A STUDY ON STRENGTHENING OF M20 MIX CONCRETE BY USING POLYPROPYLENE FIBER (RECRON)

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ABSTRACT: *The incorporation of polypropylene fibre in concrete is an emerging solution to overcome the limitations of conventional concrete, particularly in terms of brittleness, low tensile strength, and susceptibility to cracking. This study investigates the effect of polypropylene fibre on the mechanical performance of M20 grade concrete. Mechanical tests such as compressive strength and split tensile strength were conducted at 7, 14, and 28 days to examine the influence of fibre inclusion on strength development. Concrete is one of the most widely used construction materials due to its high compressive strength; however, its low tensile strength and brittle nature often lead to cracking and reduced durability. This study focuses on the* ***strengthening of M20 grade concrete using polypropylene fibre (Recron)*** *as a reinforcing admixture. An experimental investigation was carried out by incorporating varying percentages of polypropylene fibres (0%, 0.25%, 0.5%, and 0.75%) into the concrete mix to determine the optimum fibre content.The results indicate that the inclusion of polypropylene fibres significantly improves the compressive, tensile, and flexural strength of concrete, while also enhancing crack resistance and durability.*

INTRODUCTION

1.1 GENERAL

Concrete is the most widely used construction material in the world, yet its brittle nature and susceptibility to cracking remaining major limitations in structural applications. To overcome these challenges, researchers have increasingly focused on Fiber-reinforced concrete (FRC), where Fibers are incorporated into the cementitious matrix to improve its mechanical performance, durability, and crack resistance. Among the various Fibers available, polypropylene Fibers have gained significant attention due to their chemical stability, low cost, and ease of incorporation. However, conventional polypropylene Fibers often exhibit limitations in bonding efficiency and mechanical contribution, prompting the need for modifications in Fiber properties.

Modified polypropylene Fibers, through surface treatments or structural alterations, are designed to enhance Fiber–matrix interaction and improve the overall performance of concrete. Evaluating the effectiveness of these modifications requires not only experimental testing but also robust statistical analysis to validate results and establish reliability. Statistical tools help in identifying significant differences, correlations, and trends across multiple test parameters, ensuring that conclusions are scientifically sound.

The study not only contributes to the understanding of Fiber-reinforced concrete but also demonstrates the importance of statistical validation in civil engineering research. Through systematic evaluation using SPSS, the project seeks to provide reliable insights into the role of modified polypropylene Fibers in enhancing concrete performance, thereby supporting the development of more durable and sustainable construction materials.

1.2 HISTORY OF CONCRETE

Concrete is a composite material and combination of fine and coarse aggregate bonded together with a fluid cement that hardens over time. Concrete is the very important substance in the world after water, and is the generally used building material. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Concrete is probable to be a key material for structures resilient to climate disasters, as well as a solution to ease the pollution of other industries, taking wastes such as coal fly ash or bauxite tailings and residue. When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts with the water through a process called concrete hydration that hardens over several hours to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. This time allows concrete to not only be cast in forms but also to have a variety of tooled processes preformed. The hydration process is exothermic, which means ambient temperature plays a significant role in how long it takes concrete to set. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix, delay or accelerate the curing time, or otherwise change the finished material. Most concrete is poured with reinforcing materials to provide tensile strength, yielding reinforced concrete. In the past, lime-based cement binders, such as lime putty, were normally used but sometimes with other hydraulic cements, such as calcium aluminate cement or with Portland cement to form Portland cement concrete. Many other non-cementitious types of concrete exist with other methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is used for road surfaces, and polymer concretes that use polymers as a binder. Concrete is distinct from mortar. Whereas concrete is itself a building material, mortar is a bonding agent that holds bricks, tiles and other masonry units together.

1.3 ABOUT POLYPROPYLENE FIBERS ?

Polypropylene Fibers are synthetic Fibers made from thermoplastic polymer polypropylene, widely used in concrete to improve durability, reduce cracking, and enhance resistance to impact, abrasion, and chemical attack. They are lightweight, cost-effective, and increasingly adopted in civil engineering projects across India and globally

- **Material**: Derived from polypropylene, a thermoplastic polymer.

- **Form**: Fine, hair-like synthetic Fibers added to concrete mixes.

- **Purpose**: Act as reinforcement to control micro-cracks and improve structural performance.

Fig. 1.0 Polypropylene Fiber

Table 1.1 Properties of Polypropylene Fibers

PROPERTY	POLYPROPYLENE
Fiber Type	Single Type
Length (mm)	6, 12, 20
Diameter (mm)	0.034
Density	9.1
Tensile Strength (MPa)	500 - 700
Thickness (mm)	0.6
Melting point (°C)	160
Width (mm)	1.1

1.4 PROPERTIES OF POLYPROPYLENE FIBERS?

Polypropylene Fibers are synthetic, thermoplastic Fibers with a unique combination of physical, thermal, chemical, and mechanical properties that make them highly valuable in civil engineering and textile applications. Physically, they are extremely lightweight (density ~0.91 g/cm^3), hydrophobic, and flexible, which means they do not absorb water and disperse easily in concrete mixes. Thermally, they have a relatively low melting point (160–170°C) but excellent insulation due to their very low thermal conductivity, making them warmer than many natural Fibers. Chemically, they are highly resistant to acids, alkalis, and most solvents, and being noncorrosive, they do not rust or degrade in aggressive environments. Mechanically, they offer good toughness, abrasion resistance, and impact resistance, though they do not contribute significantly to tensile strength compared to steel Fibers.

1.5 USES OF POLYPROPYLENE FIBERS

Polypropylene Fibers are widely used in concrete and cement-based materials to improve performance and durability. When mixed with fresh concrete, these Fibers form a three dimensional network that controls plastic shrinkage and settlement cracks at an early age, which are common causes of durability problems. They improve the tensile and flexural behaviour of concrete by bridging micro-cracks, thereby increasing resistance to impact, abrasion, and fatigue. This makes polypropylene Fiber reinforced concrete especially suitable for floor slabs, pavements, industrial floors, and warehouse slabs subjected to repeated loads. In precast concrete elements such as blocks, pipes, panels, and tiles, the Fibers help maintain dimensional stability and reduce handling damage. In shotcrete and tunnel linings, polypropylene Fibers improve cohesion, reduce rebound losses, and enhance structural integrity. They are also used in mortar, plaster, and repair works to minimize surface cracking and improve bond strength. Additionally, polypropylene Fibers enhance fire resistance by melting at high temperatures and creating micro channels that relieve internal vapor pressure, thereby reducing explosive spalling and improving the safety and service life of concrete structures.

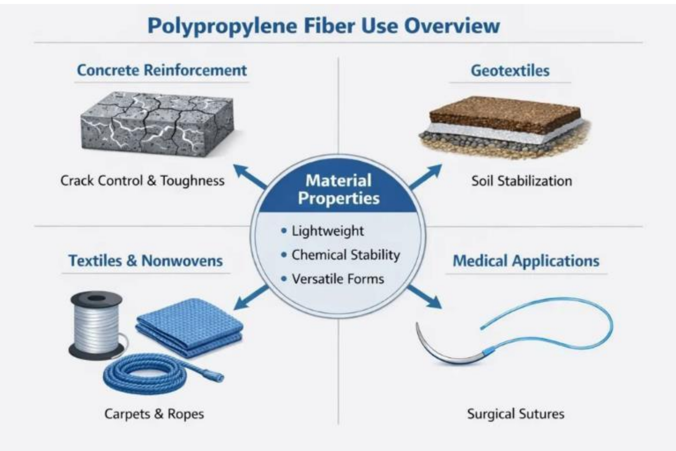

Fig. 1.1 Uses of Polypropylene Fibers

1.6 APPLICATIONS OF POLYPROPYLENE FIBERS

The polypropylene fibres find applications in ventilated facade skudo, Precast Concrete Blocks for Roads and Pavements, Concrete Flooring, high ways. Some of the applications are shown in Figures 1.2 to 1.3 .

Fig.1.2 Polypropylene reinforced precast blocks

Fig.1.3 Polypropylene fiber ventilated façade SKUDO

1.7 WHY POLYPROPYLENE IS PREFERRED IN CONCRETE?

It is estimated that more than 60% of polypropylene waste is not effectively recycled and ends up in landfills or the natural environment. Because polypropylene is non-biodegradable, it can persist in the environment for hundreds of years, contributing to soil, water, and marine pollution. In developing countries, improper waste management further increases the accumulation of polypropylene waste.

The main advantage of using (waste) polypropylene Fibers is their ability to control plastic shrinkage and early-age cracking. During the initial setting period, concrete is vulnerable to micro-cracks caused by rapid evaporation of water. Waste polypropylene Fibers form a randomly distributed Fiber network within the concrete matrix, which restrains shrinkage and bridges micro-cracks, preventing them from developing into visible cracks.

Waste polypropylene Fibers are chemically inert, non-corrosive, and moisture resistant, so they do not react with cement or aggressive chemicals. Unlike steel Fibers, they do not rust, which enhances the long-term durability of concrete, especially in environments exposed to water, chlorides, or sulphates. Their low water absorption also helps reduce bleeding and segregation, leading to a more uniform and dense concrete mix.

1.8 OBJECTIVES OF PROJECT

• To find the optimum strength characteristics of polypropylene Fiber in terms of workability and strength.

• To Compare the Normal concrete and Fiber reinforced concrete.

• To design and develop M30 grade Polypropylene Fiber Reinforced Concrete (PPFRC) with varying fiber volume fractions (0%, 0.25%, 0.50%, 0.75%).

• To analyze the influence of polypropylene fibers on mechanical performance.

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• **To identify the optimum fiber dosage** that provides maximum improvement in mechanical strength without compromising workability.

LITERATURE REVIEW

2.1 GENERAL

A literature review is a comprehensive analysis and synthesis of existing scholarly research on a specific topic. Rather than reporting new original work, its primary goal is to situate current research within the broader academic landscape, identifying patterns, trends, and knowledge.

2.2 LITERATURE REVIEW

Some of the papers that are referred during the project work are given below:

1. Alhozaimy et al. (1995) focused on the mechanical characteristics of polypropylene fiber reinforced concrete (PFRC) and the specific role of pozzolanic materials in the mix. The authors observed that the addition of pozzolans helps in densifying the interfacial transition zone between the fibers and the cement paste. This refinement leads to improved bonding, which effectively increases the flexural toughness and impact resistance of the composite compared to traditional fiber-reinforced mixes.

2. ASTM C39 (2020) serves as the definitive standard test method for determining the compressive strength of cylindrical concrete specimens. This protocol outlines the specific requirements for specimen preparation, curing, and the application of compressive loads. Adherence to this standard is fundamental in research and industry to ensure that strength data is reproducible and can be safely used for structural design and quality assurance.

3. ASTM C494 (2019) provides the essential specifications for chemical admixtures used in concrete, categorizing them into seven distinct types including water-reducers, retarders, and accelerators. This standard establishes the performance criteria that admixtures must meet to be considered effective, ensuring that chemical additives used in experimental concrete mixes do not adversely affect the long-term properties of the cementitious matrix.

4. Ahmadi and Shekarchi (2010) explored the potential of natural zeolite as a supplementary cementitious material (SCM) to replace a portion of Portland cement. Their research focused on the environmental and mechanical benefits of zeolite, discovering that its high reactive silica content contributes to a strong pozzolanic reaction. The study concluded that 10% to 15% cement replacement with zeolite can lead to significant improvements in sulfate resistance and overall durability.

5. Ahmadi-Nedushan (2012) developed advanced computational models to predict the elastic modulus of both normal and high-strength concrete. By utilizing Adaptive NeuroFuzzy Inference Systems (ANFIS) and optimal nonlinear regression, the author demonstrated that these AIdriven models could outperform traditional empirical equations. The research provides a reliable framework for engineers to estimate stiffness based on mix proportions without the need for destructive testing.

6. Eskandari et al. (2015) investigated the hybrid influence of nano-silica and micro-zeolite on the mechanical and durability properties of concrete. The researchers aimed to leverage the high surface area of nano-materials alongside the pozzolanic capacity of zeolite. The results showed a "filler effect" where the nano-particles occupied the voids between zeolite and cement grains, resulting in an exceptionally dense and high-strength concrete matrix.

7. Emam and Yehia (2017) evaluated the performance of concrete incorporating zeolite as a sustainable supplementary cementitious material. Their work focused on balancing mechanical strength with the ecological benefits of reduced cement consumption. The study confirmed that zeolite-enhanced concrete meets the rigorous demands of modern construction while significantly lowering the carbon footprint associated with traditional concrete production.

8. Gayathri and Dhanalakshmi (2017) conducted a "health analysis" of high-performance concrete (HPC) by integrating natural coconut fibers and zeolite. The study explored the environmental sustainability of using agricultural waste in construction. Their findings indicated that while zeolite improves the compressive strength, the coconut fibers provide much-needed tensile reinforcement, effectively preventing the sudden, brittle failure often seen in high-performance mixes.

9. Iswarya and Beulah (2020) provided a comprehensive review of the current literature regarding the use of zeolite and various industrial waste materials in the production of high-strength concrete. Their analysis synthesized data from multiple global studies, concluding that the integration of industrial by-products not only improves the chemical resistance of concrete but also offers a viable pathway for the construction industry to transition toward a circular economy.

10. Ikotun and Ekolu (2010) investigated the effects of modified zeolite additives on the strength and durability of concrete. By treating natural zeolite to enhance its reactivity, the researchers were able to achieve superior resistance to acid attacks and water permeability. The study emphasizes that modified zeolites are more effective than raw zeolites in ensuring the long-term structural integrity of concrete exposed to aggressive environmental conditions.

11. Jassim and Anwar (2016) performed an experimental study on the behavior of polypropylene fiber-reinforced concrete (PFRC), focusing primarily on its mechanical response. The study detailed how the addition of fibers at varying volume fractions affects the modulus of rupture and split tensile strength. They concluded that PFRC is particularly effective in structural applications where high impact resistance and crack control are prioritized over pure compressive load-bearing.

12. Ly et al. (2019) introduced an improved ANFIS model specifically designed to predict the compressive strength of concrete made with manufactured sand. Recognizing the variability in manufactured sand compared to natural river sand, the researchers developed a more robust algorithmic approach. Their improved model demonstrated high correlation coefficients, providing a precise tool for predicting concrete performance based on sand geometry and mix ratios.

13. Naseri et al. (2017) utilized Support Vector Machine (SVM) algorithms to predict the properties of self-compacting composites reinforced with polypropylene fibers and nanoCuO. The research integrated experimental observations with machine learning to navigate the non-linear relationships between the additives. The SVM model provided a highly accurate prediction of compressive and tensile strengths, proving the utility of supervised learning in advanced materials science.

14. Nagrockiene and Girskas (2016) conducted a detailed research project on the modification of concrete properties through the addition of natural zeolite. The study specifically measured the density, water absorption, and freeze-thaw resistance of the specimens. Their findings revealed that zeolite increases the volume of closed pores, which significantly enhances the frost resistance of the concrete, making it a viable additive for cold-climate infrastructure.

15. Rahman and Dev (2020) researched the application of nano-alumina in the development of highstrength concrete. Their experimental data showed that nano-alumina particles significantly accelerate the formation of Calcium-Silicate-Hydrate (C-S-H) gels during the early stages of hydration. This acceleration results in a much faster gain of early-age strength, which is highly beneficial for pre-cast concrete industries and rapid construction timelines.

16. Ramezanianpour et al. (2015) presented a comprehensive study on natural zeolitecontained concretes, analyzing the material at both micro and macro levels. By examining the pore structure and chemical composition, the researchers demonstrated that zeolite significantly reduces chloride ion penetration and water absorption. Their macro-level testing confirmed that these microscopic improvements translate into enhanced compressive strength and superior durability in harsh chemical environments.

17. Saradar et al. (2017) addressed the technical challenges associated with restrained shrinkage cracking in high-strength concrete (HSC). Since HSC is prone to brittleness and early-age cracking, the researchers introduced various fiber reinforcements to mitigate these effects. The study provided

empirical evidence that the inclusion of fibers effectively redistributes internal stresses, thereby reducing the width of shrinkage cracks and enhancing the long-term serviceability of high-performance structures.

2.3 OBJECTIVES AND SCOPE OF RESEARCH

1. Investigate the effect of different volume percentages (typically 0% to 2% by volume or weight of cement) of polypropylene fiber on the compressive, split tensile, and flexural strength of M20 grade concrete.

2. Determine the optimum dosage of polypropylene fiber that provides the maximum strengthening effect on M20 concrete while maintaining workability.

3. Analyze the workability of fresh concrete with varying percentages of PPF using slump cone and compaction factor tests.

4. Evaluate the post-cracking behavior and crack resistance of PFRC (Polypropylene Fiber Reinforced Concrete) to reduce plastic shrinkage.

5. Compare the mechanical performance of Polypropylene Fiber Reinforced Concrete with Conventional Concrete.

METHODOLOGY

3.1 METHODOLOGY

The purpose of methodology involves stages to full fill the objectives of the present research work.

1. The first step involves the identification of the research problem and reviewing the previous literature to fix the objective of the research.

2. The second step involves collecting materials, design-mix patterns for commencing the work.

3. The third step involve calculating the quantities required for casting cubes specimens.

4. The fourth involves testing materials for workability, weight proportions i.e. slump cone test, specific gravity test as per requirements of IS codes.

5. The fifth step consists of mixing concrete (hand mixing), polypropylene Fibers by weight proportions, fine & coarse aggregate, with suitable water cement ratio.as per the requirements of Indian standards code.

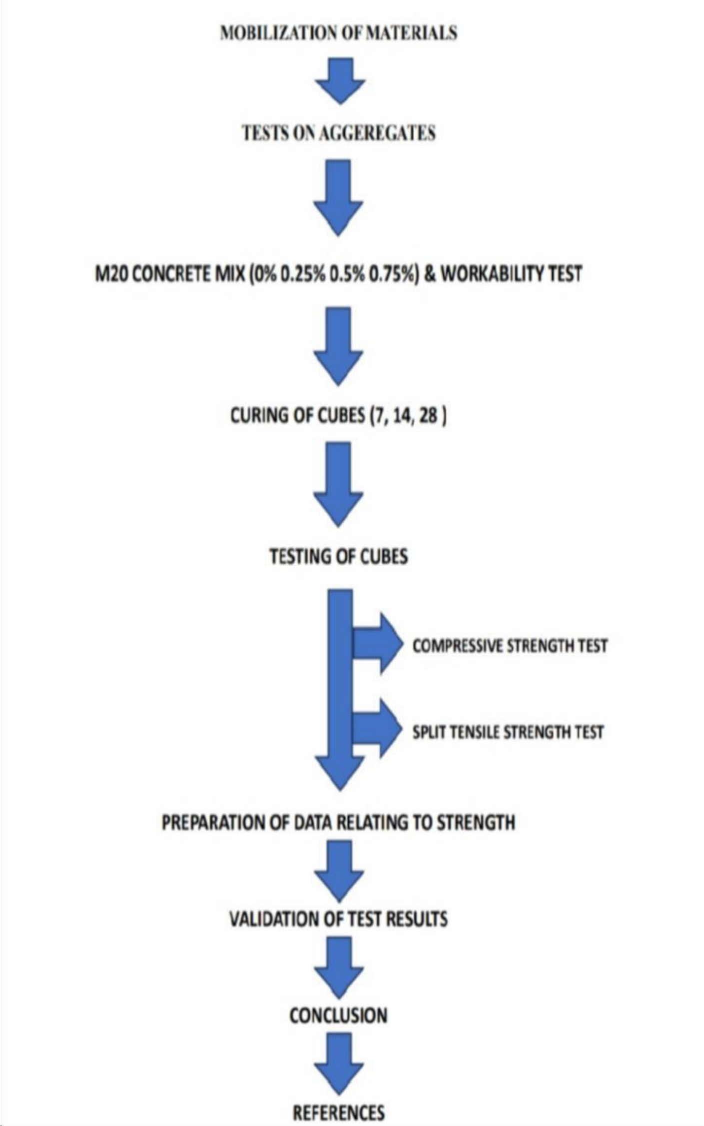
6. The sixth step involves filled the concrete mix into the cubes (150mmx150mmx150mm) and allowed to settle for hardening for 24 hours.

7. The seventh step the cube specimens are cured for respective ages.

8. The eight step, the strength test are conducted on compression testing machine (CTM). And note the result.

9. And the final step is to conduct multi-variate regression analysis for determining the performance parameters relating to fibre reinforced concrete containing Polypropylene Fiber.

3.2 FLOW CHART FOR METHODOLOGY



4.1 CEMENT:

Cement is a binder material, chemical substances used for construction that sets, harden and adheres to other materials to blind them together. Cement is seldom used for its own, but rather to blind sand and gravel (coarse aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Ordinary Portland cement of grade 53 was used and it satisfies the requirement of IS 269-2015 code. OPC 53 grade cement is a type of cement preferred for its high compressive strength. The term "53 grade" signifies that the cement attains a minimum compressive strength of 53 megapascals (MPa) after 28 days of curing period. The OPC 53 grade cement has reduced permeability that corroborates with minimizing the moisture content, chemical and pollutants, resulting in the long-term integrity of the structure.

Fig. 4.1 OPC 53 GRADE CEMENT

4.2 COMPOSITION AND PROPERTIES OF OPC 53 GRADE :

OPC 53 Grade cement is a high-strength Ordinary Portland Cement widely used in structural applications. It is composed mainly of lime (CaO), silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3), and is known for its rapid strength gain, high compressive strength, and durability.

The chemical composition is regulated by IS 12269:1987 standards:

Table 4.1 Chemical composition of OPC 53 grade

INGREDIENTS	CONCENTRATION %
CaO 66.67	CaO 66.67
SiO2 18.91	SiO2 18.91
Fe2O3 4.94	Fe2O3 4.94
Al2O3 4.51	Al2O3 4.51
SO3 2.5	SO3 2.5
MgO 0.87	MgO 0.87
K2O 0.43	K2O 0.43
Na2O 0.12	Na2O 0.12
Loss of ignition 1.05	Loss of ignition 1.05

OPC 53 grade concrete is primarily composed of calcareous and argillaceous, silica, aluminium or iron oxide-bearing materials. the ingredients are then burned at high temperature to create a nodular material called clinkers which is then grounded to form a fine powder. This fine powder is known as cement. Portland cement is widely used cement. the specific combination and proportion of these constituents influence the cement's properties. Specific gravity of cement is 3.15 as per procedures conducted conforming to IS 12269-1987 code.

USES OF CEMENT

1. Concrete Production: Cement is mixed with aggregates (sand/gravel) and water to produce concrete for building homes, skyscrapers, foundations, and high-strength structures.

2. Mortar and Masonry: Used to create mortar for binding bricks, stones, and concrete blocks, as well as for plastering walls to achieve a smooth finish.

3. Infrastructure Development: Essential in constructing roads, highways, bridges, tunnels, dams, and lighthouses.

4. Precast Concrete Members: Used in the fabrication of precast items like pipes, fencing

posts, manhole covers, railway sleepers, and concrete piles.

5. Waterproof and Specialized Structures: Applied to create watertight floors, water tanks, septic tanks, swimming pools, and sewage disposal systems.

6. Soil Stabilization: Used in engineering to strengthen soil for foundations, roadways, and slope stabilization.
7. Industrial/Decorative Applications: Used in terrazzo surfaces, architectural finishing, and decorative elements (white cement).

8. Specialty Uses: High-alumina cement is used for refractory concrete in furnaces, while other types are used for grouting and sealing joints.

4.3 POLYPROPYLENE FIBER:

Polypropylene Fibers are collected through a melt-spinning process where polypropylene resin pellets are melted, extruded through spinnerets into filaments, cooled, and then stretched to align the polymer chains. These continuous filaments are either wound onto spools or chopped into short Fibers depending on the application. Commercially available polypropylene fibres procured from Reliance Industries Ltd., Chennai were used. The properties of polypropylene fibres are presented in table.

Fig. 4.2 Polypropylene Fiber

Table 4.2 Properties of Polypropylene Fibers

SL NO.	PROPERTIES	TEST DATA
1.	Diameter (D), mm	0.04
2.	Length (L), mm	12
3.	Aspect Ratio	300
4.	Tensile Strength (MPa)	480
5.	Specific Gravity	0.910
6.	Elasticity Modulus (GPa)	5
7.	Shape	Triangular

Uses of Polypropylene in PPC mix :

1. Automotive Industry: PPC is frequently used for automotive components such as car bumpers, dashboards, interior door trims, and battery casings because of its high impact resistance and low weight.

2. Packaging: Due to its excellent toughness, it is used in rigid packaging applications, including food containers, crates, pails, and dairy tubs that need to withstand rough handling.

3. Consumer Goods: PPC is commonly used in household items like storage boxes, luggage, furniture, and toys.

4. Medical Equipment: Its durability and sterilization capability make it suitable for medical devices, such as syringes, lab ware, and pill containers.

5. Pipes and Fittings: It is used in manufacturing piping systems for potable water or industrial applications, as it resists corrosion and chemical degradation.

6. Living Hinges: Because PPC offers good fatigue resistance, it is used to create "living hinges"—thin, flexible slices of plastic that can be bent multiple times without breaking, commonly found on caps and lids.

4.4 WATER:

Water is the key ingredients, which when mixed with cement, for a paste that blinds the aggregate together. The water causes the hardening through a process called hydration. The quality of water has great influence on strength and durability of concrete.PH value of water should between 6 to 8. Water should be free from organic impurities locally available potable water free from impurities is used in present study.

4.5 FINE AGGREGATE:

Natural river sand was used as a fine aggregate. The aggregates were tested as per IS 383:2016. The

specific gravity of coarse aggregate is 2.61 and grading zone is ZONE-lll. The particles are passed from 4.75mm sieve.

Fig. 4.3 Fine Aggregate

4.6. COARSE AGGREGATE:

Crushed granite coarse aggregate was used conforming to IS 383:2016. The maximum size of coarse aggregate used was 20mm.The particles are retained on 4.75mm sieve. The specific gravity of coarse aggregate is 2.80.

Fig. 4.4 Coarse Aggregate

Properties of coarse aggregate:

1. Size and Gradation: Coarse aggregates usually range from4.75 mm to 80 mm, with ideal grading enhancing workability.

2. Shape and Texture: Angular aggregates offer better interlocking, resulting in higher strength, while rounded aggregates improve workability. Flaky or elongated particles are undesirable as they weaken the mix.

3. Strength and Hardness: They must be strong enough to withstand crushing under heavy loads and tough enough to resist abrasion (wear and tear).

4. Specific Gravity and Density: Typically, high-quality coarse aggregate has a specific gravity between 2.6 and 2.9 and high bulk density, contributing to the overall strength of the concrete.

5. Absorption and Moisture: Aggregates should have low water absorption to prevent excessive water uptake, which can affect the workability and bonding.

6. Soundness and Durability: They must withstand weather conditions, specifically freezethaw cycles and chemical attacks.

Cleanliness: Must be free from organic impurities, clay, and coatings that reduce the bond between aggregate and cement.

4.7 CONCRETE MIX DESIGN :

SL. NO	PARAMETER	VALUE
1	Grade Designation	M30
2	Type of Cement	OPC 53 Grade conforming to IS 12269:1987
3	Maximum Nominal Aggregate Size	20 mm
4	Maximum Cement Content (IS 456:2000)	300 kg/m^3
5	Maximum Water Cement Ratio (IS 456:2000)	0.50
6	Exposure Condition	Moderate
7	Workability	Medium
8	Type of Aggregate	Crushed Angular Aggregate
9	Adopted Water Cement Ratio	0.45

4.8 PRACTICAL RELEVANCE :

The water requirement for making specimens for the determinations of initial and final setting times and of tensile and compressive strength of cement sand mortars and for soundness tests depends upon the normal consistency of cement to be used. This normal consistency or water demand of cement depends upon the compound composition and fineness of the cement. The initial setting time of the cement is limiting time beyond which paste mortar of concrete made from it cannot be placed or compacted without loss of useful properties e.g. strength. The final setting time is the time limit beyond which mould can be removed. For generally available cements the normal consistency varies from 30 to 35 percentage initial setting time 30 minutes initial setting and final setting time 10 hours.
Material test performed for cement(IS 4031)

Standard Consistency of Cement:
It is the amount of water required to make a cement paste of such consistency that the Vicat plunger penetrates 5–7 mm from the bottom of the mould.

Fineness of Cement:
It is the measure of the particle size of cement, expressed as the percentage of cement retained on a 90-micron sieve.

Fig 4.5 Standard Consistency Test

Fig 4.6 Fineness of Cement

Material test performed for Fine aggregate (IS 2386)

1. Silt content :0% or nil
2. Sieve analysis :zone II
3. Specific gravity:2.63
4. Bulk density /unit weight: zoose(1239.2kg/m^3) Compacted(1451.1kg/m^3)
5. Moisture content:2.04%

Silt Content:
The silt content of the given sample is 0% (nil), indicating that the material is free from fine impurities like clay and silt.

Sieve Analysis:
The aggregate falls under Zone II, which indicates moderately graded sand suitable for concrete works.

Specific Gravity:
The specific gravity of the material is 2.63, showing it has normal density and is suitable for construction purposes.

Bulk Density / Unit Weight:
The bulk density is 1239.2 kg/m^3 (loose) and 1451.1 kg/m^3 (compacted), indicating the weight of aggregate in different conditions.

Moisture Content:
The moisture content is 2.04%, which represents the amount of water present in the aggregate.

Fig 4.7 Sieve Analysis Test

Fig 4.7 Bulk density

Material test performed for Coarse aggregate(IS 2386)

1. Specific gravity:2.69
2. Sieve analysis:well graded
3. Impact crushing strength:24.3%

Specific Gravity:

The specific gravity of the material is 2.69, indicating good strength and suitability for construction.

Sieve Analysis:

The aggregate is well graded, meaning it has a good distribution of particle sizes, which improves strength and workability.

Impact Crushing Strength:

The impact value is 24.3%, indicating that the aggregate has good resistance to impact and is suitable for concrete works.

Fig 4.8 Sieve Analysis

Fig 4.9 Crushing Strength

4.9 MIXING :

Mixing of concrete is the process of combining cement, sand, gravel, and water to make a uniform and workable mixture used in construction. The main aim is to make sure all the materials are evenly mixed so that the concrete becomes strong and durable after it hardens. This mixing can be done by hand for small works or by using machines for bigger projects, where better quality is required. It is important to use the right amount of water and mix the materials properly, because too much or too little water can affect the strength of the concrete. Good mixing helps in achieving a smooth, consistent mixture, which plays a major strength.

Fig 4.10 Mixing Machine

4.10 SLUMP TEST :

Procedure to determine workability of fresh concrete by slump test.

• Clean the internal surface of the slump cone and the base plate. Dampen them with a moist cloth to reduce surface friction, but ensure no excess water remains.

• Place the cone on the base plate and hold it down firmly by standing on the foot pieces. Fill the cone with fresh concrete in three equal layers (by volume).

• Compact each layer with 25 strokes of the tamping rod, distributing the strokes uniformly across the surface.

• After compacting the final layer, strike off the excess concrete from the top using the tamping rod in a rolling or sawing motion until it is flush with the Mold.

• Immediately remove any spilled concrete from around the base. Lift the Mold carefully and vertically in a steady motion without twisting or lateral movement. The lift should take approximately 5 to 10 seconds.

• Turn the slump cone upside down and place it next to the concrete mass. Place the tamping rod across the top of the cone so it extends over the concrete. Measure the vertical distance from the bottom of the rod to the displaced original centre of the top surface of the concrete. The difference in height in mm is the slump of the concrete.

Fig 4.11 Slump Test

4.11 CASTING:

• Clean the moulds and apply oil.
• Fill the concrete in the moulds in layers approximately 5cm thick.
• Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long pointed at lower end).
• Level the top surface and smoothen it with a trowel.

Fig 4.12 Preparation of Cubes

Fig 4.13 Compact with tamping rod

4.12 CURING AND DEMOULDING:

The concrete cubes specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the Molds and kept submerged in clear fresh water until taken out prior to test.

Demoulding is the process of removing hardened concrete from the mould after a specified time without damaging its shape or surface.

Fig 4.14 Demoulding

Fig 4.15 Curing

4.13 COMPRESSIVE STRENGTH PROCEDURE IN POLYPROPYLENE FIBER CUBES

Aim :

To find out how much crushing load a concrete cube with plastic (polypropylene) fibers can take before it breaks.

Precautions:

• No Clumping: Make sure the fibers don't stick together in balls during mixing.
• Smooth Surface: Clean the machine plates so there is no grit or sand between the metal and the cube.
• Center It: Place the cube exactly in the middle of the machine to avoid uneven breaking.
• Side Loading: Always turn the cube on its side (test the smooth faces that touched the mold, not the rough top).

Procedure:

1. Mix cement, sand, and stone. Add the fibers slowly so they spread out evenly.
2. Pour the mix into cm metal molds in 3 layers, poking each layer 35 times with a rod to remove air.
3. Let it sit for 24 hours, take it out of the mold, and put it in water for 7 or 28 days.
4. Take the wet cube out, wipe it, and put it in the testing machine.
5. Turn the machine on. It will slowly squeeze the cube until it cracks.

Result: Note down the highest number (load) on the screen.

Calculation formulae:

Strength=Maximum load (kg or N)/Area of Face

Fig 4.16 Compressive Strength Machine

Fig 4.17 Compressive Strength Test

4.14 SPLIT TENSILE STRENGTH PROCEDURE IN POLYPROPYLENE FIBER CUBES

Aim :

To find the tensile (pulling) strength of the concrete by splitting a cube.

Procedure :

1. Take the wet cube out of the curing water and wipe it dry.
2. Draw a line down the middle of two opposite faces to show where the load will go.
3. Place the cube on its side in the machine. Ensure the load hits the faces that were touching the mold, not the rough top.
4. Put thin plywood strips (thick) exactly on your marked lines, both on top and bottom of the cube.
5. Start the machine. It will press down on the strips until the cube splits vertically in two.
6. Note the maximum load at the moment of the split.

Precautions :

Alignment: The plywood strips must be perfectly centered on your marked lines.
Direction: Never apply the load to the rough "trowelled" surface from the top of the mold.
Fiber Mix: Ensure fibers are mixed evenly; any clumps will cause the cube to split unevenly.

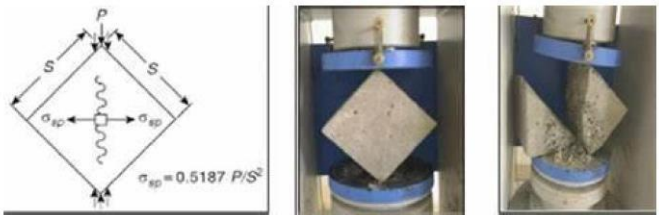


Fig 4.18 Split Tensile Strength Test

RESULTS ON MATERIALS

5.1 CEMENT

Cement of 53 Grade Ordinary Portland Cement was used.

Table 5.1 : Test Results on Cement

Sl No	Test Name	Results	Standard Range	IS Code
1	Specific Gravity of Cement	3.07	3 – 3.15	IS : 4031 - 1988
2	Fineness of Cement	7%	<10%	IS : 4031 - 1996

5.2 FINE AGGREGATE

Table 5.2 : Test Results on Fine Aggregate

Sl No	Test Name	Results	Standard Range
1	Specific Gravity	2.7	2.5 – 3
2	Fineness modulus of Fine Aggregate	2.68 (Zone - 2)	2.6 – 2.9 (Medium Sand)

5.3 COARSE AGGREGATE

Table 5.3 Test Results on Coarse Aggregate

Sl No	Test Name	Results	Standard Range
1	Aggregate Impact	16.32 %	10 – 20%
2	Flakiness Index	25.04 %	< 30 %
3	Elongation Index	22.52	< 30 %

5.4 CONCRETE NOMINAL MIX

Table 5.4 Mix Ratios of Nominal mix of Concrete

Sl. No	Material	Quantity (kg/m^3)
1	Cement	414
2	Water	186
3	Fine Aggregate	668
4	Coarse Aggregate	1110
5	Water – Cement Ratio	0.45

5.5 COMPRESSIVE STRENGTH OF CONCRETE WITH VARIOUS PROPORTIONS OF PP FIBER MIX

Table 5.5 Mix Proportions of Polypropylene Fiber Concrete

Sl N	Property	PP -1	PP – 2	PP -	PP -
1	Cement (kg/m³)	414	414	414	414
2	Polypropy l ene (%)	0	0.25	0.50	0.75
3	Fine Aggregate (kg/m³)	668	668	668	668
4	Coarse Aggregat e (kg/m³)	1110	1110	111 0	1110
5	Water (Litres)	186	186	186	186
6	W/C Ratios	0.45	0.45	0.45	0.45

Fig 5.7 SPLIT TENSILE STRENGTH RESULTS

SL No	Mix Proportions	Average Split Tensile Strength – 7 days curing (N/mm²)	Average Split Tensile Strength – 14 days of curing (N/mm²)	Averag Split Tensil Stren gth – 28 days of curin g (N/mm²)
1	MPC 0	1.916	2.126	2.306
2	MPC 1	2.234	2.449	2.677
3	MPC 2	2.475	2.821	3.028
4	MPC 3	2.329	2.745	3.079
5	MPC 4	2.191	2.326	2.531

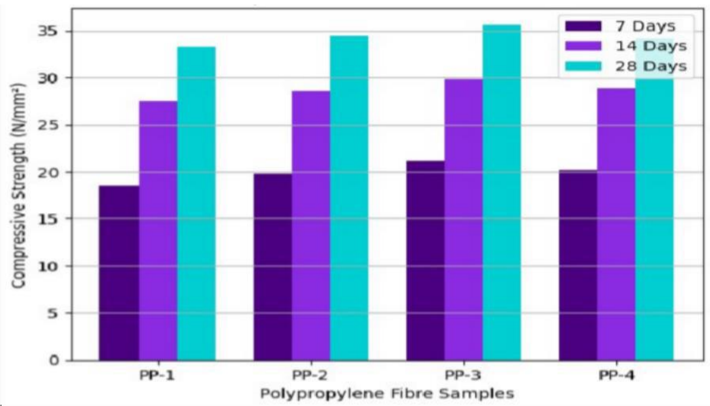


Fig 5.6 Compressive Strength of Polypropylene Fiber concrete

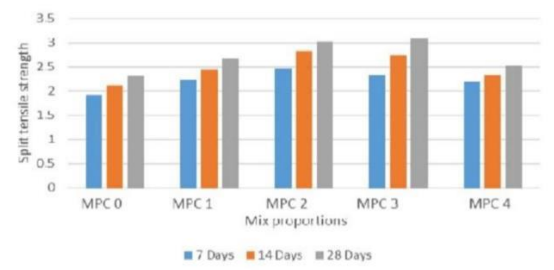


Fig 5.8 Split Tensile Strength Comparison for various mixture proportions

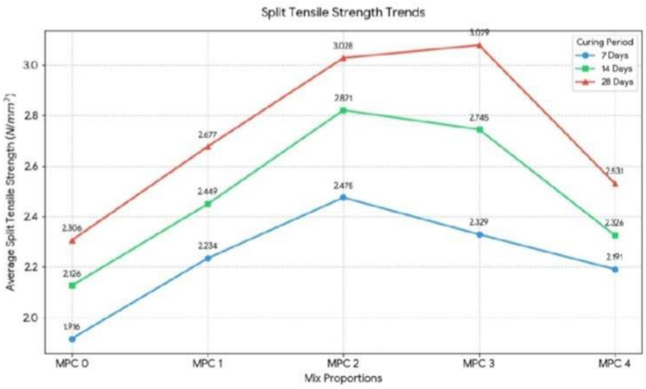


Fig 5.9 Split Tensile Strength Results

RESULTS AND DISCUSSION

6.1 COMPRESSIVE STRENGTH FOR NOMINAL CONCRETE

Table : 6.1 Compressive Strengths Cubes

S. No.	Sample	7 Days (N/mm²)	14 Days (N/mm²)	28 Days (N/mm²)
1	NC-1	17.4	26	32.79
2	NC-2	17.8	26.25	32.88
3	NC-3	17.9	26.7	32.94

The Compressive strength of nominal concrete cubes increased with curing age. At 7 days, the strength ranged from 16.7 to 17.6 N/mm². At 14 days, it increased to 26.2 to 26.4 N/mm². At 28 days, the strength reached 31.6 to 32.1 N/mm², indicating satisfactory strength development. The results confirm that the nominal M20 concrete achieved the required compressive strength and can be used as a reference mix for further comparison.

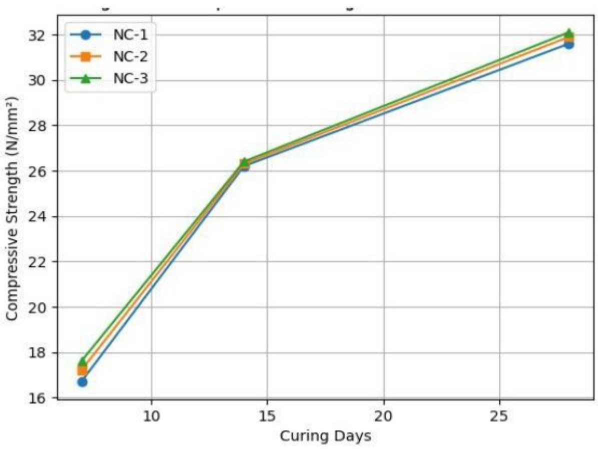


Fig 6.1 Compressive Strength of Nominal Concrete

6.2 COMPRESSIVE STRENGTH OF CONCRETE WITH PP FIBRE

Sl No	Mix	7 Days (N/mm²)	14 Days (N/mm²)	28 Days (n/mm²)
1	CC	17.7	26.3	32.87
2	PP-2 (0.25%)	18.92	26.8	35.23
3	PP-3 (0.50%)	21.01	29.4	38.56
4	PP-4 (0.75%)	18.85	27.25	36.45

COMPRESSIVE STRENGTH RESULTS

ID	PP%	% increase in 7 days	% increase in 14 days	% increase in 28 days
NC	-	-	-	-
PP-1	0.25	6.45	1.87	6.70
PP-2	0.50	15.75	10.54	14.75
PP-3	0.75	6.10	3.49	9.82

CONCLUSIONS

1. The nominal M30 concrete achieved an average compressive strength of 32 N/mm² at 28 days, satisfying IS code requirements.
2. The adopted water–cement ratio of 0.45 provided adequate strength and durability under moderate exposure conditions.
3. The addition of polypropylene fibres improved the compressive strength of concrete compared to nominal mix.
4. The compressive strength increased with fibre content up to an optimum level and then decreased beyond that.
5. The optimum polypropylene fibre content was found to be 0.5%, giving maximum strength.

6. At 0.5% fibre content, the concrete achieved a maximum compressive strength of 38.56 N/mm^2.
7. Fibre addition slightly reduced the workability of concrete due to fibre interlocking and reduced flowability.
8. Polypropylene fibres improved crack resistance, ductility, and durability of concrete.
9. The results showed a strength improvement of approximately 14% compared to nominal concrete.
10. Overall, polypropylene fibre reinforced concrete is more efficient and suitable for practical construction applications, especially where durability and crack control are important.

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