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An Exploration of Pozzolanic Materials and its Partial Replacement as Steel Fibers and Steel Bars

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ABSTRACT: Concrete is the most commonly utilized man-made construction material. Cemetery materials, water, aggregates, and other admixtures are blended in a specified ratio. Pre-cast concrete has the fluidity of new material, but it hardens over time to the rock-like quality of completed product. Because of chemical interactions between water and cement, the substance grows stronger over time. Polypropylene fiber is a relatively new material to be used in place of steel fibers and steel bars. This study used the time and lab equipment allocated to it to show the usefulness of fiber-reinforced concrete. Employing a super plasticizer, it is possible to produce the requisite strength with a low water cement ratio. The 28-day compressive strength at 3% fibre content is the maximum when using steel fiber in OPC. Polypropylene fibre in concrete lowers compressive strength by 11%. Steel and polypropylene fibres enhance compressive strength when combined. Increasing fiber percentage in both aspect ratios yields slight differences. Using the T-Test, aspect ratios of 50 and 60 in polypropylene fibre provide compressive strengths of 1.23x10-6 and 8.64x10-5. According to these results, the null hypothesis is 95% accurate. For steel and polypropylene samples with an aspect ratio of 50 and 60, split tensile strength is 0.000479 and 9.68x10-5, respectively. Method guarantees 95% of outcomes. In future researcher are studying the possibility of using pozzolanic materials such as steel fibers and polypropylene fibers as a partial cement replacement in construction to increase strength and reduce the cost of building materials.

KEYWORDS: pozzolanic materials, steel fibers, steel bars, Polypropylene fiber, T-Test

I. INTRODUCTION

Concrete is the most often used man-made building material. Cemetery materials, water, aggregates, and other admixtures are combined in a certain ratio. Pre-cast concrete has the fluidity of fresh material, but it hardens over time to the rock-like quality of finished product. Because of chemical interactions between water and cement, the material becomes stronger with time.During the last century, OPC round steel bars of mild steel, which were freely available on the market, were the principal source of RCC structures' long-term durability. The outward look, characteristics, and strength of these materials also altered throughout time. As an example, Pozzolana cement and TMT bars have replaced mild steel bars in the construction industry.The component's strength is measured in accordance with Indian Standards. The findings of the testing machines are flawless after 28 days of casting and curing cubes, cylinders, and beams in water.

Polypropylene Fiber Reinforced Concrete

Additionally, this concrete may be used in thin-shell domes, surface restoration, and as a component of overlaying systems. Over the last two decades, polypropylene fiber-reinforced concrete has become more popular.

Because of their low strength and low value modulus of elasticity in comparison to steel fibers, polypropylene fibers are unable to offer primary or 1° reinforcement to concrete construction. Other uses include supporting a desired material behavior, including shrinking and enhanced toughness.

Structural uses of polypropylene fibers have been used up until recently, however this is no longer the case. Polypropylene film fibers and monofilament fibers are easily accessible. Orifices in the spinner jet may be used to produce monofilament fiber, which can be trimmed to the required length. In theory, this film may be axially stretched into a tape. Different kinds of fibers may be made by cutting or twisting these tapes over a roller pin mechanism, which creates longitudinal cutting. It has a net-like forming structure, which is characteristic of fibrillated fibers. When fibers are extruded, certain molecular orientation may be used to enhance their tensile strength.

Although it can only withstand temperatures of roughly 100°F (5°C) for a brief time before melting, Polypropylene has a melting point of 165°C. If a chemical damages polypropylene fiber, it will have a devastating effect on the concrete mix. When exposed to either UV light or oxygen, polypropylene fibers will not degrade as easily as other

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fibers. However, when fibers are added to concrete, these cures may be omitted entirely.
Fibers that do not absorb water are hydrophobic in nature. Consequently, when combined with concrete, it must be dispersed across a large region. Monofilament fibers, which limit cracking that occurs due to shrinkage and heat stresses in the early phases, are used. Increased longevity and inexpensive maintenance are two of the economic benefits of using polypropylene fiber reinforced concrete (RC).

II. MATERIAL AND METHODS

Sections on concrete material, mix preparation, casting and curing are covered in depth in this chapter's section on testing and evaluation.

Cement

In the presence of water, cement has both cohesive and adhesive capabilities. Hydraulic cements are the name given to these types of cements. It comprises aluminates and silicates of lime derived from clay and limestone in its chemical makeup. A wide variety of cements are now available, with this research focusing on the twotypes i.e.

- Ordinary Portland Cement (OPC)
- Portland Slag Cement

The most common kind of Portland cement, OPCI, is ideally suited for usage in the manufacture of ordinary concrete. There are 33 grades, 43 grades, and I 53 grades in all. Faster strength growth is one of the most essential advantages.

By combining linker, gypsum, and blast furnace slag in the right proportions, and then grinding the mixture completely, you may get ordinary Portland cement, which is often used in cooking and in toothpaste. It's more heat-resistant and more long-lasting than most other options. manufacturing of it can be used in mass concrete

Water

The water in the concrete mix has a considerable influence on the hydration process. Due to an increase in distance between particles caused by the injection of too much water, there is a rise in prosperity as well as a decrease in length. Pervious concrete's permeability and percolation properties are not compromised when the precise amount of water is used to make it as strong as possible.

The Authority of Greater Noida provides local tap water for use in this research. Water-cement ratio (w/c): i0.5 is the pre-determined ratio employed in this investigation.

Aggregate

An aggregate property has a significant impact on the concrete's behavior since it accounts for around 80% of the bulk volume. Coarse and fine aggregates are the two main types of aggregates.

The fine aggregate is material less than 4.75 mm gauge when passed through an IS-4.75 mm sieve, whereas coarse aggregate is material larger than this stipulated size. Coarse aggregate is the primary matrix of the concrete, while fine aggregate serves as filler between coarse particles. The primary role of fine aggregate is to ensure that the concrete mixture is homogeneous and easy to work with. The fine aggregates aid the cement paste in suspending and controlling a variety of coarse aggregates.

There are four distinct zones in the IS i383:1970, each with its own name: Zone I, Zone II, Zone III, and Zone IV. I Preliminary calculations suggest the use of 20 mm-sized coarse aggregate for this project. Size limitations may not apply, therefore 40 mm or even bigger may be acceptable. 10 mm aggregates are also utilized for tight reinforcement to the concrete. This has a large influence on both the characteristics of freshly formed concrete and hardened concrete when the aggregates reach the bulk volume of the concrete.

Fiber:

3.2.4.1 An overview on fiber:
The flexural tensile strength of fiber-reinforced reinforced concrete members has been examined in recent years in a variety of investigations. The use of high-strength fiber-reinforced polymer (FRP) materials has been given the all-clear.
The discrete fibers in this composite material technology are dispersed at random throughout the concrete mass. When comparing the behaviorist efficiency of various building materials, it is invariably observed that composites outperform

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conventional cement concrete. There is a broad range of applications for FRC, from airport runways and taxiways to highway pavements to constructions that are seismically resistant or have a propensity to withstand an explosion. FRC has been extensively employed during the last two decades in these and other areas. Massive amounts of FRC research have resulted in a theoretical proposition that the addition of various fibers, such as glass, synthetic, steel, carbon, to concrete increases its strength, ductility, post breaking resistance, and toughness. With FC, there is a decrease in the creation of micro-cracks as well as an increase in the strength in terms of shear, flexure, tension and compression due to its capacity to withstand fatigue.

III. RESULTS AND DISCUSSIONS

Engineers appreciate fiber reinforced concrete's (FRC) unique combination of physical and chemical qualities. That's why our present research will focus on the SFRC and PPFRC, two materials that can be utilized as cement substitutes while still passing the essential strength tests on mortar cubes.
There are two basic components used in the production of FRC concrete: steel fibers and polypropylene fibers (PP). The 28-day study will examine the impacts of varying fiber proportions (0, 1, 2, or 3 percent) on tensile, compressive, and bending strength. The w/c ratio is expected to continue between 0.35-0.50. This project has been completed using 53-grade Portland cement.This research makes use of a variety of components, including fiber and a super plasticizer for the strength assessment in concrete.Information on concrete material, mixing, preparation, curing and sintering is presented in this chapter in great depth in each of the relevant parts.

Materials

An OPC – 53 grade is utilized in the experiment.
The cement's various qualities are indicated in the table below:

1. Fineness – 340 m^2/kg
2. Specific gravity- 2.96
3. Initial setting time - 90 min
4. Final setting time – 190 min

Fine aggregate:
Sand from the Mahanadi River (in Raipur, Chhattisgarh, India) was used in this study, and sieve analysis was performed according to IS 383:1963, utilizing various sieve sizes (IS 10mm, IS 4.75mm,IS 2.36mm, IS 1.18mm, IS 600, IS 300, IS 150).

The characteristics of a fine aggregate:
Table 1 lists some of the most essential characteristics of fine aggregates.

Table1: Properties of Fine Aggregates

Properties	ResultsObtained
SpecificGravity	2.65
Waterabsorption	0.65%
FinenessModulus	2.48

Coarse aggregate:

The maximum size of coarse material that was taken into consideration was 20 millimetres. An IS 10 mm sieve size was used for the calculation of 60 percent of the mix percentage of coarse aggregate in accordance with IS 383:1970. An IS 20 mm sieve size was used for the remaining 40 percent of the mix percentage.

Properties of coarse aggregate:
Table 2 contains information about the characteristics of coarse aggregates.

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Table 2:characteristics of coarse aggregates

Properties	ResultsObtained
SpecificGravity	2.67
Waterabsorption	0.61%
FinenessModulus	4.01

Fibers: Steel and polypropylene fibers are being used for this project. When added to concrete, it was used in proportions ranging from 0% to 3% by weight. These proportions included: 1%, 2%, and 3%.

Strengths of Specimens

The compressive strengths of the Nominal Mix are listed in Table 3 below:

Table 3: The compressive strength of the nominal mix

Zero percent fiber's compressive strength, measured in N/SqmmGrade M40		
	Observed C.S.	Avg. C.S.
Sample M1	37.4	38.78
Sample M2	36.8	
Sample M3	38.1	
Sample M4	40.8	
Sample M5	41.1	

Conventional concrete samples have been collected for testing. These are the compressive strengths of the various cube samples. Using no fibers in concrete, the strength of the finished product was 40MPa after 28 days of curing.

The compressive strength of steel fiber mixed with normal concrete is shown in Table 4.

Table 4: The compressive strength of steel fibre mix

Steel Fiber Grade M40's Compressive Strength (in N/sqmm) at 1 percent, 2 percent, and 3 percent							
Aspect Ratio		**1 %**	**Avg**	**2%**	**Avg.**	**3%**	**Avg**
50	Sample CS1.1	52.2	52.74	53.1	54.34	55.6	55.66
	Sample CS1.2	54.8		54.8		55	
	Sample CS1.3	53.2		54		54	
	Sample CS1.4	52.5		55		57.5	
	Sample CS1.5	50.9		54.8		56.2	
60	Sample CS2.1	53.3	53.4	54.8	56.94	56	58.12
	Sample CS2.2	52.1		54.5		55.8	
	Sample CS2.3	54.4		58		58	
	Sample CS2.4	55.1		58		60.2	
	Sample CS2.5	52.1		59.4		60.6	

Table 5is offered in order to get steel and polypropylene fibers' T-test compressive strength values with an aspect-ratio of 60.

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Table 5: Steel and Polypropylene Fiber Compressive Strength with AR-60

Compressive Strength(Mpa) for Aspect-Ratio 60		
Fiber %	**SFRC**	**PPFRC**
1%	53.3	40.5
	52.1	45.5
	54.4	48.9
	55.1	43.5
	52.1	48
2%	54.8	44.8
	54.5	50.4
	58	53.6
	58	52.2
	59.4	53.9
3%	56	49.4
	55.8	45.4
	58	60.1
	60.2	55.4
	60.6	62.1

T-test Result: Compressive strength test data for SFRC and PPFRC's aspect ratio 60 are shown here in a table with 30 observations. 56.153 and 50.24 are the medians. There are 7.62 and 36.88 variations. There is no difference between the hypothesized mean difference and the P-value of 8.64x10-5, which indicates a significant value.

Table 6: T-Test Summery

S.No.	**Description**	**P- Value**	**Remarks**
1	Compressive strength of steel fiber with AR-50& AR-60	0.0011	Significant
2	Polypropylene fibers have a high compressive strength with AR-50 & AR-60	0.0209	Significant
3	Flexural strength of steel fiber with AR50 & AR-60	0.0738	Significant
4	Flexural strength of Polypropylene fiber with AR-50 & AR-60	0.0611	Significant
5	Split Tensile strength of steel fiber with AR-50 & AR-60	0.3454	Significant
6	Split Tensile strength of Polypropylene fiber with AR-50 & AR-60	0.0009	Significant
7	Steel and polypropylene fiber compressive strength measured using AR-50	1.238×10^{-6}	Significant
8	Steel and polypropylene fiber with AR-60's compressive strength	8.641×10^{-5}	Significant
9	Flexural strength of steel and polypropylene fiber with AR-50	2.407×10^{-21}	Significant
10	Steel and polypropylene fiber flexural strength with AR-60	4.56×10^{-13}	Significant

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11	Steel and polypropylene fibers with AR-50 have a split tensile strength	0.00047	Significant
12	Steel and polypropylene fibers with AR-60 have a split tensile strength	9.68×10^{-5}	Significant

IV. SUMMARY & CONCLUSIONS

The whole research effort is predicated on incorporating fibers into traditional concrete. Conventional concrete resists compression stresses, whereas steel bars provide tensile strength to them. When steel bars are laid and fixed in an organized manner, progress is delayed and needless work has to be done because of these processes.

We may utilize fibers of steel to replace the heavy steel bars in tiny places, such as on the pavement of roads, since the steel density bars and fibers will be the same. In addition, steel is susceptible to corrosion as a result of environmental factors. Steel fibers will have a much less impact.

Polypropylene fiber is a relatively new material to be used in place of steel fibers and steel bars. However, as described in the thesis' literature analysis and introduction, polypropylene fiber's current utility is overstated. When it comes to improving certain attributes like toughness or water tightness, these Polypropylene fibers might be favored above all other forms of concretes. PPFRC may be used in a wide range of constructions, including buildings, bridges, highways, industrial floors, and hydraulic systems.

Foreign nations in the early stages of development are the primary users of fiber reinforced concrete (FRC). FRCs have not been used in carrying structures because the fibers have been prohibitively costly and have not been commercially viable.

There is too much difference between the methods employed in rich nations and those utilized in developing ones. Fibers were subject to their own set of criteria. Fiber reinforced concretes have been suggested by the American Concrete Institute in certain papers. Only Indian standards are used while developing processes in India.

The findings of this study's experiments suggest that many fibers should be used in lieu of reinforcing steel. It has been shown that the compressive and characteristic strength of steel FRC is greater than that of polypropylene FRC. Steel's fiber shape differs from polypropylenes in that it has a higher ductility, hence aspect ratios play a role. The polypropylene fiber was shown to have excellent flexural strength in both situations of aspect ratios, as demonstrated by three-point observations. Fibers have a greater tensile strength than steel because they have the ability to stretch axially.

We employed the t-test approach, a statistical tool for correlating generic characteristics. The null hypothesis with 0.05 alpha label values yielded a significance level of 1.96. Only by using as many samples as feasible was it able to achieve this level of data analysis excellence.

V. CONCLUSIONS

The current research has taken use of the time and laboratory equipment allotted to it in order to demonstrate the effectiveness of so-called fiber reinforced concrete. Ultimately, it was determined that:

- Using a super plasticizer, it is feasible to achieve the necessary strength with a low water cement ratio.
- The 28-day compressive strength at a 3 percent fiber content is the highest result attained while using steel fiber in OPC.
- Compressive strength is 11 percent lower than steel when polypropylene fiber is combined with normal concrete.
- When steel and polypropylene fibers (such as steel and polypropylene) are mixed together, the compressive strength improves progressively. In other words, increasing the proportion of fibers in both aspect ratios results in marginally different results.
- Comp compressive strength reaches its maximum limit for aspect ratios of both 50 and 60. This demonstrates that greater compressive strength is associated with longer fibers.

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- There will be no changes in strength if the fibers are not mixed.
- Polypropylene has the highest flexural strength of any plastic, making it an excellent material to use in the casting of beams.
- Polypropylene fibers also benefit from fiber orientations. For the simple reason that it can withstand more evenly distributed loads than steel.
- In terms of flexural strength, steel and polypropylene fibers have a significant lead over one another for aspect ratio 60.
- Steel and polypropylene have a 10% difference in split tensile strength at an aspect ratio of 50. In contrast, with aspect ratio 50, the difference is around 20%.
- The fluidity of polypropylene fibers makes them more effective in the tensile zone.
- For steel and polypropylene fibers, the null hypothesis in the T-Test for compressive strength with aspect ratios of 50 and 60 gives accurate values of 0.0011 and 0.020, which indicate the outcomes of testing.
- It is more effective to prove that samples obtained for these tests are correct if the split tensile strength in T-Test is 0.0009.
- Aspect ratios of 50 and 60 in polypropylene fiber provide compressive strength values of 1.23x10-6 and 8.64x10-5 respectively when using the statistical approach known as the T-Test. According to these findings, the null hypothesis is correct, with a 95 percent accuracy rate.

For samples of steel and polypropylene with an aspect ratio of 50 and 60, the estimated typical strength values in split tensile strength for these materials are 0.000479 and 9.68x10-5, respectively. More than 95% of the results are guaranteed by this method.

Scope for future work

Pozzolanas and other pozzolanic materials and fibers have received only a small amount of investigation. However, it opens up a broad range of possibilities for further research, including the following:

- Good strength development necessitates partial replacement of cement with sand of varying percentages and fineness.
- In order to reduce the cost of construction, researchers are studying steel fiber and polypropylene fibers with increased aspect ratios as a partial cement replacement material.
- For the creation of high-strength, high-performance concrete, the right mixing proportions may not be attainable manually. To achieve the desired outcome with better precision and efficiency, global optimization approaches are thus required.

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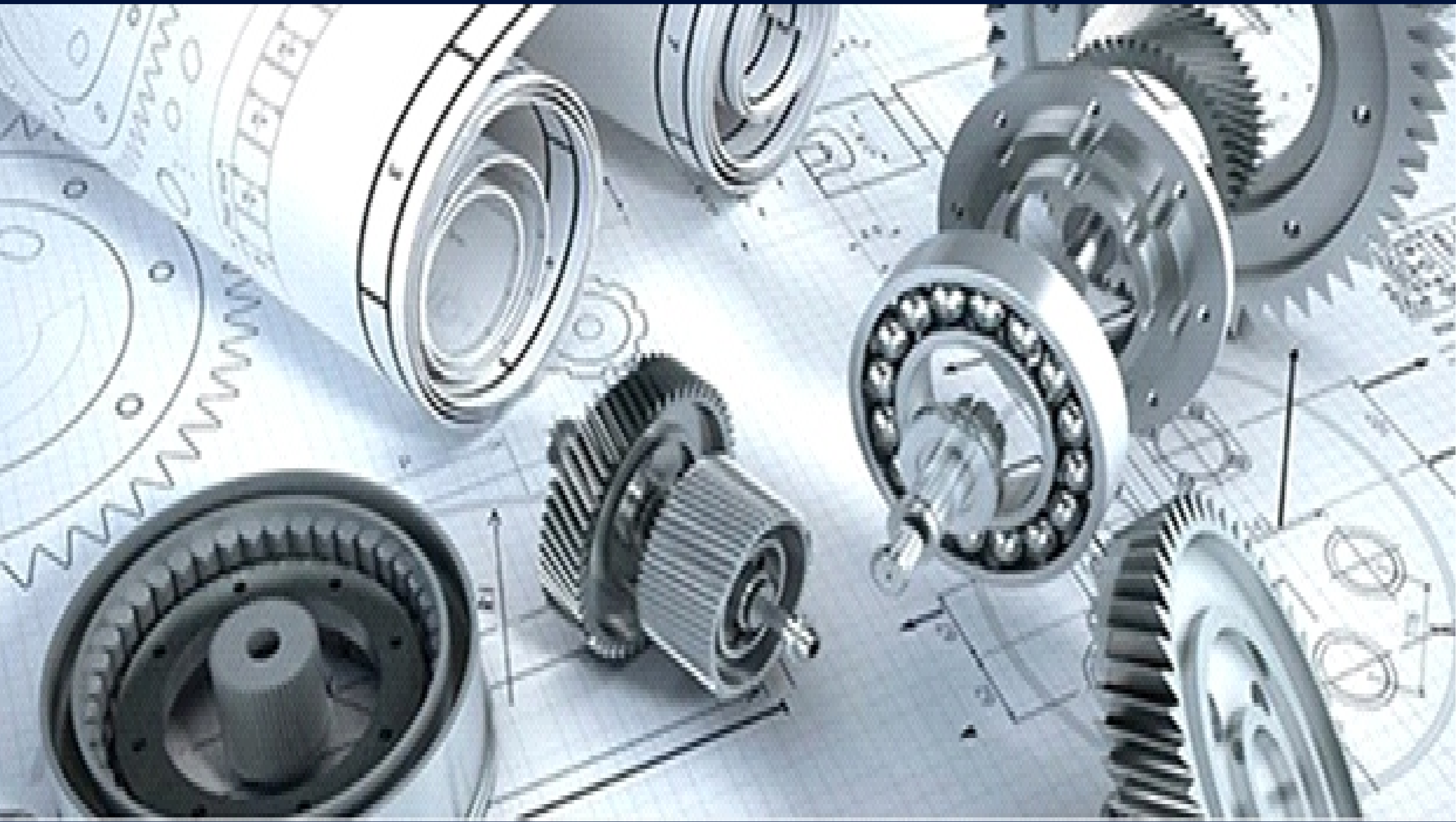

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