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Performance Evaluation of Recycled PET Fiber Reinforced Concrete with Structural Health Monitoring

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ABSTRACT

The increasing generation of plastic waste and the growing demand for durable and sustainable construction materials have motivated researchers to explore alternative reinforcement materials in concrete. Polyethylene Terephthalate (PET), a widely used plastic in beverage bottles, poses serious environmental concerns due to its non-biodegradable nature. This project investigates the performance of concrete reinforced with recycled PET fibers and evaluates its structural behaviour using Structural Health Monitoring (SHM)–based crack detection techniques. Recycled PET fibres extracted from waste plastic bottles are incorporated into concrete at varying volume fractions. The mechanical properties, such as compressive strength, split tensile strength, and flexural strength, are experimentally evaluated. Furthermore, crack initiation and propagation in PET fiber-reinforced concrete are monitored using SHM techniques, including surface-mounted sensors and visual crack mapping.

INTRODUCTION

Concrete is generally recognized for its compressive strength. Mild Steel bars were used in concrete to improve the tensile strength and bending nature of it. The fibers were introduced in the concrete by many researchers from the past two decades to enhance the durability of the concrete. Many researchers were used wide variety of fibers in practice. Some of them are aluminum, steel, copper, glass, silica and Nano fibers. In recent days the usage of Polyethylene Terephthalate (PET) bottle is increased rapidly, and the disposal of the waste PET bottle is considered as a major solid waste management. The waste PET bottles were recycled and reused in various categories viz strips, sheets, plates and fibers, etc. Using the PET fibers which is obtained from the waste bottles will be a best alternative for the solid waste disposal as well as for the concrete to improve its flexural strength.

OBJECTIVES

- To utilize recycled PET fibres obtained from waste plastic bottles as reinforcement in concrete.
- To study the effect of PET fibres on the mechanical properties of concrete.
- To evaluate crack initiation and propagation in PET fibre reinforced concrete.
- To implement Structural Health Monitoring MATLAB Programming techniques for crack detection.
- To compare the performance of PET fibre reinforced concrete with conventional concrete.
- To promote sustainable eco-friendly construction by recycling plastic waste in concrete.

WORKING PROCESS

- Collect and process waste PET bottles into uniform fibers.
- Design control concrete mix as per standards.
- Add PET fibers in different percentages to the mix.
- Cure specimens for required durations (7, 14, 28 days).
- Conduct fresh concrete tests (slump, density).
- Perform mechanical tests (compressive, tensile, flexural).
- Monitor strain and crack development using SHM sensors.
- Carry out durability tests (water absorption, RCPT, chemical resistance).
- Identify optimal PET fiber dosage and evaluate performance.

MATERIALS USED

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Polyethylene Terephthalate Fibers
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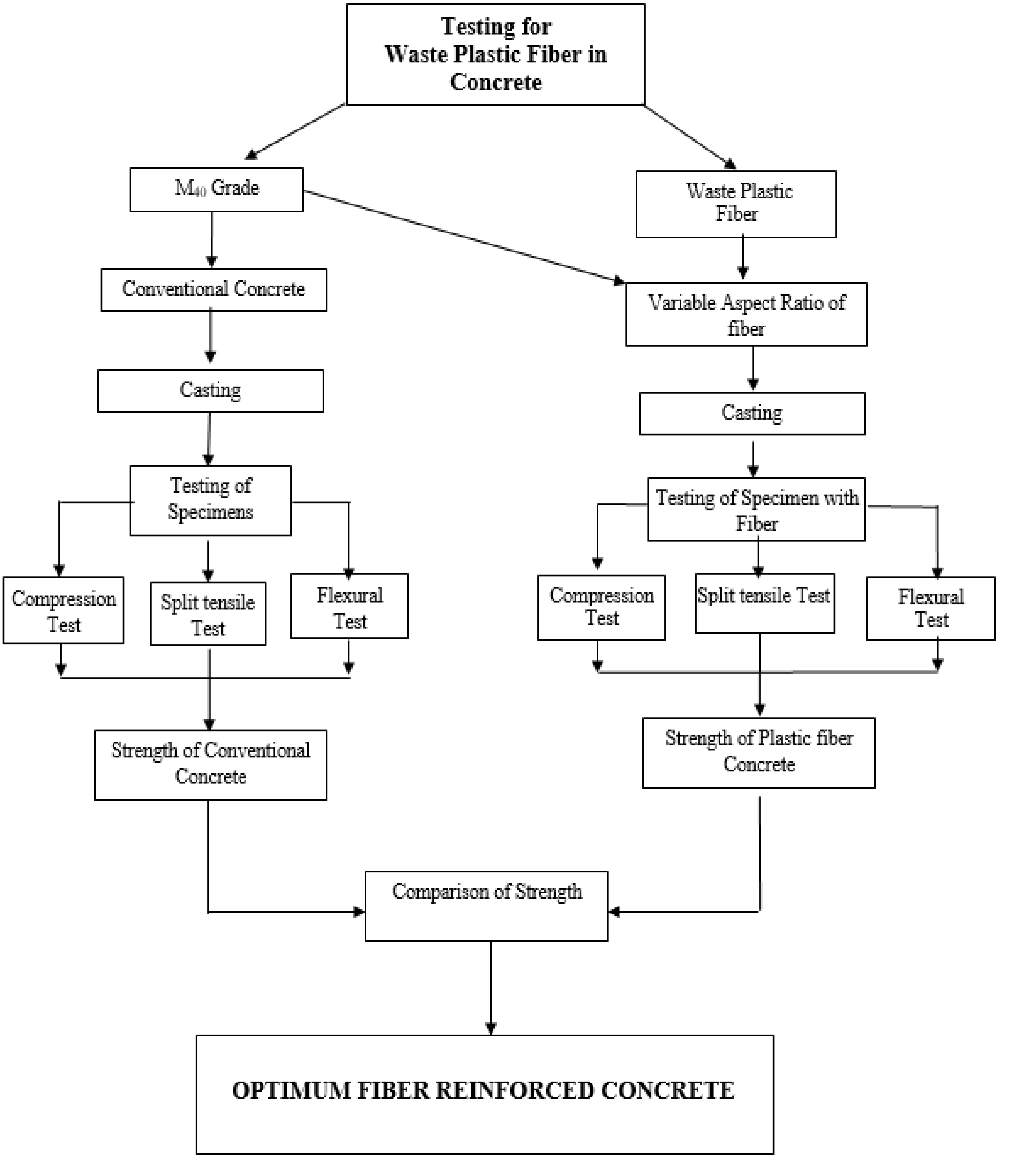
METHODOLOGY



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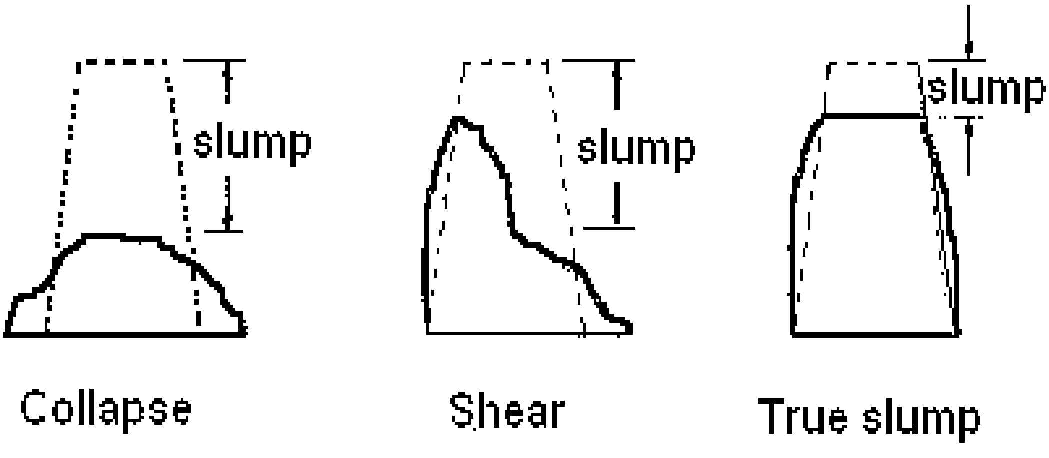
WORKABILITY OF CONCRETE

Workability in concrete refers to how ease a freshly mixed concrete could be helpful in mixing, compacting, and placing without experiencing excessive segregation or loss of homogeneity in the material. It is a critical characteristic that significantly influences the construction process, including placement and finishing of concrete structures. The importance of workability has its impact on the ease of construction activities.

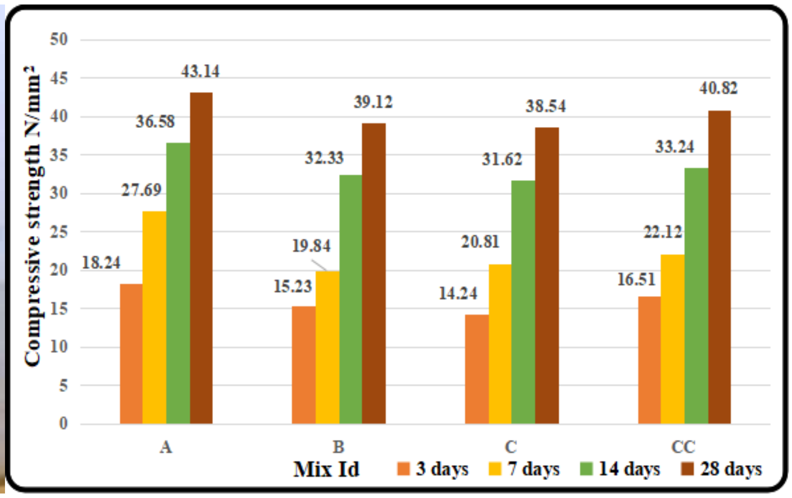


CASTING AND CURIG

- Concrete specimens were casted for the arrived mix design. Test specimens were casted using the moulds and placed in the curing tank for normal conventional method of curing.
- The samples were casted for each mould. Normal tap water that available in the laboratory were utilized for curing the specimen.

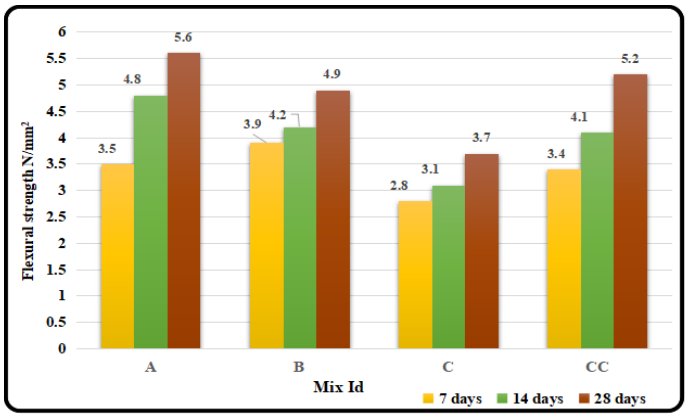
SPLIT TENSILE TEST

The split tensile test is used to determine the tensile strength of concrete. Concrete is strong in compression but weak in tension, so this test evaluates its tensile behavior. Cylindrical specimens (usually 150 mm diameter and 300 mm height) are cast and cured for 28 days. After curing, the specimen is placed in a compression testing machine and a diametrical compressive load is applied until it cracks. The crack usually starts at the center and spreads outward.



FLEXURAL STRENGTH TEST

The flexural test is used to determine the flexural strength (modulus of rupture) of concrete. It measures the ability of concrete beams or slabs to resist bending forces. This test helps evaluate the tensile behaviour of concrete in structural elements such as beams, slabs, and pavements.In this test, prism specimens of size 500 mm × 100 mm × 100 mm are cast and cured under normal conditions. The specimen is placed on two supports, and a load is applied at the centre until the specimen fails. The applied load creates a bending moment, causing the concrete to crack and break.



ADVANTAGES

- Recycled PET fibers reduce crack width and delay crack propagation.
- PET fibers improve post-cracking behavior and load-carrying capacity.
- Concrete shows better energy absorption and reduced brittle failure.
- SHM provides continuous monitoring of strain and damage.
- Effective reuse of plastic waste reduces environmental pollution.
- Early warning through SHM helps prevent sudden failures.
- Condition-based maintenance replaces frequent manual inspections.

CONCULISION

The study on Performance Evaluation of Recycled PET Fiber Reinforced Concrete with Structural Health Monitoring (SHM) shows that the inclusion of recycled PET fibers significantly improves the overall performance of concrete. The addition of PET fibers enhances tensile strength, flexural strength, and crack resistance while reducing brittleness in concrete. It also improves durability and impact resistance, making the material more reliable for structural applications.

Structural Health Monitoring techniques help in continuously assessing the condition of the concrete structure and detecting early signs of damage or stress. This allows timely maintenance and increases the safety and service life of structures made with PET fiber reinforced concrete.

Moreover, the use of recycled PET fibers contributes to environmental sustainability by reducing plastic waste and promoting eco-friendly construction materials. Therefore, recycled PET fiber reinforced concrete combined with structural health monitoring can be considered an effective, durable, and sustainable solution for modern construction practices.

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