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Experimental Investigation on Fresh and Hardened Properties of Polyester Fiber Reinforced Concrete

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ABSTRACT: The present research aims to experimentally investigate the effect of polyester fiber on the fresh and hardened properties of M30 grade concrete with the objective of enhancing its mechanical performance and crack resistance. Conventional concrete possesses high compressive strength but exhibits relatively low tensile strength due to its brittle nature. The incorporation of polyester fibers is an effective technique to improve the ductility, toughness, and durability of concrete by controlling crack propagation.

In the present experimental investigation, polyester fibers were incorporated into M30 grade concrete at varying dosages of 0%, 0.4%, 0.8%, and 1.2% by weight of cement. The fresh property of concrete was evaluated using the slump cone test, while the hardened properties were determined through compressive strength, tensile strength after 7 and 28 days of water curing. The experimental results indicated that the addition of polyester fibers improved the overall mechanical performance of concrete up to an optimum dosage of 0.8%. At this fiber content, the concrete exhibited the highest compressive, split tensile, and flexural strengths compared to conventional concrete. A slight reduction in strength was observed at 1.2% fiber dosage due to reduced workability and non-uniform fiber distribution; however, the strength remained higher than that of the control mix. The study confirms that polyester fiber is a promising reinforcing material for producing durable, crack-resistant, and high-performance concrete suitable for modern construction applications.

KEYWORDS: Polyester Fiber, Fiber Reinforced Concrete, M30 Grade Concrete, Workability, Compressive Strength, Tensile Strength, Flexural Strength, Crack Resistance, Hardened Properties

I. INTRODUCTION

Concrete is the most widely used construction material worldwide due to its excellent compressive strength, durability, and ease of construction. However, despite these advantages, conventional concrete exhibits relatively low tensile strength, flexural strength, and ductility, making it susceptible to cracking under tensile stresses and repeated loading conditions. To overcome these limitations, researchers have increasingly focused on incorporating fibers into concrete to improve its mechanical performance and long-term durability. Among the various synthetic fibers available, polyester fiber has gained considerable attention because of its high tensile strength, excellent chemical resistance, low water absorption, and ability to effectively control crack propagation.

The growing demand for durable and sustainable construction materials has encouraged the development of fiber reinforced concrete (FRC), which enhances the structural performance of conventional concrete without significantly altering the production process. Polyester fibers act as micro-reinforcement within the cement matrix by bridging microcracks and delaying their propagation, thereby improving the toughness, impact resistance, and post-cracking behavior of concrete. In addition, polyester fibers reduce plastic shrinkage cracking, improve energy absorption capacity, and enhance the overall service life of concrete structures. These characteristics make polyester fiber reinforced concrete particularly suitable for pavements, industrial floors, bridge decks, precast elements, and other structures subjected to dynamic loading and harsh environmental conditions.

The present experimental investigation evaluates the influence of polyester fiber on the fresh and hardened properties of M30 grade concrete. Polyester fibers were incorporated at different dosages of 0%, 0.4%, 0.8%, and 1.2% by weight of cement to determine their effect on workability and mechanical properties. The fresh properties were assessed using the slump cone test, while the hardened properties were evaluated through compressive strength, split tensile strength, and flexural strength tests after 7 and 28 days of water curing in accordance with relevant Indian Standard (IS) specifications. The experimental results were compared with conventional concrete to identify the optimum fiber dosage and to evaluate the effectiveness of polyester fibers in improving the performance of concrete.

1.1 Need of Study:

The rapid growth of infrastructure and urbanization has led to a significant increase in the consumption of concrete, making it one of the most widely used construction materials worldwide. Although conventional concrete possesses high compressive strength, it is inherently brittle and exhibits relatively low tensile and flexural strength, making it vulnerable to crack formation and propagation under service loads. These limitations reduce the durability and service life of concrete structures, thereby increasing maintenance and repair costs. Hence, there is a growing need to develop concrete with improved mechanical performance, crack resistance, and long-term durability.

In recent years, fiber reinforced concrete (FRC) has emerged as an effective solution for enhancing the performance of conventional concrete. Among the various synthetic fibers, polyester fiber has attracted considerable attention due to its high tensile strength, excellent chemical resistance, low water absorption, lightweight nature, and superior crack-bridging capability. The inclusion of polyester fibers in concrete helps control plastic and drying shrinkage cracks, improves post-cracking behavior, increases toughness, and enhances resistance to impact and fatigue loading. These characteristics make polyester fiber reinforced concrete a promising material for modern structural and pavement applications.

II. LITERATURE SURVEY

Karthikeyan K. R. et al. (2024) investigated the performance of fiber-reinforced concrete using synthetic polyester fibers in M25 grade concrete. The study aimed to improve the mechanical properties, crack resistance, and durability of conventional concrete, which is inherently brittle and weak in tension. Polyester fibers were incorporated in varying proportions by weight of cement, and experimental investigations were conducted to evaluate compressive strength, flexural strength, tensile strength, workability, water absorption, and durability characteristics. The results demonstrated that the inclusion of polyester fibers significantly enhanced crack resistance, toughness, and post-crack behavior of concrete. An optimum fiber content was observed, beyond which workability reduced due to fiber interlocking. Microstructural analysis indicated effective fiber–matrix bonding and uniform fiber distribution, contributing to improved mechanical performance. The authors concluded that polyester fiber reinforced concrete is a sustainable, cost-effective alternative suitable for structural applications requiring enhanced ductility and durability.

Ali et al. (2020) investigated the effect of polyester fiber on the workability properties of high-strength concrete (HSC). The study aimed to control excessive workability and bleeding in HSC produced using a polycarboxylic ether-based superplasticizer (BASF Master Polyheed 996). A target compressive strength of 60–63 MPa was achieved at 28 days with a water–cement ratio of 0.33. Polyester fibers of 32 mm length were added in varying proportions of 0.2%, 0.3%, 0.4%, and 0.5% by weight of cement. Slump cone tests revealed that workability decreased linearly with increasing fiber content. The slump value reduced from 178 mm for control mix to 76 mm at 0.5% fiber dosage, corresponding to a reduction of 14%–57%. The reduction was attributed to fiber obstruction, water absorption, and reduced mobility of concrete constituents. The authors concluded that polyester fibers are effective in controlling bleeding and shrinkage in HSC but require careful dosage optimization to maintain acceptable workability.

Alex Tharun P. J. et al. (2018) studied the strength characteristics of polyester fiber reinforced concrete with partial replacement of cement by fly ash. The study aimed to overcome the low tensile strength and brittle nature of conventional concrete. M30 grade concrete was prepared using 53-grade OPC with 10% fly ash replacement and varying polyester fiber content from 0% to 0.1%. Experimental investigations included workability, compressive strength, split tensile strength, flexural strength, impact resistance, and modulus of elasticity. Results showed that workability decreased with increasing fiber content, while significant improvements were observed in mechanical

properties. Compressive strength increased by about 21.5%, split tensile strength by 65.5%, and flexural strength by 66.66% at optimum fiber dosage. Impact resistance and ductility also improved, whereas modulus of elasticity slightly decreased. The study concluded that polyester fiber with fly ash produces stronger, durable, and economical concrete.

Ramakrishna Hegde et al. (2018) carried out an experimental investigation on the utilization of polyester fibres to enhance the mechanical properties of concrete. Polyester fibres were added as a partial replacement of cement in proportions of 0.20%, 0.40%, and 0.60%. The study evaluated compressive strength, split tensile strength, and flexural strength at 7, 14, and 28 days. Experimental results revealed that the inclusion of polyester fibres significantly improved the strength characteristics of concrete up to an optimum fibre content of 0.40%. At this dosage, maximum compressive strength of 25.49 N/mm², flexural strength of 10.98 N/mm², and split tensile strength of 2.846 N/mm² were achieved at 28 days. Beyond the optimum fibre content, a reduction in strength was observed due to poor bonding and fibre congestion. The authors concluded that polyester fibres improve ductility, crack resistance, and toughness of concrete and can be effectively used as secondary reinforcement, leading to cost savings and enhanced durability.

T. V. Chandra Sekhar (2018) conducted an experimental study to evaluate the mechanical properties of concrete incorporating artificial polyester fibers and natural coconut fibers as partial replacement materials. The study aimed to overcome the brittle nature and low tensile strength of conventional concrete by introducing short, randomly distributed fibers. M20 grade concrete was prepared with polyester fiber content varying from 0.5% to 2.0% and coconut fiber content from 0.5% to 2.5% by weight of cement. Experimental investigations included workability, compressive strength, split tensile strength, and flexural strength tests at 7, 14, and 28 days. Results indicated that workability decreased with increasing fiber dosage due to obstruction in concrete flow. However, significant improvements were observed in mechanical properties up to optimum fiber contents. The optimum dosage was found to be 1.5% for polyester fiber and 2.0% for coconut fiber. Beyond these levels, strength values declined due to fiber clustering. The study concluded that both polyester and coconut fibers effectively enhance strength and ductility of concrete when used in optimum proportions.

III. OBJECTIVE OF STUDY

1. To study the effect of polyester fiber on the fresh properties of M30 grade concrete, including workability and slump characteristics.
2. To investigate the influence of different percentages of polyester fiber (0%, 0.4%, 0.8%, and 1.2%) on the hardened properties of concrete, namely compressive strength, tensile strength.
3. To determine the optimum percentage of polyester fiber that provides the maximum improvement in the mechanical properties of concrete.
4. To compare the performance of polyester fiber reinforced concrete with conventional concrete by evaluating the improvements in strength, crack resistance, toughness, and overall structural behavior.
5. To evaluate the suitability and practical application of polyester fiber reinforced concrete for durable, crack-resistant, and sustainable construction.

IV. MATERIALS USED

4.1 Cement:

Cement, one of the most important building materials, is a binding agent that sets and hardens to adhere to building units such as stones, bricks, tiles, etc. Cement generally refers to a very fine powdery substance chiefly made up of limestone (calcium), sand or clay (silicon), bauxite (aluminum), and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. The raw ingredients are processed in cement manufacturing plants and heated to form a rock-hard substance, which is then ground into a fine powder to be sold. Cement mixed with water causes a chemical reaction and forms a paste that sets and hardens to bind individual structures of building materials.

4.2 Coarse Aggregate:

Coarse aggregates are granular materials. It is often used in construction for concrete making. Its major composition includes crushed stone, gravel, or recycled concrete. Coarse aggregates typically account for more than 60-80% of the volume of the concrete. Their durability depends on the quality of the coarse aggregate, significantly impacting the

strength and workability of the concrete. Coarse aggregates are classified as those larger than 4.75 mm according to sieve analysis, with a common diameter range between 3/8 inch (approximately 9.5 mm) and 1.5 inch (approximately 38 mm).

4.3 Fine Aggregate:

Fine aggregate plays a vital role in concrete by filling the voids between coarse aggregate particles and producing a dense, workable, and durable concrete matrix. In the present study, Manufactured Sand (M-Sand) was used as the fine aggregate instead of natural river sand. M-Sand is an artificially produced fine aggregate obtained by crushing hard granite rocks into fine particles using advanced crushing and screening techniques. Due to the increasing depletion of natural river sand and environmental concerns associated with river sand mining, M-Sand has become a sustainable and economical alternative in concrete production.

4.4 Water:

Water that is safe for drinking is generally considered suitable for use in concrete production. Such water ensures proper cement hydration, which is the chemical process responsible for the hardening and strength development of concrete. In addition to initiating hydration, mixing water also functions as a lubricant, allowing the ingredients—cement, aggregates, and admixtures—to blend uniformly and achieve the required workability. It is essential that the water used in concrete be free from harmful contaminants. Substances such as acids, oils, alkalis, salts, sugars, and organic materials can interfere with the hydration process, reduce bonding between cement and aggregates, or introduce undesirable chemical reactions. These effects may lead to reduced strength, delayed setting, or long-term deterioration of the concrete. Even the use of very soft water can be problematic, as its low mineral content may result in weaker concrete compared to mixes prepared with moderately hard water.

4.5 Polyester Fiber:

Polyester fiber is a synthetic fiber manufactured from polyethylene terephthalate (PET), a polymer obtained through the chemical reaction of purified terephthalic acid and ethylene glycol. Due to its excellent tensile strength, durability, corrosion resistance, and low water absorption characteristics, polyester fiber is widely used as a reinforcing material in concrete. In the present study, polyester fibers were incorporated into the concrete mix to improve its fresh and hardened properties. The fibers were randomly distributed throughout the concrete matrix, providing three-dimensional reinforcement and enhancing crack resistance. Polyester fibers help in controlling plastic shrinkage cracks, reducing crack propagation, increasing toughness, and improving the post-cracking behavior of concrete. The addition of polyester fibers improves the tensile and flexural strength of concrete by bridging micro-cracks developed during loading. These fibers also enhance impact resistance, energy absorption capacity, and durability of concrete structures. Unlike steel fibers, polyester fibers are non-corrosive, lightweight, chemically stable, and easy to handle during mixing.

4.6 Applications of Polyester Fiber:

1. INDUSTRIAL FLOORS: USED IN FACTORIES, WAREHOUSES, AND WORKSHOPS TO IMPROVE ABRASION RESISTANCE AND MINIMIZE SHRINKAGE CRACKING.
2. RIGID PAVEMENTS: APPLIED IN HIGHWAYS, AIRPORT RUNWAYS, AND PARKING AREAS TO ENHANCE CRACK RESISTANCE, FATIGUE PERFORMANCE, AND DURABILITY UNDER REPEATED TRAFFIC LOADS.
3. BRIDGE DECKS: IMPROVES FLEXURAL STRENGTH AND REDUCES CRACK FORMATION CAUSED BY DYNAMIC LOADING AND ENVIRONMENTAL EFFECTS.
4. PRECAST CONCRETE ELEMENTS: SUITABLE FOR PIPES, BLOCKS, SLABS, PANELS, AND WALL SECTIONS BY IMPROVING STRENGTH AND REDUCING HANDLING DAMAGE.
5. RESIDENTIAL AND COMMERCIAL BUILDINGS: USED IN BEAMS, COLUMNS, SLABS, AND FOUNDATIONS TO ENHANCE TOUGHNESS AND REDUCE SHRINKAGE CRACKS.
6. TUNNEL LININGS AND UNDERGROUND STRUCTURES: PROVIDES BETTER CRACK CONTROL, IMPACT RESISTANCE, AND LONG-TERM DURABILITY UNDER SEVERE SERVICE CONDITIONS.
7. WATER RETAINING STRUCTURES: USED IN RESERVOIRS, WATER TANKS, CANALS, AND SEWAGE TREATMENT PLANTS TO REDUCE PERMEABILITY AND IMPROVE CRACK RESISTANCE.
8. Marine Structures: Suitable for jetties, docks, ports, and coastal structures due to its excellent resistance to corrosion, moisture, and aggressive environments.
9. Shotcrete and Repair Works: Improves adhesion, toughness, and resistance to shrinkage, making it suitable for repair and rehabilitation of damaged concrete structures.



Fig. 1: Polyester Fiber

v. MIX DESIGN

Concrete mix was designed for M30 grade as per IS 10262:2019 standards by trail mix for 1 m³ of concrete. Polyester fiber was additive used to cement by weight in the following proportions: 0% (conventional), 0.4%, 0.8% and 1.2%.

Water (Kg/m ³)	Cement (Kg/m ³)	Fine Aggregate / M-Sand (Kg/m ³)	Coarse Aggregate (Kg/m ³)
197.16	469.43	628.23	1146.83
0.42	1	1.33	2.44

Table 1: Mix Proportions

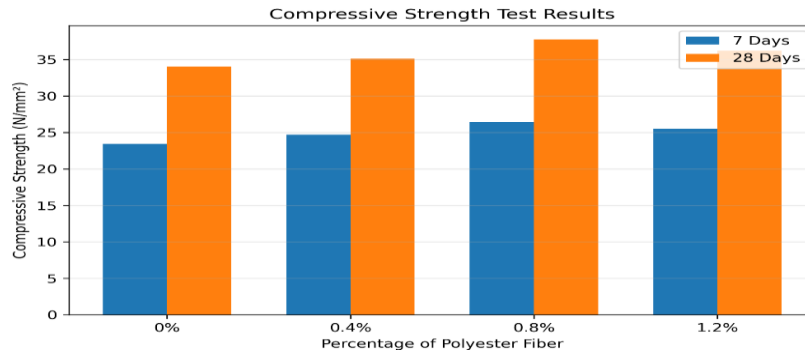
vi. RESULTS AND DISCUSSION

6.1 Compressive Strength Test:

Compressive strength is defined as the ability of a material or structural component to resist axial compressive forces that tend to reduce its dimensions. Test is done according to IS code specification IS 516:1959. To determine the compressive strength, cube mould of size 150x150x150 mm were casted. Cubes were prepared and tested at 7 and 28 days of curing in water. A gradual load is applied on the surface of the cube to obtain maximum compressive load. The cubes are tested under universal testing machine (UTM). Readings are noted and graphs are drawn. The results of compressive strength at the age of 7 and 28 days are shown.

Sr. No.	Percentage of Polyester Fiber	Compressive Strength (N/mm ²)	
		7 Days	28 Days
1.	0%	23.45	34.05
2.	0.4%	24.70	35.12
3.	0.8%	26.47	37.78
4.	1.2%	25.53	36.22

Table 2: Results of Compressive Tests



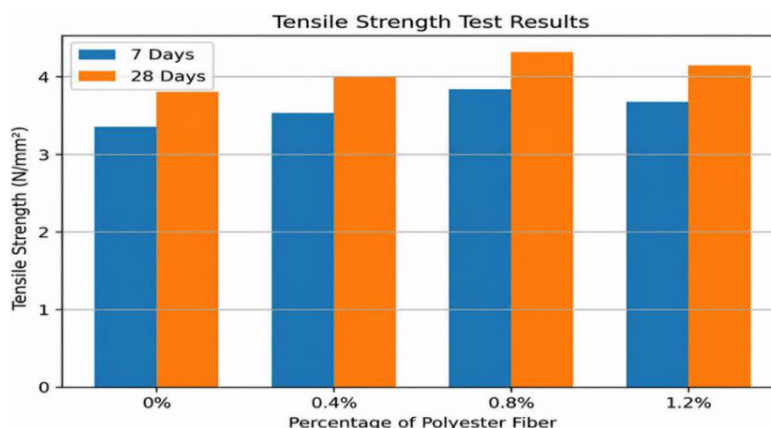
Graph 1: Compressive Strength Tests

6.2 Tensile Strength Test:

The tensile strength test is a critical mechanical evaluation technique used to analyze how materials respond when subjected to uniaxial tensile loads. It plays a significant role in determining a material's capacity to resist stretching forces without experiencing irreversible deformation or failure. Commonly expressed as the ultimate tensile strength (UTS), this parameter indicates the maximum stress a material can withstand before it fractures. This test is essential for material selection, quality assurance, and optimizing manufacturing techniques. During testing, a standardized specimen is exposed to a progressively increasing tensile force while monitoring its elongation. The results provide valuable information regarding the strength, ductility, and overall mechanical reliability of the material, supporting its suitability for structural and industrial applications.

Sr. No.	Percentage of Polyester Fiber	Tensile Strength (N/mm ²)	
		7 Days	28 Days
1.	0%	3.36	3.81
2.	0.4%	3.54	4.00
3.	0.8%	3.84	4.31
4.	1.2%	3.68	4.15

Table 3: Results of Tensile Strength Tests



Graph 2: Tensile Strength Tests

VII. CONCLUSION

• Compressive Strength at the Age of 7 Days

1. The compressive strength of conventional concrete (0% polyester fiber) was found to be 23.46 N/mm² for M30 grade concrete.
2. The compressive strength of concrete containing 0.4% polyester fiber was found to be 24.71 N/mm², which is about 5.33% higher than the conventional concrete.
3. The compressive strength of concrete containing 0.8% polyester fiber was found to be 26.42 N/mm², showing an increase of about 12.62% over the conventional concrete. This indicates the optimum fiber dosage for improving compressive strength.
4. The compressive strength of concrete containing 1.2% polyester fiber was found to be 25.53 N/mm², which is about 8.82% higher than the conventional concrete. Although the strength decreased slightly compared to the 0.8% mix, it remained higher than the control concrete.

• Compressive Strength at the Age of 28 Days

1. The compressive strength of conventional concrete (0% polyester fiber) was found to be 34.05 N/mm².
2. The compressive strength of concrete containing 0.4% polyester fiber was found to be 35.12 N/mm², representing an increase of about 3.14% over the conventional concrete.
3. The compressive strength of concrete containing 0.8% polyester fiber was found to be 37.78 N/mm², representing an increase of about 10.96% compared to the conventional concrete.

• Tensile Strength at the Age of 7 Days

1. The tensile strength of conventional concrete was found to be 3.36 N/mm².
2. The tensile strength of concrete containing 0.4% polyester fiber was 3.54 N/mm², showing an increase of about 5.36%.
3. The tensile strength of concrete containing 0.8% polyester fiber was 3.84 N/mm², showing an increase of about 14.29% compared to the control mix.
4. The tensile strength of concrete containing 1.2% polyester fiber was 3.68 N/mm², representing an increase of about 9.52% over conventional concrete.

• Tensile Strength at the Age of 28 Days

1. The tensile strength of conventional concrete was found to be 3.81 N/mm².
2. The tensile strength of concrete containing 0.4% polyester fiber was 4.00 N/mm², showing an increase of about 4.99%.
3. The tensile strength of concrete containing 0.8% polyester fiber was 4.31 N/mm², representing an increase of about 13.12% over the control concrete.
4. The tensile strength of concrete containing 1.2% polyester fiber was 4.15 N/mm², showing an increase of about 8.92% compared to conventional concrete.

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