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Experimental Investigation of Partial Replacement of Cement with Marble Dust and Prolpropylene Fiber in the Concrete Mix

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ABSTRACT

Rate of the cement production every year over worldwide is around 3 billion tons. Cement is the binding material which is important for building sector. Emission of CO2 due to cement industry is around 7% of worldwide. Concrete when used without reinforcement tends to be brittle in nature with very poor tensile strength and less strain capacity. During construction of concrete structures various hard circumstances get subjected on it which includes chemical attacks such as chloride, sulphate, and acid which in result gave a negative impact on the durability of structure. Polypropylene Fiber is a thermoplastic polymer which adds adhesive force due to its nature and hold the concrete mix together, reducing bleeding, shrinkage (both plastic and elastic), and cracks. Marble dust is also added to the mix in replacement of cement by 10%weightand the fibers used in quantity of 0.5%to 2% and check result. The methodology, procedure of tests used according to the IS codes and the results are tabulated.

KEY WORDS - Polypropylene fibers , Marble dust

I. INTRODUCTION

Concrete is a mixture of aggregates such as coarse aggregate, fine aggregate and cement, sand. Other additive and admixtures may be present. It is the world's most essential building material, and humans have been utilizing it for a long time. Aggregate is the most important component after cement to employ in concrete. Cement is produced at a rate of over 3 billion tons per year. For the manufacture of concrete, the building sector relies on cement. Cement industry emissions account for around 7% of worldwide CO2 emissions. To lower this emission, we must limit cement usage. It has become a competitive building material due to its properties like relative economy and high versatility which meets a wide range of needs in general. The demand for concrete in today's infrastructure expansion is gradually increasing.

Concrete without reinforcing is brittle in nature, which have very poor tensile strength and a limited strain capacity. Concrete constructions are subjected to a variety of harsh circumstances, including chemical attacks such as chloride, sulphate, and acid. These attacks have a negative impact on the concrete structures' durability. Corrosion, which is induced by chloride attack on hardened reinforced concrete, is the most significant effect. These chemicals seeped into concrete structures through fractures, corroding them and causing deterioration, which has an impact on the structure's durability.

From past time fibers are used to provide the flexural and tensile strength of concrete since ancient times, and some academics have also researched about the effect which occurs after using fiber on various characteristics of the concrete. Since the time, many types of fibers, like carbon, steel, glass and as well as polypropylene fiber have been employed in concrete. The addition of fiber to concrete affects its brittleness and ductility. These chemicals seeped into concrete structures through fractures, corroding them and causing deterioration, which has an impact on the structure's durability.

Polypropylene Fiber is a thermoplastic polymer that, because of its thermoplastic nature, adds to adhesive force and can hold the concrete mix together, reducing bleeding, shrinkage (both plastic and elastic), and cracks.

Fiber scattered in concrete forms a bridge across fissures, allowing for some ductility after cracking. Fiber reinforced concrete may endure significant stresses across a relatively high strain in the post-cracking condition if polypropylene fibers are used that are strong enough and form excellent connections with the material. Polypropylene fibers of various sorts can be used to strengthen concrete, reducing the formation of cracks.

Polypropylene fibers improve several qualities of concrete mixes, including tensile strength, flexural strength, toughness, and strength of the impact, and also define the failure modes. Polypropylene fiber is used because it binds the concrete mix together, slowing the settlement of coarse particles and reducing bleeding, which indirectly slows the rate of drying, resulting in less shrinkage. Polypropylene fibers resist fractures and offer strength as any other secondary reinforcement in hardened concrete. The fibers prevent cracks from propagating by holding the concrete together, preventing cracks from spreading wider or becoming longer. Polypropylene fibers, on the other hand, are effective near to where fractures begin at the aggregate paste interface because they are disseminated throughout the concrete.

This research investigates the effect of polypropylene fiber on concrete mix when replacement of cement is done with marble dust. And also, the comparison between different grades of concrete i.e., M25 & M30 to analyse a cost-effective parameter

II. LITERATURE REVIEW

1. **Rani and Priyanka (2017)** conducted an experimental investigation employing polypropylene fiber to investigate the behavior of mechanical properties of self-compacting concrete, including compressive and flexural strength. There was also a comparison of polypropylene fibers and traditional fibers. According to the findings, the maximum amount of fiber in SCC was 0.75 percent to 1% of the total cement content per mix.
2. **Yeswanth et al., (2016)** with the inclusion of fibers and fly ash, the effect of polypropylene fiber on concrete was tested. Different amounts of fiber (0%, 0.05 %, 0.1 %, 0.15 %, 0.2 %, 0.25 %, 0.30 %, 0.35 %, 0.40 %) were added to the volume of concrete, while different amounts of fly ash (0 percent, 10%, 20%, 30%, and 40%) were added to the volume of cement. The addition of PPF to concrete containing fly ash has been found to have a minor negative effect on the workability of the concrete; however the addition of PPF and fly ash increase the strength of hardened concrete. In comparison to other concrete composites without fiber and fly ash, there was also an increase in cracking resistance.
3. **Dhillon et al., (2014)** The influence of fly ash content on the characteristics of fly ash concrete was examined using steel and polypropylene fibers. By weight, 15 percent, 20 percent, and 25 percent fly ash have been used to replace cement. Steel and polypropylene fibers were used in 0.5 percent and 1.0 percent by volume, respectively. The effect of different percentages of steel and polypropylene fibers on the compressive strength, split tensile strength, and flexural strength of fly ash concrete was investigated. The compressive strength, split tensile strength, and flexural strength of concrete decrease as the proportion of fly ash component increases, although this decrease is offset by the usage of fibers in concrete. Steel fibers outperform polypropylene fibers in terms of performance. In addition, as the proportion of fiber content increases, so does the percentage increase in all strengths.
4. **Panda and Ray (2014)** An experimental study was carried out to investigate the design technique and operations of polymer fiber reinforced concrete pavements. They provided a brief comparison of PFRC and traditional concrete pavement. They looked into how several types of recycled fibers, such as plastic waste, used tyres, carpet trash, and textile waste, can be used as fiber reinforcement. Over regular concrete, the polymer fiber enhances compressive strength by 12 to 16 % and flexural strength by 7 to 14%.
5. **Ahmed et.al, (2012)** The effects of various quantities of polypropylene fiber on concrete parameters such as compressive, tensile, flexural, shear, and plastic shrinkage cracking were investigated. Flexural, tensile, and shear strength all increased significantly. However, there was no difference in compression strength. The addition of fibers in the 0.35% to 0.50 % range has been shown to minimize shrinkage cracking by 83% to 85 %.

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6. **Pannirselvam et.al, (2009)** the experimental strength characteristics of a fiber reinforced polymer reinforced beam was investigated. They discovered that fiber reinforced polymer can be used to strengthen constructions. The goal of their research is to figure out how strong reinforced concrete beams are in terms of structural behavior. They discovered that the deflection ductility values for beams increased when compared to the corresponding reference beams.
7. **Patel and Kulkarni (2013)** The qualities of high-strength concrete with varying percentages of polypropylene fiber were investigated. The trials are being carried out to see how it affects compressive, tensile, flexural, shear, and plastic shrinkage cracking strength. Flexural, tensile, and shear strength all increased significantly. Varied proportions of Polypropylene fiber in the mix are utilized to create concrete of grade M40, and the optimum content of Polypropylene fiber is verified for different percentages like 0.5 %, 1.0 %, and 1.5 %. Concrete specimens were examined for mechanical properties of concrete such as cube compressive strength, split tensile strength, flexural strength, and other tests at various ages for the evaluation.

III. MATERIALS USED.

1. CEMENT

Ordinary Portland cement (53 Grade) was used for casting all the specimens The type of cement affects the rate of hydration, so that the strengths at 21 early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement. Properties of cement physical properties of the cement in the present experimental work are given below.

1. Physical Properties of Cement

S.NO	PROPERTY	VALUES
1.	Fineness of cement	220m^2/kg
2.	Specific gravity	3.2
3.	Normal consistency	36%
4.	Setting Time Initial setting time Final setting time	60mins 8 hours
5.	Compressive strength 3days 7days 28days	32N/mm^2 45N/mm^2 53N/mm^2

2. FINE AGGREGATE: -

River sand from local sources was used as the fine aggregate. The specific gravity of sand is 2.68. Properties of Fine Aggregate Physical properties of the fine aggregate used in the present work are given below.

1. Physical Properties of Fine Aggregate

S.NO	PROPERTY	VALUES
1.	Specific gravity	2.75

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2.	Bulk density Loose state Compacted state	 14.56KN /mm^3 17.34kN /mm^3
3.	Water Absorption	0.7%
4.	Flakiness index	16.75%
5.	Elongation index	22%
6.	Crushing value	28%
7.	Impact value	12%
8.	Fineness modulus	3.45

3. WATER: -

Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.

4. COARSE AGGREGATE : -

Crushed granite aggregate with specific gravity of 2.7 and passing through 20 mm sieve and retained on 10 mm was used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

1. Physical Properties of Coarse Aggregate

S.NO	PROPERTY	VALUES
1.	Specific Gravity	2.75
2.	Bulk Density Loose state Compacted state	 17.8KN /m^3 16.65KN /m^3
3.	Grading of sand	Zone – II

5. Polypropylene

Polypropylene is made from monomeric C3H6, a completely hydrocarbon compound. As mentioned below, the characteristic of polypropylene fibers is quite useful:

- The hydrophobic surface, which is not moistened by cement paste, prevents chopped fibers from balling up during mixing, as it does with other fibers.
- Polypropylene fibers have no water requirements.
- Because of the orientation, the film is weak in the lateral direction, allowing fibrillations to form. As a result, the cement matrix can penetrate the mesh structure between individual fibrils, forming a mechanical link between the matrix and the fiber..

PPF comes in a variety of forms, including fibrillated bundles, mono filaments, and microfilaments. The fibrillated PF are made by stretching a plastic film that is then cut into strips and sliced. The insertion of buttons to the ends of monofilament fibers improves the pull out load.

Polypropylene fibers are made from a synthetic resin made from propylene polymerization. Toughness, flexibility, light

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weight, and heat resistance are all advantages of polypropylene.
For this study, polypropylene fibers with an aspect ratio of 250 and a specific gravity of 0.954 were obtained through India Mart's online service

7 . Marble dust

Marble is a metamorphic rock made up mostly of recrystallized carbonate minerals like calcite and dolomite. Marble can have foliation. Marble is a metamorphic rock formed when limestone is heated and compressed during metamorphism. It is largely made up of the mineral calcite ($CaCO_3$), but it may also contain clay minerals, micas, quartz, pyrite, iron oxides, and graphite. Calcite in limestone recrystallized during metamorphism, resulting in a rock that is a mass of interconnecting calcite crystals. When dolostone is heated and compressed, a related rock called dolomitic marble is formed.

Marble polishing waste was collected from the industry. This study used marble powder from from Kishangarh Marble Industry, Kishangarh, Rajasthan which is supplied to Jay Goga construction; Ahmadabad (Gujarat) had a specific gravity of 2.77, fineness of 24.4 percent, water absorption of 1%, and a pH of 8.89.

V-MIX DESIGN

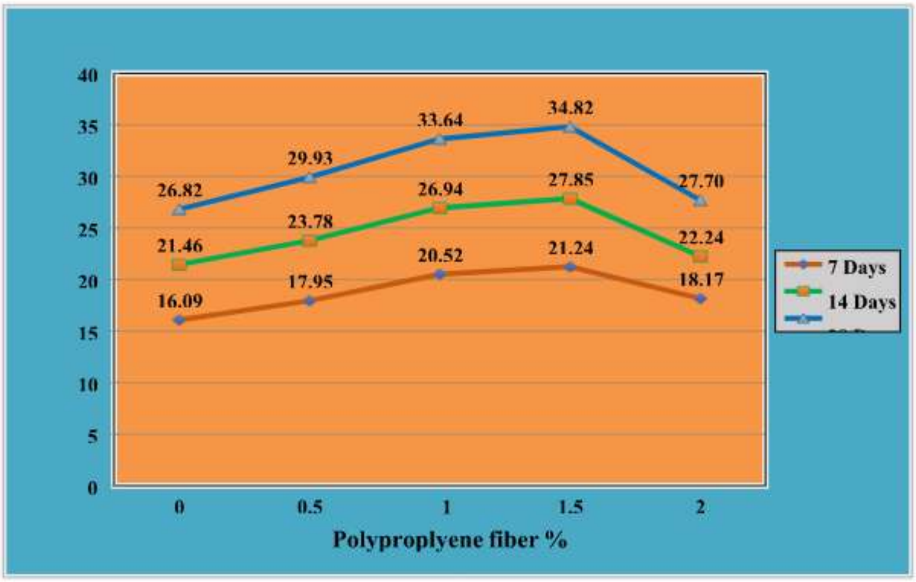
Mix Proportioning of M-25 Concrete (Using polypropylene fiber and marble dust as Partial Replacement of Cement)

Nominal mix of M 25 concrete 1:1:2

IV. RESULT AND ANALYSIS

Comparative Compressive Strength of M25 Grade

Polypropylene Fiber %	Compressive Strength(N/mm^2)		
	7 Days	14 Days	28 Days
0.0	16.09	21.46	26.82
0.5	17.95	23.78	29.93
1.0	20.52	26.94	33.64
1.5	21.24	27.85	34.82
2.0	18.17	22.24	27.70



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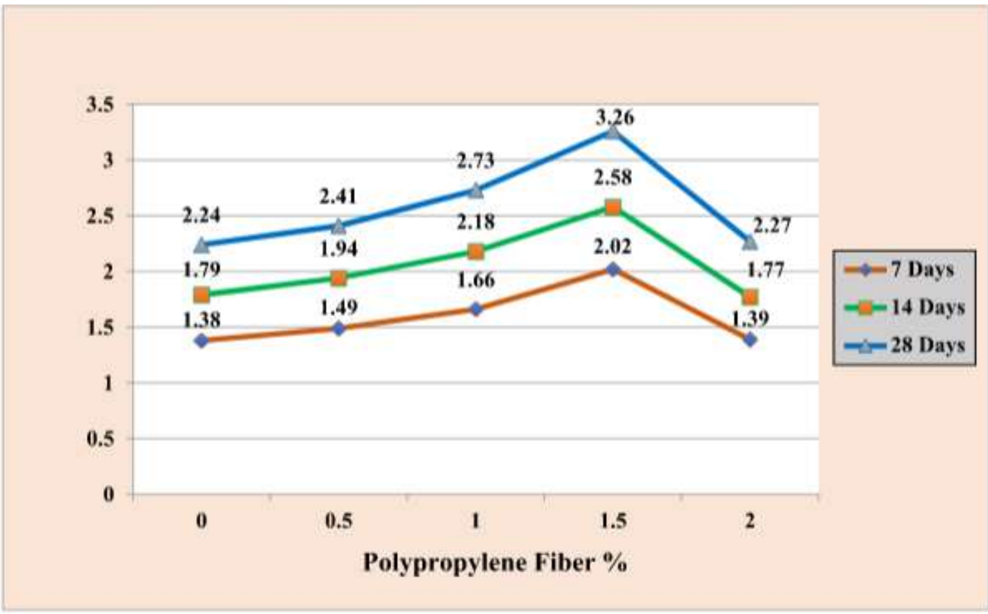
Splitting Tensile Strength of M25 grade

Polypropylene Fiber %	Splitting Tensile Strength(N/mm^2)		
	7 Days	14 Days	28 Days
0.0	1.38	1.79	2.24
0.5	1.49	1.94	2.41
1.0	1.66	2.18	2.73
1.5	2.02	2.58	3.26
2.0	1.39	1.77	2.27



V. CONCLUSION

From above experimental test, following conclusions are drawn:

Compressive Strength:

After 1.5 percent of PPF compressive strength drops for both 14 days and 28 days cube strength, the compressive strength grew as the percentage (percent) of polypropylene fiber (0 percent to 1.5 percent) increased.The ideal percentage increase in concrete compressive strength was found to be 29.82 percent after 28 days of curing.

Split Tensile Strength:

At 14 and 28 days of curing, the least split tensile strength was obtained with 0% polypropylene fiber addition, while the maximum split tensile strength was obtained with 1.5 percent polypropylene fiber addition.

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