researchers propose employing PPF modified with nanoactive powder or subjecting it to chemical treatments. These strategies aim to enhance dispersion and bolster bonding, thereby maximizing the effectiveness of PPF in concrete applications. Looking ahead, the future research prospects for concrete incorporating PPFs appear promising. Continued investigation into optimizing PPF properties and refining its integration into concrete matrices could unlock further enhancements in concrete durability and performance.

S. Govindasami et al [2018] This study examines the impact of polypropylene (PP) fiber on the strength performance of concrete. The researchers tested various volume fractions (Vf) of PP fiber, ranging from 0% to 2%, in M25 grade concrete. The concrete mix included Ordinary Portland Cement, M-Sand, and blue metal, both with and without the addition of fibers.

One notable finding was that as the Vf of PP fiber increased from 0.5% to 2.0%, the workability of the concrete decreased. However, despite this decrease in workability, the addition of PP fiber led to improvements in compressive, flexural, and split tensile strength compared to conventional concrete. Specifically, the study observed a 7.67% improvement in compressive strength and a 26.57% improvement in flexural strength at a Vf of 1%. At a Vf of 1.5%, the improvements further increased to 33.61% for compressive strength and flexural strength. However, it's worth noting that beyond a Vf of 1%, there was a reduction in strength. Therefore, the study suggests that the optimum percentage of polypropylene fiber in this concrete mix is 1%, as it provided the best balance of strength improvement without compromising workability. Beyond this percentage, the strength improvement began to diminish.

Divya S et al (2016) India, as a leading developing country, is continuously advancing in the field of construction. High strength and high performance concrete is increasingly needed for various construction works to ensure durability, safety, and sustainability. One of the innovative approaches in achieving these properties is through the use of Fiber-Reinforced Concrete (FRC). FRC is concrete that incorporates fibrous materials to enhance its structural integrity. The addition of fibers affects the properties of the concrete, including its workability, strength, and durability. The effectiveness of FRC depends on the type of fibers used, their geometries, distribution, orientation, and densities. Polypropylene fibers are a type of lightweight synthetic fiber. When added to concrete, they help prevent crack formation, enhance structural reinforcement, and improve overall performance. This project investigates the use of blended polypropylene fibers in varying percentages to evaluate their impact on concrete properties.

Milind V et al (2015) the study investigates the influence of varying proportions of polypropylene fibers on the mechanical properties of high-strength concrete (HSC) mixes (M30 and M40). The experimental program aimed to assess the effects of polypropylene fiber additions (0%, 0.5%, 1%, 1.5%, and 2%) on compressive, tensile, and flexural strengths under different curing conditions. The primary objective was to identify the optimal polypropylene fiber content that enhances these properties. Concrete specimens were tested at various ages to determine their mechanical properties, including cube compressive strength, split tensile strength, and flexural strength. Specimens were divided into two groups: one cured in a curing tank and the other exposed to ambient conditions. Initially, specimens exposed to ambient conditions showed appreciable strength, but those in curing tanks demonstrated superior strength over time. The addition of polypropylene fibers notably increased compressive, tensile, and flexural strengths. Further research is recommended to gain a deeper understanding of the mechanical properties of fiber-reinforced concrete.

Anthony Nkem Ede et al (2014) the construction industry significantly impacts the economies of many nations, with concrete being a key material due to its widespread use. In the United States, the ready-mix concrete production industry is a $30 billion business annually, while Nigeria has a cement consumption rate of about 106 kg per person. Given its importance, it is crucial to ensure that concrete used in construction has the best possible properties. Reinforced concrete structural designs rely on high-quality concrete and reinforcing materials. However, research in Nigeria has revealed that the quality of commonly used reinforcement steel is substandard. In 2010, over 40% of 12 mm and 16 mm steel reinforcement in Lagos failed to meet the 460 N/mm² yield strength benchmark set by BS8110 of 1997. To address this issue, the use of micro fibers in concrete has been proposed as a method to enhance its strength and compensate for the declining quality of reinforcement steel. Additionally, this approach can improve the strength of non-reinforced concrete-sand crate block buildings. This research focuses on the effects of incorporating micro synthetic polypropylene fibers into concrete to improve its compressive and flexural strengths. The study aims to identify the optimal fiber content for achieving these improvements. Samples with polypropylene fiber contents of 0.25%, 0.5%, 0.75%, and 1% were tested alongside control samples. Destructive and non-destructive compressive strength tests and destructive flexural strength tests were conducted after 7, 14, 21, and 28 days of curing. The results indicate that the optimal percentage of polypropylene fiber for improved compressive and flexural strengths lies between 0.25% and 0.5%. This finding suggests that incorporating polypropylene fibers within this range can significantly enhance the performance of concrete, offering a viable solution to the issues of declining reinforcement steel quality in Nigeria.

Kolli.Ramujee et al (2013) the interest in using fibers for reinforcing composites has significantly increased over the past several years. Fibers are favorably characterized by a combination of high strength, stiffness, and thermal resistance. In this study, the strength properties of polypropylene fiber-reinforced concrete are presented. The compressive strength and splitting tensile strength of concrete samples made with varying amounts of fibers—0%, 0.5%, 1%, 1.5%, and 2.0%—were examined. The samples with 1.5% added polypropylene fibers demonstrated better results compared to the others. The addition of polypropylene fibers influenced the compressive strength of the concrete. The optimal fiber content was 1.5%, which showed superior performance compared to other fiber amounts. Similar to compressive strength, the splitting tensile strength was also enhanced with the inclusion of polypropylene fibers. The sample with 1.5% fiber content exhibited the highest tensile strength among all tested amounts. For applications requiring high strength and durability, incorporating polypropylene fibers at the identified optimal percentage could be beneficial. While 1.5% fiber content showed the best results in this study, further research could explore the effects of different fiber types, lengths, and other mix design parameters to optimize fiber-reinforced concrete further.

Ashish Kumar Yadav et al [2007] Polypropylene fiber-reinforced concrete (PFRC) indeed addresses some of the limitations of traditional concrete, especially in applications where flexibility and resilience are crucial, such as seismic zones. The addition of polypropylene fibers enhances the ductility and toughness of concrete, mitigating its brittle behavior. The inclusion of polypropylene fibers enhances the ductility of concrete, allowing it to deform without fracturing easily. This flexibility is especially important in seismic applications where structures need to withstand significant ground motion. Polypropylene fibers help in absorbing energy and redistributing stresses within the concrete matrix, improving its resistance to cracking and spalling under dynamic loads. Polypropylene fibers are chemically inert, making them resistant to most chemicals. This property enhances the durability of concrete in aggressive environments, such as marine or industrial settings. Polypropylene is one of the most cost-effective polymers available, making PFRC a financially viable solution for various construction projects. Polypropylene fibers have a high melting point, which enables them to retain their mechanical properties even at elevated temperatures, contributing to the fire resistance of concrete structures.

METHODOLOGY

This chapter details the experimental programs designed to measure the fresh and strength properties of concrete mixes with varying percentages of polypropylene fiber. The chapter is structured as follows: The workability and consistency of the concrete mix are assessed using standard tests such as the slump test. The primary focus is on the compressive strength of the concrete, which is evaluated through a series of tests on prepared specimens. A brief overview of the mix design process, including the proportioning of materials and the rationale for selecting specific percentages of polypropylene fiber. Description of the curing procedures adopted to ensure the concrete reaches its desired properties. Concrete specimens are cast into molds, cured for specific periods, and then subjected to compression until failure. The maximum load at failure is used to calculate the compressive strength.

CONCLUSION

The chapter concludes with a summary of the various tests conducted on the concrete specimens, emphasizing the influence of polypropylene fiber on the fresh and strength properties of the concrete. The results from these tests provide insights into the optimal fiber content for enhancing concrete performance.

REFERENCES

[1] Anthony Nkem Ede1 (PhD) and AbimbolaOluwabambi Ige "Optimal Polypropylene Fiber Content for Improved Compressive and Flexural Strength of Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. IV (May- Jun. 2014), PP 129-135 www.iosrjournals.org.

[2] Milind V. Mohod "Performance of Polypropylene Fibre Reinforced Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 1 Ver. I (Jan- Feb. 2015), PP 28-36 www.iosrjournals.org.

[3] Yamuna Bhagwat, Gopinatha Nayak, Poornachandra Pandit & Aishwarya Lakshmi "Effect of polypropylene fibres on strength and durability performance of M-sand self compacting concrete" Bhagwat et al., Cogent Engineering (2023), 10: 2233783 https://doi.org/10.1080/23311916.2023.223378

[4] Kanchan S. Wawge1, Jagruti V. Chavan "Experimental Study of Polypropylene Fibre Concrete with Admixture" International Journal of Scientific Research in Engineering and Management (IJSREM) Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930.

[5] Divya S Dharan1, Aswathy Lal2 "STUDY THE EFFECT OF POLYPROPYLENE FIBER IN CONCRETE" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072.

[6] Yanzhu Liu , 1 Liang Wang , 1,2 Ke Cao , 1 and Lei Sun "Review on the Durability of Polypropylene Fibre-Reinforced Concrete" Advances in Civil Engineering Volume 2021, Article ID 6652077, 13 pages https://doi.org/10.1155/2021/6652077.

[7] Mr.Ashish Kumar Yadav1 , Dr.Brajkishor Prasad2 , Dr.Virendra Kumar3 and Meenu Mohan "Properties of Polypropylene Fiber Reinforced Concrete and Structural Behaviour of Beam" International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Website: www.ijirset.com Vol. 6, Issue 6, June 2017.

[8] S. Govindasami1, P.B. Sakthivel2* and R. Harish "Strength Assessment of Polypropylene Fibre Reinforced Concrete (PPFRC)" International Journal of Engineering & Technology Website: www.sciencepubco.com/index.php/IJET 7 (3.34) (2018) 436-438.