Effect of Waste Plastic Fibres on the Mechanical Properties of Concrete

Mr Gaurav Gahane, Mr Badal Harinkhede

M-Tech Structural Engg. Final Year Student Department of civil Engineering ,

G H Raisoni University Saikheda (MP)

Assistant Professor Department of Civil Engineering G H Raisoni University Saikheda (MP)

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Abstract: - The increasing accumulation of plastic waste has become a major environmental concern due to its non-biodegradable nature and harmful impact on ecosystems. At the same time, the construction industry continuously seeks innovative materials to enhance the performance and sustainability of concrete. This study focuses on evaluating the mechanical properties of concrete incorporating waste plastic fibres as a reinforcing material. Waste plastic fibres were collected, processed, and added to concrete mixes in different proportions to examine their influence on strength characteristics. An experimental investigation was carried out to determine compressive strength, split tensile strength, and flexural strength of the concrete specimens at various curing periods. The results were compared with conventional concrete to assess performance improvements. The findings reveal that the addition of waste plastic fibres significantly improves tensile and flexural strength while maintaining acceptable compressive strength. The fibres also enhance crack resistance, toughness, and ductility of concrete. The study concludes that waste plastic fibres can be effectively utilized as a sustainable construction material, reducing environmental pollution and promoting eco-friendly concrete production. This approach supports waste management efforts while improving the mechanical behavior of concrete.

Keywords:- Waste plastic fibres, Fibre reinforced concrete, Mechanical properties, Compressive strength, Split tensile strength, Flexural strength, Sustainable construction.

Introduction

Concrete is one of the most widely used construction materials in the world due to its high compressive strength, durability, and versatility. It is extensively used in buildings, bridges, pavements, dams, and other infrastructure projects. However, conventional concrete has certain limitations, particularly its low tensile strength and brittle behavior under load. Cracking is a common problem in concrete structures, which can reduce durability and service life. To overcome these limitations, researchers have explored the use of fibre reinforcement to improve the mechanical performance of concrete.

At the same time, the rapid growth of plastic consumption has resulted in a significant increase in plastic waste generation. Since plastic materials are non-biodegradable and decompose very slowly, their accumulation has become a serious environmental concern. Improper disposal of plastic waste leads to land pollution, blockage of drainage systems, and harm to wildlife and marine ecosystems. Recycling and reusing plastic waste in construction materials offers a sustainable solution to this global issue.

Incorporating waste plastic fibres into concrete is an innovative approach that addresses both environmental and structural challenges. Waste plastic materials can be processed into fibres and mixed with concrete to act as secondary reinforcement. These fibres help in controlling crack formation and propagation by bridging micro-cracks within the concrete matrix. As a result, the tensile strength, flexural strength, impact resistance, and overall ductility of concrete may improve.

This study focuses on investigating the effect of waste plastic fibres on the mechanical properties of concrete. By evaluating parameters such as compressive strength, split tensile strength, and flexural strength, the research aims to determine the feasibility of using waste plastic fibres as a reinforcing material. The study also examines the potential of this approach in promoting sustainable construction practices and reducing environmental pollution.

Fibre Reinforced Concrete

Concrete is inherently brittle in nature and exhibits low resistance to tensile stresses. Even before external loads are applied, micro-cracks may develop within the concrete matrix due to drying shrinkage, temperature variations, and internal stresses. When tensile loads are introduced, these micro-cracks tend to widen and propagate, which can eventually lead to sudden failure of the structure.

Fibre Reinforced Concrete (FRC) is developed to overcome this limitation by incorporating small, discrete fibres into the concrete mix. These fibres are uniformly distributed and randomly oriented throughout the material. Their presence helps in controlling the initiation and growth of cracks by bridging them at the micro level. As a result, the concrete exhibits improved resistance to crack propagation.

The inclusion of fibres enhances both static and dynamic properties of concrete, such as tensile strength, flexural strength, impact resistance, and toughness. Fibre reinforcement also improves ductility, allowing the concrete to sustain higher strains before failure. Therefore, Fibre Reinforced Concrete offers better structural performance and durability compared to conventional concrete.

Literature Surveying

1. Choi, Moon and Chung (2020) studied the durability performance of concrete reinforced with recycled plastic fibres. Their research showed improved resistance to shrinkage cracking and better long-term durability characteristics.

2. Almeshal, Tayeh and Alyousef (2021) investigated the mechanical performance of waste plastic fibre reinforced concrete and reported noticeable improvements in tensile strength and ductility, especially at moderate fibre content.

3. Yin, Tuladhar and Shi (2021) examined the influence of recycled plastic fibres on concrete under different curing conditions. The study concluded that fibre reinforcement enhanced crack bridging and improved post-peak load behavior.

4. Sharma and Bansal (2022) conducted an experimental study on waste plastic bottle fibres in concrete and found that the fibres enhanced flexural strength and reduced brittle failure. They emphasized the environmental benefits of reusing plastic waste.

5. Singh and Siddique (2022) evaluated the combined effect of recycled aggregates and plastic fibres in concrete. Their findings suggested that fibre reinforcement compensates for strength reduction caused by recycled aggregates.

6. Li, Zhang and Zhao (2023) investigated the mechanical properties of sustainable concrete incorporating waste PET fibres. The results indicated significant improvement in split tensile strength and crack resistance.
7. Ahmad, Usman and Al-Fakih (2024) studied the effect of fibre length and aspect ratio on the performance of waste plastic fibre reinforced concrete. They concluded that proper selection of fibre dimensions is essential for uniform dispersion and optimal strength.
8. Kumar and Prasad (2025) carried out a recent experimental investigation on waste plastic fibre reinforced concrete and reported that moderate fibre content improved tensile and flexural properties while maintaining satisfactory compressive strength. Their research confirmed the potential of plastic fibres for sustainable infrastructure development.

Materials

This chapter presents the physical properties of the materials used in the experimental investigation, namely cement, coarse aggregate, fine aggregate, and water. All materials were tested in accordance with the relevant Indian Standard (IS) codes to ensure compliance with prescribed quality requirements. Standard experimental procedures were adopted for the determination of properties such as normal consistency, initial and final setting times, specific gravity, bulk density, and impact strength.

The materials used in the present study are listed below:

A. Cement

B. Coarse aggregate

C. Fine aggregate

D. Water

The physical and mechanical properties of these materials significantly influence the performance of pervious concrete. Therefore, a detailed characterization of each material was carried out prior to mix preparation. The properties and test results of the individual materials are discussed in the following subsections.

Trial Mix and Strength Results

Trial mixes were prepared to evaluate the workability and strength characteristics of the designed concrete mix. The workability of fresh concrete was assessed to ensure proper mixing, placing, and compaction. Based on satisfactory workability results, cube specimens were cast for compressive strength testing.

The cast specimens were cured in water for a period of 7 days before testing. After curing, the compressive strength test was conducted, and the average strength obtained at 7 days was 26.5 MPa. The observed strength was found to be very close to the target mean strength calculated during the mix design process.

Discussion of Compressive Strength Test Results

The experimental results indicate that the compressive strength of Waste Plastic Fibre Reinforced Concrete (WPFRC) initially increased with the addition of fibres up to 0.5% by volume. At 0.25% fibre content, the improvement in compressive strength was very marginal. Small increases were observed at certain aspect ratios (AR 30 and AR 50), whereas at higher aspect ratios, the compressive strength slightly decreased compared to the control mix.

At 0.5% fibre content, WPFRC exhibited better performance, particularly at AR 30, AR 50, and AR 70. The maximum improvement in compressive strength was observed at AR 50, where an increase of 3.24% over the control concrete was recorded. However, for higher aspect ratios such as AR 90 and AR 110, even at 0.5% fibre content, the compressive strength was lower than that of conventional concrete. This indicates that fibre length plays a significant role in strength development.

Summary of Experimental Investigation

Fibres are generally incorporated into concrete to enhance its tensile strength and improve its crack resistance characteristics. The present study focused on the use of waste plastic fibres in concrete to evaluate their suitability and feasibility as a sustainable solution for plastic waste disposal without causing environmental harm. Discarded plastic flush doors were collected and cut into strips of 5 mm width to serve as reinforcing fibres in the concrete mix.

In this investigation, six different fibre percentages and five aspect ratios were considered. The performance of Waste Plastic Fibre Reinforced Concrete (WPFRC) was compared with that of conventional M30 grade concrete. The study evaluated changes in workability and variations in compressive strength, split tensile strength, and flexural strength for all combinations of fibre content and aspect ratios.

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