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Use of Micro Synthetic Fibers in Concrete

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ABSTRACT: This project investigates the influence of micro synthetic fibers on the mechanical and durability properties of M25 grade concrete using Portland Pozzolana Cement (PPC) as the primary binder. While concrete is one of the most widely used construction materials, it exhibits inherent weaknesses such as brittleness, low tensile strength, and susceptibility to shrinkage cracks. The integration of micro synthetic fibers is aimed at overcoming these limitations by enhancing toughness, durability, and crack resistance. The experimental study involved the preparation of fiber-reinforced and conventional concrete mixes, followed by a series of tests to assess performance. Workability was evaluated using the slump cone method, while compressive strength was measured at 7, 14, 21, and 28 days of curing. The findings revealed a slight reduction in workability with the inclusion of fibers; however, this was offset by a noticeable improvement in compressive strength and early-age performance. Additionally, the fibers contributed to better crack control, reducing shrinkage-related issues and improving the structural integrity of the concrete. Overall, the study demonstrates that micro synthetic fiber-reinforced concrete is a promising and practical approach for enhancing the performance and longevity of concrete structures, particularly in applications requiring greater resistance to cracking, impact, and environmental degradation.

KEYWORDS: Text detection, Inpainting, Morphological operations, Connected component labelling.

I. INTRODUCTION

Concrete remains the most widely used construction material worldwide due to its affordability, moldability, and high compressive strength. However, despite its widespread use, concrete possesses inherent limitations such as low tensile strength, brittleness, and susceptibility to cracking caused by shrinkage, thermal fluctuations, and mechanical loading. These cracks can compromise structural durability, leading to increased maintenance costs and shortened service life. While traditional reinforcement methods such as steel bars and macro fibers provide additional strength, they often fall short in controlling micro-cracks and ensuring long-term performance. In response to these challenges, the integration of micro synthetic fibers has gained attention as a promising solution for improving the performance characteristics of concrete.

Micro synthetic fibers, primarily made from materials like polypropylene and polyester, offer a range of benefits, including improved crack resistance, enhanced toughness, and better impact absorption. These fibers are lightweight, non-corrosive, chemically stable, and cost-effective, making them an attractive alternative to conventional reinforcements. Their fine diameter and high surface area promote better bonding with the concrete matrix, leading to reduced plastic shrinkage cracks and improved overall durability. Additionally, the incorporation of micro synthetic fibers can lead to enhanced thermal insulation, lower permeability, and greater resistance to environmental degradation.

This research focuses on evaluating the effects of micro synthetic fibers on the properties of M25 grade concrete using Portland Pozzolana Cement (PPC) as the binding agent. The study includes a detailed assessment of workability, compressive strength, early-age strength, and durability through slump cone and strength tests conducted at 7, 14, 21, and 28 days. Various dosages of fibers will be incorporated to identify the optimal content that delivers maximum benefit. The investigation also extends to comparing the performance of fiber-reinforced concrete with conventional mixes and analyzing the economic feasibility of fiber integration.

The overarching objective of this study is to determine whether micro synthetic fibers can serve as a sustainable, high-performance solution for modern construction challenges. With growing demands for durable, cost-effective, and environmentally resilient infrastructure, this research provides critical insights into the practical application of synthetic fibers in concrete. The findings aim to support the broader adoption of fiber-reinforced concrete in infrastructure

projects, especially in applications such as pavements, industrial floors, bridge decks, and earthquake-prone structures where durability and crack resistance are paramount.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. LITERATURE SURVEY

Concrete is one of the most widely used construction materials due to its high compressive strength and durability. However, its inherent weakness in tension and susceptibility to cracking have led to the development of fiber-reinforced concrete. Among the various types of fibers available, synthetic fibers have gained significant attention for their ability to enhance the performance of concrete without the risk of corrosion associated with steel fibers. Researchers have extensively studied different types of synthetic fibers, including polypropylene, polyester, nylon, and polyethylene. Polypropylene fibers are particularly well known for their effectiveness in controlling plastic shrinkage cracks and improving impact resistance. Polyester fibers, on the other hand, contribute to higher tensile strength and chemical resistance, making them suitable for aggressive environments. Nylon fibers enhance abrasion resistance, while polyethylene fibers improve the ductility and energy absorption capacity of concrete.

1. Li et al. (2005)
 - Investigated the effect of polypropylene fibers on early-age cracking in concrete.
 - Found that fiber addition significantly reduced plastic shrinkage cracks.
 - Concluded that micro synthetic fibers improve tensile properties but have minimal impact on compressive strength.
2. Bentur & Mindess (2007)
 - Studied the durability aspects of fiber-reinforced concrete.
 - Reported that micro synthetic fibers enhance resistance to water penetration and sulfate attack.
 - Highlighted that synthetic fibers are more resistant to environmental degradation compared to steel fibers.
3. Siddique & Kaur (2012)
 - Analyzed the mechanical performance of concrete reinforced with polyester and polypropylene fibers.
 - Results showed improvements in flexural strength and impact resistance.
 - Suggested that fiber dispersion plays a key role in achieving uniform strength distribution.
4. Grzybowski & Shah (2013)
 - Focused on the energy absorption capacity of fiber-reinforced concrete.
 - Demonstrated that micro synthetic fibers increase ductility and post-crack load-bearing capacity.
 - Recommended their use in high-impact applications like pavements and overlays.
5. Afroughsabet & Ozbakkaloglu (2015)
 - Conducted an experimental study on hybrid fiber reinforcement in concrete.
 - Found that combining micro synthetic fibers with macro fibers led to superior performance in toughness and crack control.
 - Concluded that hybrid reinforcement provides better overall durability than using a single type of fiber.

Several researchers have explored the potential of micro synthetic fibers in enhancing concrete performance across various construction applications. Banthia and Soleimani (2016) evaluated the use of fiber-reinforced shotcrete in tunneling projects and found that micro synthetic fibers significantly improved adhesion while reducing spalling. Their lightweight nature and resistance to corrosion made them particularly suitable for underground construction environments. Similarly, Kakooei et al. (2017) investigated the long-term durability of polypropylene fiber-reinforced concrete and observed a notable reduction in permeability along with enhanced resistance to freeze-thaw cycles. These properties make micro fibers especially beneficial for infrastructure projects in cold-climate regions. In another study, Thomas and Ramaswamy (2019) focused on the effect of micro synthetic fibers on self-compacting concrete (SCC). Their findings revealed that the inclusion of fibers improved the viscosity and mix stability, making fiber-reinforced SCC a promising option for high-performance structural applications. Furthermore, Jain et al. (2021) analyzed the

economic feasibility of incorporating micro synthetic fibers in large-scale construction. While acknowledging slightly higher initial costs, they concluded that the substantial reduction in long-term maintenance expenses positions micro synthetic fibers as a cost-effective and sustainable choice for modern construction practices. Collectively, these studies highlight the diverse advantages and growing acceptance of micro synthetic fibers in improving the strength, durability, and economy of concrete systems.

Micro synthetic fibers, such as polypropylene and polyester, effectively reduce plastic shrinkage cracks and improve tensile and flexural strength. They have minimal impact on compressive strength but enhance ductility and post-crack load bearing capacity. Studies confirm improved durability, including lower permeability, better resistance to sulfate attack, and enhanced freeze-thaw performance. Their application in specialized areas like shotcrete and self-compacting concrete improves adhesion and stability. Although initial costs may be slightly higher, long-term benefits include reduced maintenance and increased structural longevity. algorithm.

III. METHODOLOGY

The methodology adopted in this project aims to systematically assess the influence of micro synthetic fibers on the mechanical and durability properties of M25 grade concrete. The experimental approach is divided into two main parts: preparation and testing of conventional M25 grade concrete (Part I), and preparation and testing of micro synthetic fiber-reinforced M25 grade concrete (Part II). This allows a comparative analysis to evaluate the benefits and feasibility of fiber incorporation.

Part I: Preparation and Testing of Conventional M25 Grade Concrete

a) **Material Selection:**

Materials were selected as per relevant IS standards to ensure quality and consistency. Portland Pozzolana Cement (PPC) was used for its improved durability and chemical resistance. Fine aggregate (river sand) was chosen to meet IS 383:1970 specifications, and crushed coarse aggregate (20 mm nominal size) was used for strength and density. Clean potable water conforming to IS 456:2000 was used throughout.

b) **Mix Proportion:**

A nominal mix ratio of 1:1:2 (cement:sand:coarse aggregate) was adopted for M25 grade concrete with a water-cement ratio between 0.45–0.50, suitable for PPC.

c) **Casting and Compaction:**

Concrete was mixed using a mechanical mixer for consistency. The mix was placed in 150 mm × 150 mm × 150 mm cube molds in layers, each compacted with a tamping rod and vibrating table to eliminate air voids. Proper surface finishing was done using a trowel.

d) **Curing:**

Specimens were demolded after 24 hours and cured in clean water at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 7, 14, 21, and 28 days to ensure optimal hydration and strength development.

e) **Testing and Quality Control:**

- **Workability:** Measured using the slump cone test as per IS 1199:1959, which yielded a slump value of 135 mm, indicating high workability.
- **Compressive Strength:** Evaluated on the 7th, 14th, 21st, and 28th days as per IS 516:1959 using a Compression Testing Machine (CTM). The results were recorded and used to plot strength gain over time.

Part II: Preparation and Testing of Micro Synthetic Fiber-Reinforced M25 Concrete

a) **Material Selection and Fiber Characteristics:**

Micro synthetic fibers (e.g., polypropylene or polyester), less than 0.3 mm in diameter, were selected for their corrosion resistance, toughness, and dispersion capability. Cement and aggregates were identical to Part I for consistency.

b) **Mixing and Casting:**

Dry materials were first mixed in a concrete mixer, followed by the gradual addition of synthetic fibers to avoid clumping. Water was added slowly to ensure uniform mixing. The resulting mix was poured into molds in layers, compacted carefully to maintain fiber distribution, and finished with a trowel.

c) **Curing Process:**

As with conventional concrete, specimens were cured in water at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 7, 14, 21, and 28 days.

d) Testing and Quality Control:

- **Workability:** The slump cone test indicated a slightly lower slump value compared to conventional concrete, due to the presence of fibers affecting flowability.
- **Compressive Strength:** As per IS 516, compressive strength tests were conducted at each curing interval using CTM. The results were recorded and compared with Part I to observe the effect of fiber inclusion.

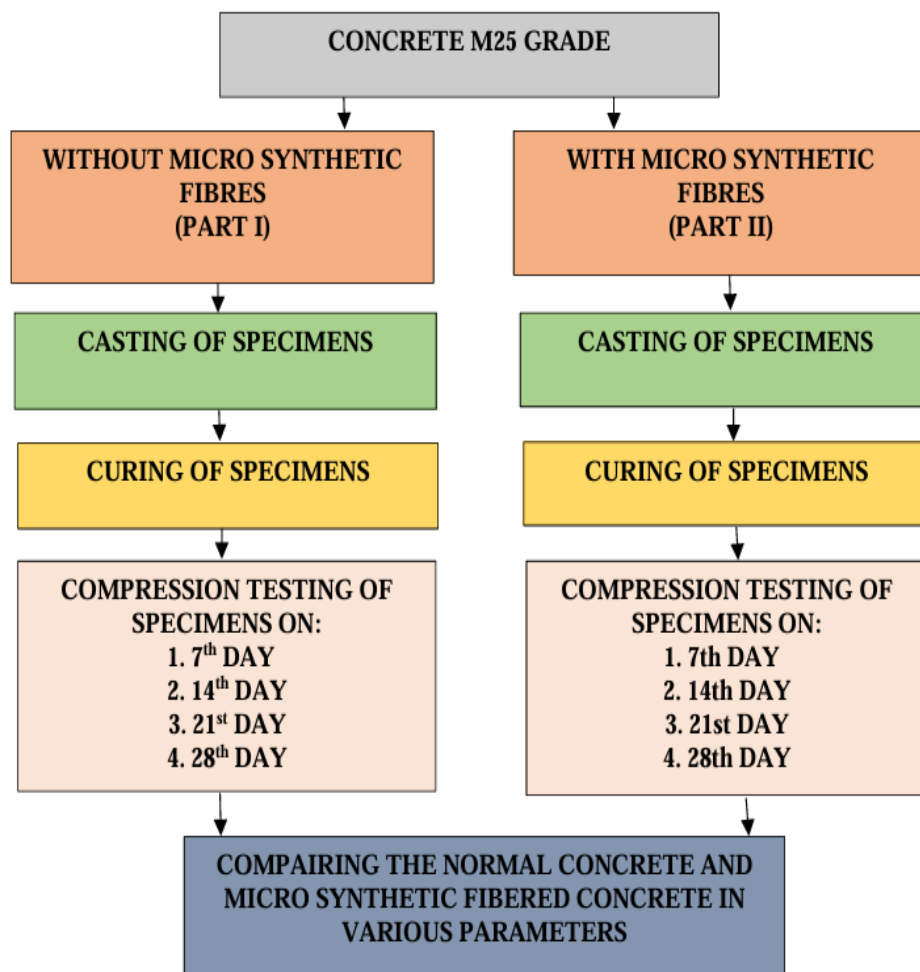


Fig: Flow Of System

Comparative Analysis

The results from both parts were compared on the basis of:

- **Workability** (via slump values),
- **Compressive strength development** (across curing intervals),
- **Observations on mix behavior** (e.g., fiber dispersion, surface finish),
- **Durability aspects** (analyzed through additional tests such as water absorption and sulfate resistance if applicable).

This comparative evaluation allowed determination of the optimal fiber dosage and its practical feasibility in construction applications.

IV. EXPERIMENTAL RESULTS

In this section, we present the results obtained from the experimental study on the incorporation of micro synthetic fibers in M25 grade concrete. The investigation focused on assessing the effects of fiber reinforcement on workability and compressive strength at different curing intervals—7, 14, 21, and 28 days. The results provide insights into the potential of micro synthetic fibers to enhance the mechanical performance and durability of concrete.

Workability Test**➤ Slump Value Comparison**

The workability of the concrete mixes was evaluated using the slump cone test, which measures the consistency and ease of placement of the fresh concrete.

Concrete Type	Slump Value (mm)
Normal M25 Concrete	135
Micro Synthetic Fiber Concrete	110

Normal Concrete:

The slump value of 135 mm for conventional M25 concrete indicates a high level of workability, making it easy to mix, handle, and place. The mix had a smooth consistency with no signs of segregation or bleeding.

Fiber-Reinforced Concrete:

The fiber-reinforced concrete exhibited a reduced slump of 110 mm. The presence of micro synthetic fibers increased internal friction, resulting in a stiffer mix with slightly reduced flowability. This outcome is typical in fiber-reinforced mixes due to the obstruction fibers create against the free movement of concrete particles.

Observation:

Although the workability decreased with the addition of fibers, the mix remained workable and suitable for construction, provided adequate compaction techniques are applied.

Compressive Strength Test

Compressive strength tests were conducted to evaluate the strength development of both normal and fiber-reinforced M25 concrete over time. Results are tabulated below:

Curing Period	Normal Concrete (MPa)	Fiber-Reinforced Concrete (MPa)
7 Days	15.0	17.0
14 Days	20.0	21.4
21 Days	23.0	24.8
28 Days	24.5	28.5

Normal Concrete:

The strength of conventional M25 concrete increased steadily with curing time, reaching 24.5 MPa on the 28th day, consistent with the design target.

Micro Synthetic Fiber Concrete:

The fiber-reinforced mix demonstrated improved strength at all curing stages. At 28 days, it reached 28.5 MPa—an enhancement of approximately 8–10% compared to the control mix.

Evaluation:

The improved performance of the fiber-reinforced concrete can be attributed to the fiber's ability to bridge micro-

cracks, restrain crack propagation, and improve the post-cracking behavior of the matrix. This resulted in enhanced compressive strength, particularly at early and later stages of curing.

Summary of Key Findings

- **Workability:** Slight reduction observed due to fibers, but still within an acceptable range for practical applications.
- **Compressive Strength:** Micro synthetic fibers contributed to better strength gain across all curing stages, with the most significant gain seen at 28 days.
- **Performance Insight:** The addition of micro synthetic fibers positively influenced the structural integrity and durability potential of M25 concrete.

SR.NO	DAY	AVERAGE STRENGTH OF NORMAL CONCRETE (M25 GRADE)	AVERAGE STRENGTH OF MICRO SYNTHETIC FIBEROUS CONCRETE (M25 GRADE)
1	7	15 MPa	17 MPa
2	14	20 MPa	21.4 MPa
3	21	23 MPa	24.8 MPa
4	28	25.5 MPa	28.5 MPa

Comprehensive Strength Test Results

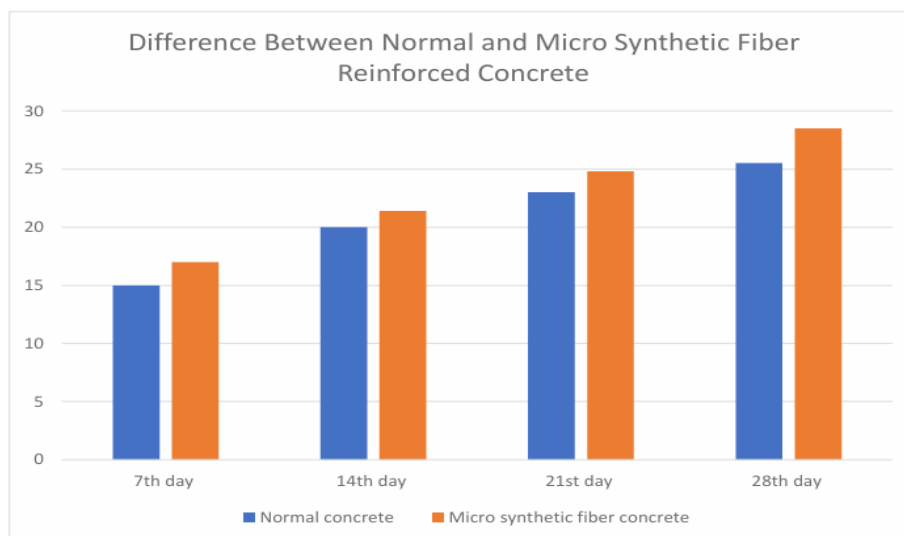


Fig: Result Comparison Graph

V. CONCLUSION

The experimental investigation into the use of micro synthetic fibers in concrete has demonstrated notable enhancements in the mechanical and durability properties of the material. The incorporation of micro synthetic fibers resulted in a significant improvement in compressive strength, with an observed increase of approximately 8–10% over conventional concrete at 28 days, indicating enhanced load-bearing capacity. While the fiber addition led to a reduction in workability, as evidenced by lower slump values, this limitation can be effectively mitigated through the use of superplasticizers. Importantly, the presence of fibers played a crucial role in controlling micro-cracks and reducing shrinkage-induced cracking, thereby improving the overall crack resistance and extending the service life of the concrete. Furthermore, micro synthetic fiber-reinforced concrete exhibited superior early-age strength at 7, 14, and 21 days, making it especially suitable for fast-track construction projects where early strength gain is critical. The study also revealed enhancements in toughness and ductility, reducing the inherent brittleness of concrete and making it more resilient to dynamic loads and sudden impacts. These performance improvements position micro synthetic fiber-reinforced concrete as a viable and effective material for a range of structural applications, including pavements, bridge decks, industrial floors, and earthquake-resistant infrastructure, where strength, durability, and crack resistance are essential.

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