



A REVIEW STUDY ON VARIOUS TYPES OF FIBER-REINFORCED CONCRETE

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Abstract:

The effectiveness of fiber reinforced concrete (FRC) in a variety of civil engineering applications is unquestionable. FRC has been successfully employed in numerous settings, including slabs on grade, architectural panels, precast products, offshore structures, constructions in seismic zones, repairs, crash barriers, footings, hydraulic structures, and many more. Fiber reinforced concrete is increasingly recognized as a viable method to enhance concrete performance. Fibers are now being incorporated in applications such as tunnelling, bridge decks, pavements, loading docks, thin unbonded overlays, concrete pads, and slabs. Fiber reinforced concrete (FRC) has gained significant attention in modern construction due to its enhanced mechanical properties and durability compared to conventional concrete. This review paper provides a comprehensive overview of the various types of fibers used in FRC, including steel, glass, synthetic, and natural fibers, and examines their impact on the concrete's tensile strength, toughness, and ductility. Future research directions are highlighted, focusing on optimizing fiber types and combinations, improving sustainability through eco-friendly materials, and developing innovative testing methodologies. By consolidating current knowledge and identifying gaps in research, this review aims to facilitate the effective utilization of fiber reinforced concrete in civil engineering applications, promoting safer and more resilient infrastructure.

Keywords: fiber-reinforced concrete, mechanical properties, durability, structural applications.

INTRODUCTION

Fiber reinforced concrete (FRC) has emerged as a transformative solution to address the limitations inherent in traditional concrete, particularly its low tensile strength and brittleness. These characteristics often result in cracking, compromising structural integrity and performance. To enhance concrete's structural capabilities, conventional reinforcement typically involves embedding continuous steel bars to counteract tensile and shear stresses. However, FRC employs short, discontinuous fibers that are randomly distributed throughout the concrete mix, creating a composite material that significantly improves crack control and overall mechanical performance. The close spacing of these fibers enables better reinforcement than traditional steel bars, as they effectively arrest crack propagation and enhance ductility. Importantly, while FRC fibers are not a direct substitute for steel reinforcement, they serve a complementary role, allowing for both systems to coexist within various applications. This synergy enhances the overall structural performance, particularly in environments requiring increased resilience, such as seismic zones and dynamic load applications like pavements and offshore structures. Furthermore, the use of FRC can lead to reduced material consumption, as it allows for thinner and lighter structural elements without sacrificing strength. The versatility of FRC has been validated through successful applications in diverse civil engineering projects, including slabs on grade, architectural panels, precast elements, and repair works. Documented performance metrics illustrate FRC's ability to meet the rigorous demands of modern construction while simultaneously addressing durability and maintenance challenges.

Despite its numerous advantages, the integration of fibers into concrete poses several challenges that warrant careful consideration. Achieving uniform fiber distribution is critical, yet can be technically demanding, as it is influenced by factors such as fiber type, length, and aspect ratio. Additionally, the presence of fibers may affect the workability of the concrete mix, necessitating adjustments in mixing and placement processes to maintain optimal performance. As research in the field of FRC continues to advance, there is a concerted effort to optimize fiber types and combinations to further enhance performance characteristics. Innovations in manufacturing techniques and the development of eco-friendly fiber materials are paving the way for more sustainable construction practices, expanding the potential applications of FRC in various sectors. Moreover, ongoing studies focus on establishing standardized testing methodologies to better assess the mechanical properties and long-term durability of FRC. This review paper aims to consolidate the current understanding of fiber reinforced concrete by examining the different types of fibers used, their

mechanical effects, and the challenges and opportunities associated with their implementation. By providing a comprehensive overview of recent advancements and future directions in FRC research, this paper seeks to inform and inspire both researchers and practitioners in civil engineering, ultimately promoting the effective utilization of fiber reinforced concrete in the evolution of modern infrastructure development. Through a deeper understanding of FRC's capabilities and limitations, stakeholders can better harness its benefits to improve construction practices and outcomes.

LITERATURE REVIEW:

The evolution of concrete technology has continually sought to address the limitations of traditional concrete, particularly its inherent brittleness and low tensile strength. In response to these challenges, researchers have increasingly focused on the integration of fibers into the concrete matrix, leading to the development of fiber reinforced concrete (FRC). Early studies highlighted the potential of various fiber types—such as steel, glass, and synthetic materials—to enhance the mechanical properties of concrete, thereby improving its performance in structural applications. This literature review aims to synthesize existing findings on the mechanical properties of different types of FRC.

1. Steel fibers:

Addition of the steel fiber in concrete have an impact on concrete's mechanical properties. In increasing of steel fiber volume leads to reduced workability. Notably, a 3% fiber volume fraction significantly enhances compressive strength, achieving an 18.27% increase compare to traditional concrete, and improves flexural strength by 51.72%, showcasing its role in enhancing ductility. The study establishes 3% as the optimal fiber content, maximizing strength while minimizing workability loss. Overall, while the compressive strength improvement is modest, the substantial gains in flexural strength highlight the importance of steel fibers in enhancing concrete's performance, making it more resistant to cracking and failure. [1]

while steel fibers reduce workability, the use of superplasticizers can counteract this issue. Increasing fiber volume enhances compressive, tensile, and shear strengths across various concrete grades (M20 to M40). The study highlights significant improvements in toughness and ductility, with fiber-reinforced concrete (FRC) exhibiting more ductile failure modes compared to conventional concrete's brittle failures. [2]

Uniaxial compressive tests reveal that while compressive strength is largely unaffected by fibers, the failure mode shifts from brittle to ductile. Four-point bending tests demonstrate that increased fiber content and length enhance ductility and toughness, with distinct cracking patterns observed. The study also highlights the differing post-cracking behaviours based on fiber length. A numerical comparison with an analytical model shows strong alignment, with short fibers increasing tensile strength and long fibers enhancing ultimate strain, reinforcing the benefits of SFRC in construction applications. [3]

2. Glass Fiber:

The benefits of using glass fiber as reinforcement in concrete and mortar are as; the Key findings show that adding glass fibers enhances compressive strength by up to 9.3% and splitting tensile strength by up to 12.5% in concrete. The modulus of elasticity and energy dissipative capacity also increase significantly. Additionally, the splitting tensile strength of glass fiber reinforced concrete (GFRC) ranges from 9% to 11% of compressive strength. [4]

The study highlights that alkali-resistant glass fibers (Cem-FIL anti Crack HD) outperform other glass fibers in enhancing mechanical properties of concrete. Specifically, flexural strength and split tensile strength increase by 15% to 20% compared to mixes without glass fibers. Additionally, the compressive strength of glass fiber concrete mixes shows a notable improvement of 20% to 25% compared to the 28-day compressive strength of conventional concrete, demonstrating the efficacy of these fibers in concrete applications. [5]

The use of waste glass fibers from the glass industry as a reinforcement material in concrete., the addition of glass fibers decreased workability, as indicated by lower slump values, these effects conclude that incorporating glass fibers not only enhances concrete properties but also offers cost savings and provides an environmentally friendly solution for waste disposal. Overall, the findings suggest a promising avenue for sustainable construction practices.[6]

3. Polypropylene fiber:

The effects of polypropylene fiber reinforcement in concrete concludes that increasing fiber content leads to a reduction in slump, particularly beyond a 1.5% dosage, making the mix more fibrous and difficult to handle. Notably, both compressive strength and splitting tensile strength improved proportionately with higher fiber volume ratios, with a maximum increase of 34% in compressive strength and 40% in splitting tensile strength compared to control samples. The 1.5% fiber content was identified as the optimal level, yielding the best overall results in the study.[7]

The study highlights that incorporating 1.5% blended length polypropylene fibers in concrete results in significant improvements compared to conventional concrete in modulus of elasticity by 11%. These findings demonstrate that using polypropylene fibers is an effective method for enhancing the strength and durability of concrete. The optimal fiber content of 1.5% was identified as yielding the maximum strength, confirming its potential for improving concrete performance.[8]

4. Jute fiber:

study examines the impact of jute fiber reinforcement on the compressive and split tensile strength of concrete. For 0.1% jute fiber, compressive strength improved by 0.16% to 6.81%, while 0.25% jute fiber showed significant gains of 9.61% to 29.56% across all days and lengths, with the highest increase at 22.51%, 29.56%, and 26.15% for 7, 14, and 28 days, respectively. Conversely, 0.5% jute fiber resulted in reduced strength for both compressive and split tensile tests. The best

performance was consistently observed with 0.25% jute fiber at 10 mm length, highlighting its potential for enhancing concrete properties.[9]

The effects of jute fiber added at 0.5%, 1.0%, and 1.5% in M25, M30, and M40 grades of concrete. Findings reveal that workability decreases with increased jute fiber due to its hydrophilic nature, absorbing water essential for mix consistency. Compressive strength peaks at 1.5% fiber content, with improvements of 19.7%, 9.7%, and 8.1% for M25, M30, and M40, respectively. However, acid curing significantly reduces strength due to jute fiber decay. Similarly, split tensile strength improves but shows declines under acid conditions, indicating that jute fiber reinforced concrete is unsuitable for marine environments.[10]

5. Bamboo fiber:

The properties of bamboo fiber reinforced concrete, focusing on fresh and hardened characteristics such as air content, slump, flexural strength, tensile strength, compressive strength, elastic modulus, and density. Key findings reveal that tensile strength significantly increases with higher fiber volume fractions. However, the addition of bamboo fibers does not notably affect flexural or compressive strength. Notably, strength improvements were observed between 28 and 56 days, indicating that the curing duration positively influences the performance of bamboo fiber reinforced concrete. Overall, the research highlights the potential benefits of using bamboo fibers in concrete applications.[11]

the addition of bamboo fiber reduces slump value, indicating decreased workability. Flexural strength increases by nearly 10% compared to traditional concrete. However, compressive strength shows an initial increase with a small fiber addition (0.5%), followed by a decline with further fiber increments. Additionally, the results indicate a positive correlation between flexural strength and tensile strength, suggesting that enhancements in flexural strength contribute to improved tensile performance. Overall, bamboo fiber proves beneficial for certain mechanical properties of concrete, although excessive fiber may compromise compressive strength. [12]

6. Synthetic Fiber:

The material behavior of synthetic fiber reinforced concrete with the goal of potentially reducing or eliminating the need for traditional structural reinforcement. The findings indicate that increasing fiber dosages enhance both shear and flexural strength and toughness. Interestingly, lower fiber dosages were found to have a more pronounced effect on compressive strength compared to higher dosages, suggesting an optimal balance in fiber application for improved performance.[13]

The mechanical behavior of concrete reinforced with macro synthetic fibers, focusing on compressive, tensile, and shear strength, as well as stress-strain behavior. Unlike plain concrete, which fails suddenly, fiber-reinforced specimens maintain integrity post-cracking, demonstrating improved energy absorption. Although ultimate stress improvements were minimal, increased ultimate strain indicates enhanced ductility. Overall, the findings suggest that macro synthetic fibers can significantly enhance concrete's mechanical properties, paving the way for stronger, more durable structures in construction engineering.[14]

The review of fiber reinforced concrete (FRC) highlights several key challenges. Achieving uniform fiber distribution is crucial, as inconsistencies can affect mechanical properties. Additionally, the incorporation of fibers often reduces workability, complicating handling and placement. Optimizing fiber type and content remains a challenge, as different fibers enhance certain properties while negatively impacting others. Long-term durability is a concern, with limited data on how environmental factors affect performance. The lack of standardized testing methods complicates comparisons across studies. Finally, economic considerations regarding fiber costs versus performance benefits must be evaluated for broader adoption in construction practices.

To address these challenges in fiber reinforced concrete (FRC), several solutions can be implemented. Ensuring uniform fiber distribution can be achieved through advanced mixing techniques and the use of dispersing agents. To improve workability, incorporating superplasticizers can help maintain consistency without compromising performance. Establishing guidelines for optimal fiber types and dosages through standardized testing methods will enhance understanding and comparability. Long-term durability can be assessed through accelerated aging tests that simulate environmental exposure. Finally, evaluating the economic implications through cost-benefit analyses will support informed decisions, promoting the effective adoption of FRC in modern construction practices.

CONCLUSION:

In conclusion, fiber reinforced concrete (FRC) represents a significant advancement in concrete technology, addressing the inherent limitations of traditional concrete through the incorporation of various fibers. This review has highlighted the mechanical benefits of different fiber types, including steel, glass, polypropylene, jute, bamboo, and synthetic fibers, which enhance strength, ductility, and resistance to cracking. However, challenges such as achieving uniform fiber distribution, maintaining workability, optimizing fiber content, and ensuring long-term durability remain critical issues. To overcome these obstacles, innovative mixing techniques, the use of superplasticizers, and standardized testing methodologies are essential. Future research should focus on developing eco-friendly fibers and conducting comprehensive durability assessments under various environmental conditions. Additionally, a detailed economic analysis will help assess the feasibility of FRC in practical applications. By addressing these challenges, stakeholders can effectively harness the benefits of FRC, promoting its wider adoption in modern infrastructure projects and enhancing the resilience and sustainability of construction practices. Overall, this review underscores the transformative potential of FRC in shaping the future of civil engineering and construction.

REFERENCES:

1. Ashfaqe Ahmed Jhatial, Samiullah Sohu, Nadeem-ul-Karim Bhatti, Muhammad Tahir Lakhari, Raja Oad. Effect of steel fibres on the compressive and flexural strength of concrete, International Journal of Advanced and Applied Sciences 5(10) 2018, Pages: 16-21
2. Avinash Joshi, Pradeep reddy, Punith kumar and Pramod hatker, Experimental work on steel fibre reinforced concrete International Journal of Scientific & Engineering Research, Volume 7, Issue 10, October-2016
3. R.S. Olivito, F.A. Zuccarello, An experimental study on the tensile strength of steel fiber reinforced concrete,
4. Muna M. Abdullah, Eman K. Jallo, Mechanical Properties of Glass Fiber Reinforced Concrete.
5. Shrikant Harle, Glass Fiber Reinforced Concrete & Its Properties, International journal of engineering sciences & research technology.
6. Yogesh Iyer Murthy, Apoorv Sharda, Gourav Jain, Performance of Glass Fiber Reinforced Concrete, International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 6, June 2012
7. Kolli.Ramujee, Strength Properties Of Polypropylene Fiber Reinforced Concrete, International Journal Of Innovative Research In Science, Engineering And Technology, Vol. 2, Issue 8, August 2013.
8. Divya S Dharan, Aswathy Lal, Study the Effect of Polypropylene Fiber In Concrete, International Research Journal Of Engineering And Technology (Irjet), Volume: 03 Issue: 06 | June-2016
9. S. Rahman, A. K. Azad, Investigation on Mechanical Strength of Jute Fiber Reinforced Concrete (JFRC) Compared to Plain Concrete, International Journal of Scientific & Engineering Research Volume 9, Issue 3, March-2018.
10. S Tiwari, A K Sahu and R P Pathak, Mechanical Properties and Durability Study of Jute Fiber Reinforced Concrete
11. Masakazu Terai, Koichi Minami, Basic Study On Mechanical Properties Of Bamboo Fiber Reinforced Concrete
12. Durgesh Kumar Gupta, R. C. Singh, An Experimental Evaluation of Compressive Strength and Flexural Strength of Bamboo Fiber Reinforced Concrete, International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 09 | Sep 2018
13. Mahnaz Mostafazadeh And Ali Abolmaal, Shear Behavior of Synthetic Fiber Reinforced Concrete
14. M. J. Hasan, M. Afroz And H. M. I. Mahmud, An Experimental Investigation On Mechanical Behavior Of Macro Synthetic Fiber Reinforced Concrete, International Journal Of Civil & Environmental Engineering Ijcee-Ijens Vol: 11 No: 03

