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Study of the Mechanical Behavior of Fiber Reinforced Concrete Using Waste Polypropylene Fibers

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ABSTRACT-

Because increasing production of industrial trash threatens ecological balance on Earth's surface. The release of carbon dioxide and other harmful substances into the atmosphere from the production of fibers contributes to global warming. Furthermore, it manages trash created during manufacturing and in the field. We made several samples with varying amounts of polypropylene trash (0, 0.25, 0.5, 0.75, and 1.00 percent). Fiber-reinforced concrete (FRC) compressive strength and split tensile strength are tested after 7 and 28 days of curing, respectively; the density of FRC is measured immediately after the concrete mix is formed. The density of modern fiber-reinforced concrete (FRC) has been shown to decrease very slightly from 2397 kg/m3 to 2393 kg/m3 in laboratory tests. The strength of fiber reinforced concrete (FRC) can be increased to a certain degree by using waste polypropylene fiber. After then, fiber-reinforced concrete (FRC) strength gradually degrades. Adding 0.5% polypropylene fiber improves strength and reduces brittleness. Fiber-reinforced concrete's (FRC) split tensile strength increases by 16.9908% and 9.988470% when 0.5% waste polypropylene fiber is added.

Key Words: Rice Husk Ash, Fibre Reinforced Mortar, Fibre Reinforced Concrete, Polyethylene Terephthalate

I. Introduction

Cement concrete is the most widely-used building material on a global scale. It is essential to gain a deeper comprehension of it and to enhance its qualities. Utilizing waste and recycled materials in cement concrete compositions is becoming increasingly important for the management and treatment of both municipal and industrial solid waste. Plastic was one of the 20th century's most significant innovations. Plastic consumption has risen consistently and is now a significant environmental concern. Considered a viable solution for the disposal of a substantial amount of recovered plastic material, the use of plastic in the concrete industry is viewed as a viable application for repurposing recovered plastic. According to a number of researchers, the physical, chemical, and mechanical properties of plastic material particles used as aggregate in cement concrete mixture were evaluated. The results demonstrated that adding 10% by volume of polymeric components to a cement matrix does not significantly alter the mechanical properties of cement concrete.

Several researchers computed the use of discarded plastic bottles as a partial replacement for the fine aggregate in composite building materials. The study demonstrates that PET particles from pulverized plastic bottles can be used to partially replace fine aggregate in cementations concrete composites. This appears to present an attractive, low-cost material with consistent or reliable properties, and it would assist in resolving some of the solid waste issues resulting from the production of plastics. Silica fume is frequently utilized in two ways: as a cement substitute to reduce cement content (primarily for budgetary reasons), and as an additive to improve the quality of concrete (in both the fresh and hardened phases). Consequently, the combination of silica fume treatment and fly ash application provides an intriguing option for enhancing the early strength of concrete containing fly ash, and numerous researchers have recently conducted experiments utilizing this combination. Numerous studies indicate, however, that the addition of silica particulate may result in a more brittle concrete structure. Since improving ductility is a primary objective in concrete science, researchers must take this into account.

II. Objective of the work

1. To investigate how well industrial waste polymer fibre performs physically and mechanically when utilised in concrete mixtures.
2. Employing industrial waste fibre to prepare the different polymer modified concrete proportions.
3. To ascertain the ideal proportion of industrial waste fibre to cement in order to create concrete with the best density test, workability, compressive strength, and split tensile strength.
4. To study the possibility of using industrial waste fibre into cement concrete.
5. To evaluate the workability, compressive strength and split tensile strength, which is made of industrial waste fibre.

III. LITERATURE REVIEW

Heyang Wu et al. (2020) Due to its superior mechanical qualities compared to regular concrete, fibre reinforced concrete (FRC) has seen a rise in popularity in recent years. Fire resistance must always be taken into consideration when applying FRC to structures such as infrastructure, buildings, and other strategically significant structures. The fire resistance of FRC would be impacted by various fibre kinds, fibre doses, and cementitious matrix designs, according to the results of the current tests. This essay provides a thorough analysis of recent studies on the fire resistance of FRC. We address the permeability, spalling, compressive strength, tensile strength, elastic modulus, toughness, and mass loss of steel fibre reinforced concrete, polypropylene fibre reinforced concrete, and hybrid fibre reinforced concrete in particular. Additionally, a summary and comparison of the current FRC residual property forecasting equations are provided.

Khan et al. (2020) the multi-level process of cracking causes damage to cement- or concrete-based materials. Multi-scale hybrid fibres can now be used in concrete to increase its resistance to cracking. In this study, the reinforcing index and constitutive modelling are examined for varied basalt fibre concentrations in plain concrete, single fibre reinforced concrete, two hybrid fibre reinforced concrete, and multi-scale hybrid fibre reinforced concrete. Empirical equations between strength characteristics and the reinforcing index are derived, and the reinforcing index is computed for hybrid fibres. Additionally, it is possible to compare experimental results with various models and the constitutive models of the compressive stress-strain relationship. Additionally, from the stress-strain and load-deflection curves, compressive and flexural characteristics' absorbed energies and toughness indices are derived, respectively. The SEM examination is carried out to investigate the fiber-matrix bond and multi-level cracking process. The results of the empirical equation were consistent with the experimental findings in terms of strength attributes. The results of several uniaxial compressive stress-strain curve mathematical models are in good accord with the results of the experiments. It is discovered that 0.8% basalt fibre content, 1% $CaCO_3$ whisker, and 0.25% steel fibre content produced the best mechanical performance for multi-scale hybrid fibre reinforced concrete.

Xu et al. (2020) Experimental research is done on the mechanical characteristics of concrete reinforced with cellulose fibre (CTF), polyvinyl alcohol fibre (PF), and polyolefin fibre appropriate for different sprays (VS). On axial compressive strength, splitting tensile strength, and shear strength of concrete, the individual effects of single fibre as well as the synergistic effect of hybrid fibre are explored. A specimen of fiber-reinforced concrete's microstructures and stress-strain relationship are both seen. The findings indicate that CTF alone strengthens the axial compressive strength of concrete but weakens the splitting tensile strength. VS also weakens the splitting tensile strength but has no influence on the other two strengths. Only with the right fibre dosage does hybrid fibre have a favourable synergistic effect on mechanical characteristics. The synergistic effect of hybrid fibre varies with dosage. CTF-PF hybrid fibre is shown to work best when combined with 1.0 kg/m3 polyvinyl alcohol fibre and 1.5 kg/m3 cellulose fibre to produce the best synergistic effect. Also presented are the practical ramifications of CTF, PF, and VS.

Zhu and Jia (2021) The effects of glass fibre (GF) and polypropylene fibre (PPF) on the mechanical and microstructural characteristics of concrete as a function of the water/binder ratio and fibre content are the subject of a thorough experimental study, the findings of which are presented in this paper. The concrete specimens for the experiment were made using various water/binder ratios (0.30 and 0.35), GF and PPF contents (0.45, 0.90, and 1.35% by volume fractions), and curing durations (7 and 28 d). The compressive, splitting, and four-point flexural tensile strengths as well as the complete curves of water absorption of glass- and polypropylene-fiber reinforced concrete (GFRC) were measured. In-depth analyses were done on the strengths and water absorption characteristics of GFRC/PPFRC. To examine the mechanism underlying the impacts of the water/binder ratio and the fibre, scanning electron microscope observation was carried out. The findings demonstrated that the ideal fibre content can be influenced by the water to binder ratio. The influence of the water/binder ratio should be taken into account when considering how fibres can improve the mechanical or microstructural qualities of concrete. When it came to improving water absorption, GF's effect was noticeably better than PPF's. The water absorption of GFRC and PPFRC tended to be steady as the test went on when the water/binder ratio was 0.30, but when it was increased to 0.35, the water absorption of the GFRC and PPFRC with the greatest fibre dosage continued to rise as the testing period was extended.

Zhang et al. (2022) Concrete has been strengthened using basalt fibre reinforced polymer (BFRP) fibres. A recently proposed BFRP fibre with a double-helix structure has a better bond-slip behaviour between the fibre and concrete matrix, improving the reinforcing effects on concrete materials. This study conducts laboratory tests to look into the static and dynamic properties of BFRP fibre reinforced concrete (BFRC) under compression and tension loadings in order to further analyse the contribution of double-helix BFRP fibres to the impact resistance of concrete material. First up is an analysis of how the volume fraction of double-helix BFRP fibres affects the mechanical characteristics of concrete under quasi-static loads. It has been discovered that raising the volume fraction of BFRP fibres to 1.5% enhances the BFRC's compressive strength, splitting tensile strength, and flexural performance. At a 3 mm deflection, the BFRC's toughness is 3.8 times more than plain concrete's, and its uniaxial compressive strength and splitting tensile strength are both improved by 10.7% and 16.2%, respectively. Furthermore, utilising split Hopkinson pressure bar test equipment, compressive, spitting tensile, and spall tests were conducted to examine the dynamic mechanical characteristics of BFRC with 1.5% fibre volume percent. According to test results, the insertion of double-helix BFRP fibres improves concrete's strain rate sensitivity in terms of its strength, ductility, and energy absorption capacity. The rate sensitivity increases with the strain rate and becomes more pronounced. Empirical formulas of DIF-strain rate relations for the compressive and tensile strengths of BFRC are proposed based on the test results.

IV. METHODOLOGY

1. Binding Material

By claiming lime and clay, the binding substance known as cement is created as a powder. It can be used to build mortar when combined with potable water, or concrete when combined with sand, stone, and water. Along with iron ore, silica sand, clay, slate, and blast furnace slag, common cement-making materials include limestone, chalk, and shells. Silicates and lime aluminates produced from clay and limestone are the primary building blocks of cement. Cement is made by claiming, or heating the aforementioned ingredients to 1450 °C in a kiln. The hardest type of cement, OPC, is made from clinker, a hard material that is pulverized into a powder along with some gypsum. The following is a list of the various cement varieties classified by the Bureau of Indian Standards (BIS):

- Ordinary Cement, Portland
- Portland Podzolana Cement
- Unslow Hardening Cement, Portland
- Cement from Portland Slag
- Hydrophobic Cement, Portland
- Light Heat Cement, Portland
- Defying Sulfate Cement from Portland.

2. Fine Aggregate

During the experimental sieving procedure, the majority of the aggregates pass through a 4.75 mm BIS screen known as fine aggregates sieve.

1. Natural Sand: Fine aggregates formed by the slow dissolution of rock that have been left behind by glaciers or rivers.
2. Crushed Stone Sand – crushed stone sand is a first-rate combination made by means of crushing tough stone.
3. Beaten Gravel Sand - crushed gravel stone is a pleasant combination made with the aid of crushing natural gravel.

Figure-1 Photograph of Fine Aggregate used present Work

3. Coarse Aggregates

Coarse aggregates comprise the majority of the particles that were retained on the 4.75 mm BIS Sieve in the laboratory sieve research. The various varieties of coarse aggregates include the following:

1. Uncrushed gravel or stone that is produced as a result of the weathering process naturally destroying rock.
2. Crushed stone or gravel that is produced when hard stone or gravel is crushed in a quarry.
3. Gravel or stone that has been partially crushed when it is a byproduct of combining the first two.

4. Industrial Waste Polypropylene Fibre

Thermoplastic polymer polypropylene (PP), commonly referred to as polypropene, is hired in a wide range of programs. They rank after polyesters, polyamides, and acrylics as the fourth most widely manufactured material. Each year, over 4 million tonnes of polypropylene fibers are manufactured globally. The mill uses conventional melt spinning to produce such fibers. The term "Stealth" formerly applied to polypropylene fibers. These monofilament fibers, which are 100% virgin photopolymer polypropylene, are categorized as micro reinforcing fibers. The best hydrocarbon, monomeric molecule C_3H_6, is the source of polypropylene.

5 Potable Water

The electricity of unsusceptible fibre strengthen composite and how soon unworn special plant up attend largely at the bounteous of aquatic we utilize (FRC). Furthermore, it raises the risk of fiber deterioration, especially when using techniques to harden fibers. However for you to leaf mould and obligation Ferro-concrete in the accurate regulate and placing, in title to hydroxide conglutinate, moiré is enjoin According to their analysis, in accordance with (4) (Balladur and Shah, 1992), a minimum dilute/glue rate of 0.28 is necessary for a consonant extension for hydration.

6. Compressive Strength of Test Cement as Per BIS: 4031 (Part 6) – 1988

Cubes of cement mortar with a composition of one part cement and three parts standard sand, measuring 70.6 mm x 70.6 mm x 70.6 mm, are used to measure the cement's compressive strength. The following materials were used in equal amounts for each cube.

Table-1. Quantity of Materials for Compressive Strength Test of Cement

Material	**Quantity**
Cement	200 gm
Standard Sand	600 gm
Water	(P/4+3) Percent Weight of Cement And Sand

7. Water Absorption

The water absorption value for coarse aggregates, which are frequently used in road surface course, normally ranges from 0.1 to about 2 percent. The Indian Road Congress (IRC) and Ministry of Road Transport and Highways (MORTH) have specified maximum water absorption values of 1.0 percent for aggregates used in bituminous surface treatment. According to MORTH specifications

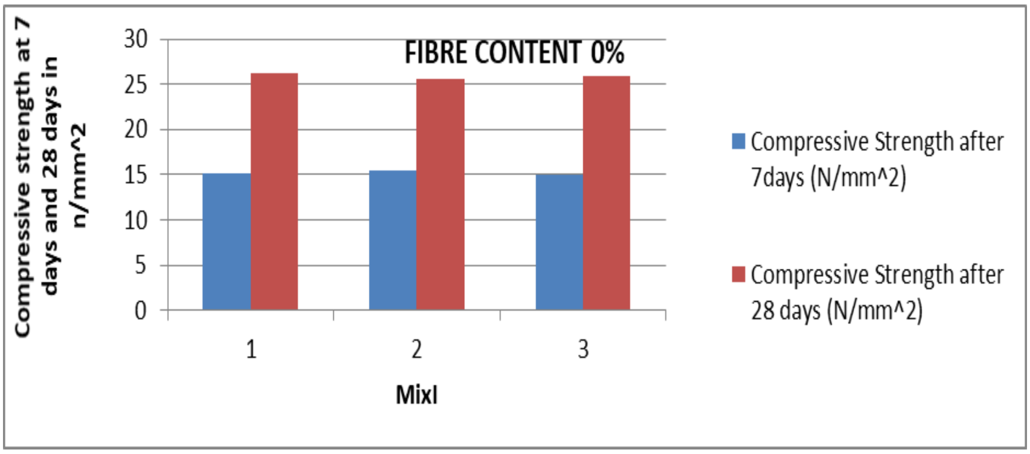
V. RESULTS AND DISCUSSION

1. Compressive Strength of Fibre Reinforced Concrete

The compressive strength of all the prepared mixes is determined at the ages of 7 and 28 days for the various addition levels of polypropylene fibre with cement concrete. The values of average compressive strength for different mixes prepared by addition of polypropylene fibre (0%, 0.25%, 0.50%, 0.75% and 1.00%) at the completion of different curing periods (7 days and 28 days) are given in the various Tables below.

Table-2. Compressive Strength of Fibre Reinforced Concrete (Mix-I)

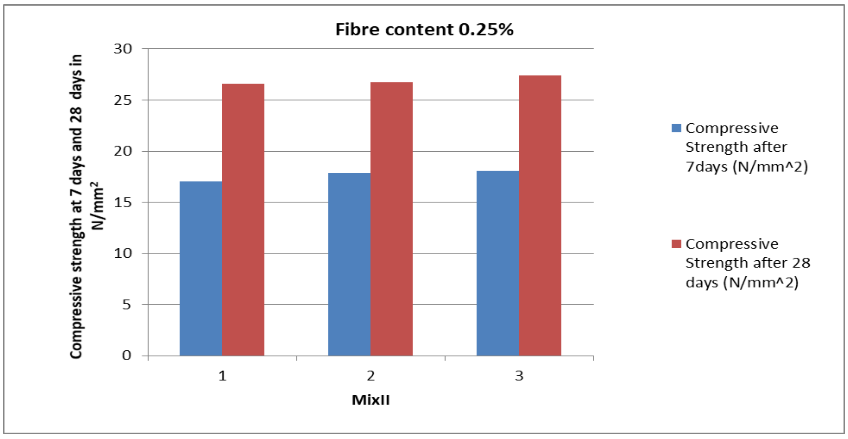
S. No.	Fibre Content	Compressive Strength After 7 Days (N/mm^2)	Compressive Strength After 28 Days (N/mm^2)
1	0%	15.2003075	26.23278875
2	0%	15.44547375	25.54632325
3	0%	14.95514125	25.84052275



Graph-1 Compressive Strength of Fibre Reinforced Concrete v/s Mix1

Table-3 Compressive Strength of Fibre Reinforced Concrete (Mix-II)

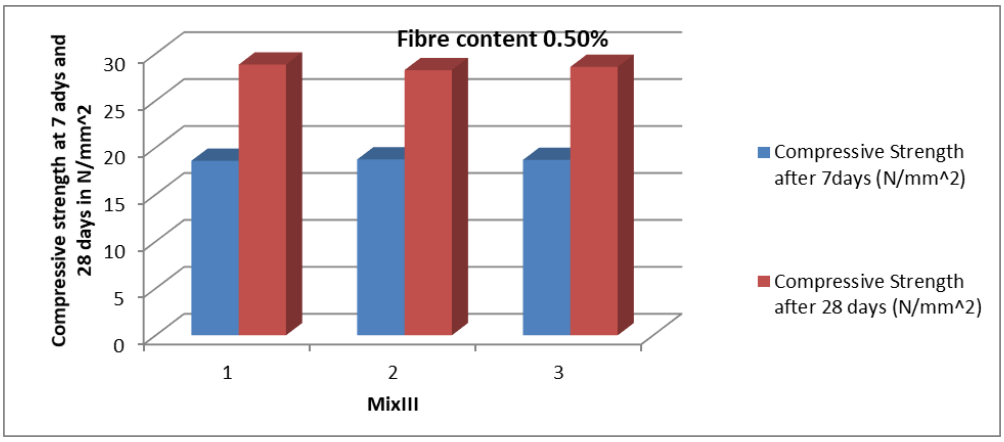
S. No.	Fibre content	Compressive Strength after 7 days (N/mm^2)	Compressive Strength after 28 days (N/mm^2)
1	0.25%	17.01453775	26.5760215
2	0.25%	17.848103	26.72312125
3	0.25%	18.09326925	27.40958675



Graph-2 Compressive support of Fibre Reinforced Concrete v/s mixII

Table-4 Compressive Strength of Fibre Reinforced Concrete (Mix-III)

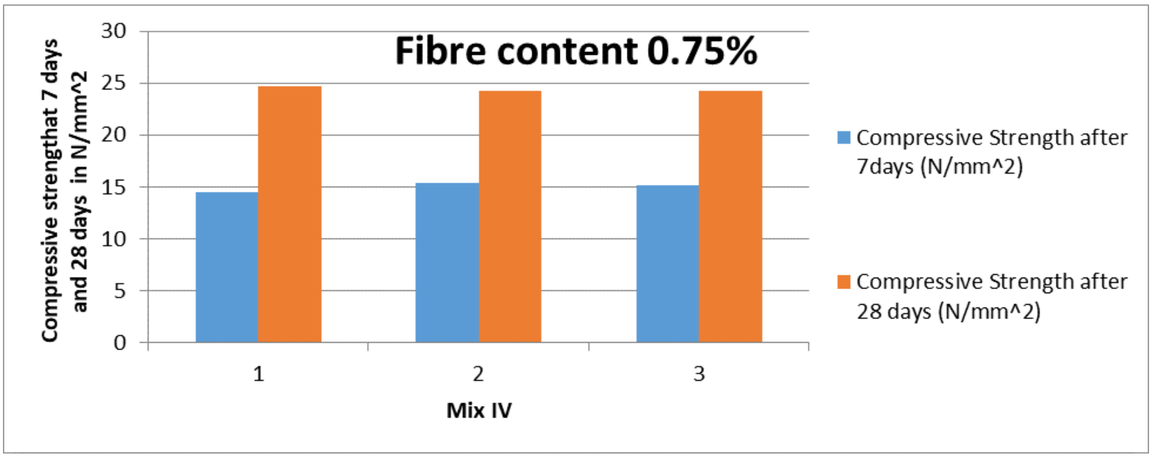
S.No.	Fibre content	Compressive Strength after 7days (N/mm^2)	Compressive Strength after 28 days (N/mm^2)
1	0.50%	18.58360175	28.831551
2	0.50%	18.7307015	28.243152
3	0.50%	18.68166825	28.58638475



Graph-3 Compressive Strength of Fibre Reinforced Concrete v/s MixIII

Table-5. Compressive Strength of Fibre Reinforced Concrete (Mix-IV)

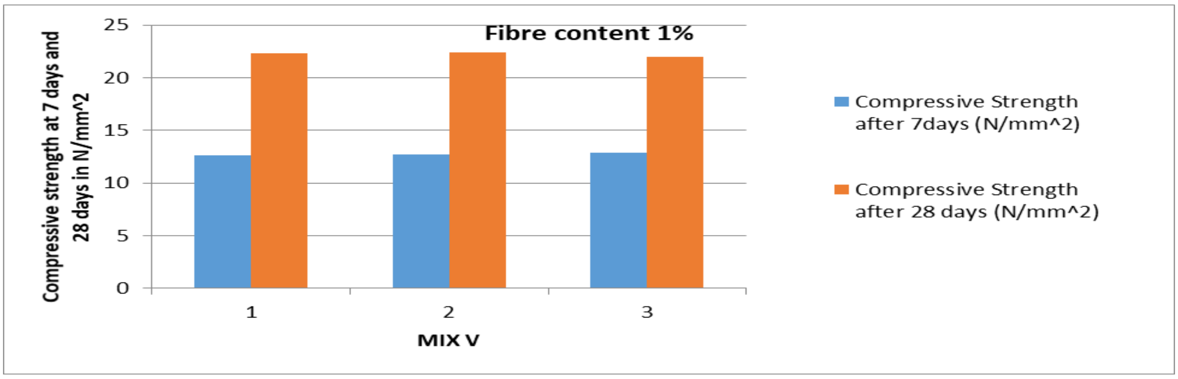
S. No.	Fibre content	Compressive Strength after 7days (N/mm^2)	Compressive Strength after 28 days (N/mm^2)
1	0.75%	14.46480875	24.66372475
2	0.75%	15.3964405	24.2224255
3	0.75%	15.2003075	24.27145875



Graph-4 Compressive Strength of Fibre Reinforced Concrete v/s MixIV

Table-6 Compressive Strength of Fibre Reinforced Concrete (Mix-V)

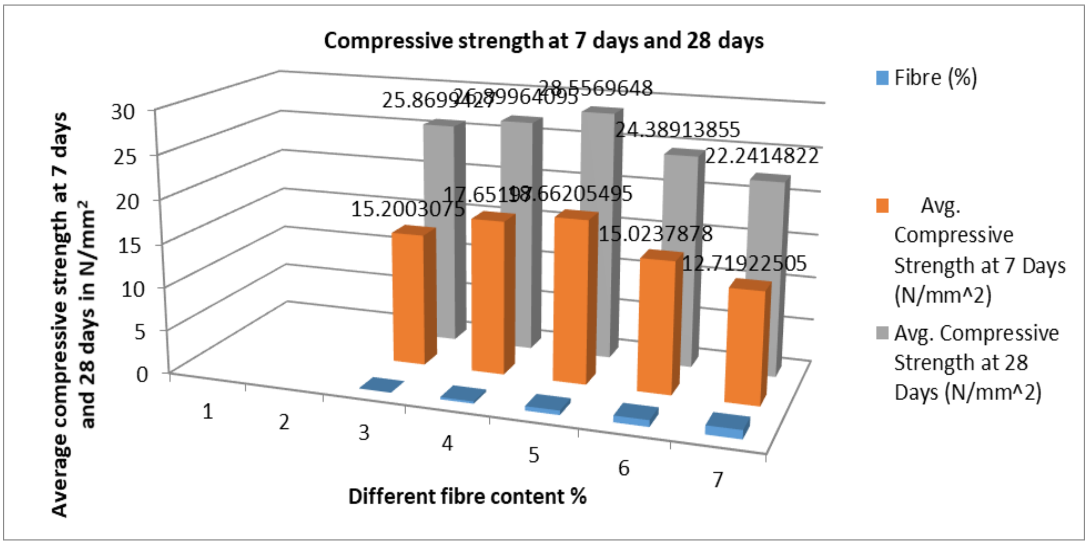
S.No.	Fibre content	Compressive Strength after 7days (N/mm^2)	Compressive Strength after 28 days (N/mm^2)
1	1.00%	12.60154525	22.31012875
2	1.00%	12.69961175	22.40819525
3	1.00%	12.8467115	22.01592925



Graph-5 Compressive Strength of Fibre Reinforced Concrete v/s MIXV

Table-7 Combine Table for Compressive Strength of Fibre Reinforced Concrete

S. No.	Fibre (%)	Avg. Compressive Strength at 7 Days (N/mm^2)	Avg. Compressive Strength at 28 Days (N/mm^2)
1	0	15.2003075	25.8699427
2	0.25	17.65197	26.89964095
3	0.5	18.66205495	28.5569648
4	0.75	15.0237878	24.38913855
5	1	12.71922505	22.2414822



Graph-6 Combined Test Results of Compressive Strength of Fibre Reinforced Concrete v/s % of fibre content

VI Conclusions

1. A thorough analysis of the test data reveals that the addition of waste polypropylene fibre significantly affects the fibre reinforced concrete's 7 and 28 day compressive strength (FRC).
2. The compression strength of conventional concrete are raised by up to 10% and 17%, respectively, by adding 0.5% of the weight of cement, it is clear from the large change that the addition of waste polypropylene fibre in a specific quantity.
3. At 7 days and 28 days of curing with 0.25% and 0.50% addition of fibre, the compressive strength of Fiber Reinforced Concrete (FRC) gradually increased, but after that point, it started to decrease as the amount of fibre added increased.
4. With fibre additions of 0.25% and 0.50%, the split tensile strength of Fiber Reinforced Concrete (FRC) gradually grew at 7 days and 28 days of curing, but as the amount of fibre added increased, it then began to drop.
5. Using discarded polypropylene fibre raises the strength of concrete for all curing ages up to a point. After that, the fiber-reinforced concrete's strength suddenly starts to decline (FRC). Because higher dosages of concrete cause it to lose its ability to establish a good connection.

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