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Strength Properties of Polypropylene Fibre Reinforced Concrete

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ABSTRACT

My project deals with the effects of addition of various proportions of polypropylene fibres on the properties of M20 mix design concrete. An experimental programme was carried out to explore its effects on compressive strength under curing conditions. The main aim of the investigation programme is to study the effect of polypropylene fibre mix by varying content such as 0%, 0.5%, 1%, 2% and finding the optimum polypropylene fibre content. The concrete specimens were tested at different age level for mechanical properties of concrete namely, cube compressive strength.

The scope of present study is

- *To study the workability in terms of compaction factor.*
- *To study the slump value.*
- *To study the strength characteristics in terms of compressive strength.*
- *Standard cubes of 150 X 150 X 150 mm have been cast and tested for obtaining 7 days, 14 days, 28 days compressive strength.*

The most common reason for adding admixtures is to alter the workability, improve the rate of gain of strength. Here we are using polypropylene fibre as admixture and mix design of M20 grade

Key words: *Compaction factor, polypropylene fibre, Slump value, compressive strength.*

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1. INTRODUCTION

In recent years, many studies have been conducted in the mechanical characteristics of fibre reinforced concrete. Such concrete is also used in retrofitting and repairing the covering of concrete structure, tunnels, etc..... Polypropylene fibres (at relatively low volume fractions <0.3%) are used for secondary temperature shrinkage reinforcement, overlays and pavements, slabs, flooring systems, crash barriers, precast pile shells and shotcrete for tunnel linings, canals and reservoirs.

According to the researches, the increase of formability and bending strength are the extra advantages of adding the fibres to the concrete.

There are two kinds of fibres are used:

- Natural fibre
- Artificial fibre

In artificial fibres two kinds of fibre that very often used in the concrete are:

- steel fibre
- polypropylene fibre

The evaporation of concrete surface water is a factor in creating the contract paste fracture in concrete which leads to the formation of tension stress since the concrete starts to strengthen mentioned that using polypropylene fibres can improve spelling behaviour of concrete. The paste fractures are formed when the acceleration of water evaporation is more than the movement of concrete emulsion to the surface. Here, the negative pressure is generated in the capillaries through which the concrete paste flows and proportionately the tension stress is formed. Such stress is developed during the concrete strengthening and the concrete is cracked where the stress is more than the concrete strength.

Table 1.1: The Characteristics Of Different Fibres

Type	Specific gravity (g/cm^3)	Tensile strength (MPa)	Young's modules(E) (GN/m^2)	Elongation at failure (%)	Common V (%)
Polypropylene	0.91	500-700	3.5-6.8	21	<2
Steel	7.86	400-1200	200	-3.5	<2
Glass	2.7	1200-1700	73	-3.5	4-6
Asbestos	2.55	210-2000	59	2-3	7-18

1.2 OBJECTIVE OF STUDY The main objectives of the present investigation is to find the COMPRESSIVE STRENGTH of concrete using the polypropylene fibre as admixture by Replacing the cement content, fine aggregates.

1.3 SCOPE OF STUDY

The primary role of fibres in a cementitious composite is to control cracks, increase the tensile strength, toughness and to improve the deformation characteristics of the composite. The performance of FRC depends on the type of the fibres used. Inclusion of polypropylene fibres reduces the water permeability, increases the flexural strength due to its high modulus of elasticity. In the post cracking stage, as the fibres are pulled out, energy is absorbed and cracking is reduced.

2. EXPERIMENTAL DETAIL

In the present investigation the following materials were used

- Ordinary Portland Cement of 53 Grade cement conforming to IS: 169-1989
- Fine aggregate conforming to IS: 2386-1963.
- Coarse aggregate
- polypropylene fibre
- water

2.1 Cement

Cement is a material with adhesive and cohesive properties which is capable of bonding mineral fragments into a compact-solid whole. Ordinary Portland cement is the most common type of cement in general uses all around the world as a basic ingredient of concrete, mortar. Ordinary Portland Cement of 53 Grade of brand name KPC, available in the local market was used for the investigation. The physical properties of the cement are listed in Table

Table 1.2. Properties Of Cement Used In This Investigation

Sl. .NO	PARAMETER	VALUE
1	Fineness of cement	4%
2	Normal consistency	30%
3	Initial setting time	42 min

2.2 Fine Aggregate

Sand is an inorganic material. It consists of small angular or rounded or sharp grains of Silica. Sand is formed by decomposition of sand stone under the effect of weathering agencies. Various sizes or grades of sand are formed depending on the amount of wearing. The characteristics of sand is listed in

Table 3. PROPERTIES OF FINE AGGREGATES

Specific gravity	2.62
Fineness modulus	3.2
Bulk Density (gm/cm³)	1.52
Sieve Analysis	Well graded

2.3 COARSE AGGREGATES

The aggregates are used in concrete for very specific purposes. The use of coarse aggregate in concrete provides significant economic benefits for the final cost of concrete. Aggregates typically make up about 60 to 75% of the volume of concrete mixture. The aggregates of size 20mm and 12mm are used in project.

Table 4. Grading Of Fine And Coarse Aggregates

IS SEVIES	%OF PASSING FINE AGGREGATE	% OF PASSING COARSE AGGREGATE
20mm	....	95
12.5mm	....	....
10mm	....	11.4
6.36mm	....	....
4.75mm	100	....
2.36mm	85	....
1.18mm	61.6	....
600µ	41.2	....
300µ	9.2	....

2.4 Polypropylene Fibres

Polypropylene is available in two forms, monofilament fibres and film fibres. Monofilament fibres are produced by an extrusion process through the orifices in a spinneret and then cut to the desired length. The newer film process is similar except that the polypropylene is extruded through a die-that produces a tubular or flat film. This film is then slit into tapes and uniaxially stretched. These tapes are then stretched over carefully designed roller pin systems which generate longitudinal splits and these can be cut or twisted to form various types of fibrillated fibres. The fibrillated fibres have a net-like physical structure. The tensile strength of the fibres is developed by the molecular orientation obtained during the extrusion process. The draw ratio (final length/initial length), a measure of the extension applied to the fibre during fabrication, of polypropylene fibres is generally about eight Polypropylene has a melting point of 165 degrees C and can withstand temperatures of over 100 degrees C for short periods of time before softening'. It is chemically inert and any chemical that can harm these fibres will probably be much more detrimental to the concrete matrix'.

Fig. 1. POLYPROPYLENE FIBRE

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Table 5. Properties Of Polypropylene Fibre

Fibre Type	Length (mm)	Diameter (mm)	Tensile strength (MPa)	Modulus of elasticity (GPa)	Specific surface (m^2/kg)	Density (kg/cm^3)
Micro-filament	12-20	0.05-0.20	330-414	3.70-5.50	225	0.91

2.5 Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6.

2.5 Mix Proportions In this project following are the mix proportions drawn by using ACI method

3. CONCRETE MIX DESIGN: (M20 Grade)

a) Design stipulations:

1. Characteristic compressive strength required in the field at 28 days is 20N/mm^2
2. Maximum size of aggregate 20mm(angular)
3. Degree of quality control Good
4. Degree of Workability 0.9compacting factor
5. Type of exposure mild

b) Test data for materials:

1. Cement used OPC satisfying the requirements of IS:269-1967
2. Specific gravity of cement 3.01
3. Specific gravity
a. Coarse aggregate 2.50
b. Fine aggregate 2.62
4. Water absorption
a. Coarse aggregate 0.40%
b. Fine aggregate 1%
5. Free moisture
a. Coarse aggregate NULL
b. Fine aggregate 2%
6. Compressive strength of cement @7 days Satisfies the requirement

c) Target mean strength:

20+1.65*4=26.8 Mpa

d) Selection for w/c ratio for target mean strength of 26.8 Mpa is 0.5. this is lower than maximum of 0.65.solution w/c ratio=0.50.

e) Selection of water and sand content for maximum 20mm size aggregate and confirmed is to grade zone2. water content per cubic metre of concrete is 186kg.and sand content as percentage of total aggregate by absolute volume=35%

Table 6. Aggregate content

Adjustment aggregate	**Water content**	**sand in total**
For decrease in W/C ratio 0.60-0.50=0.1	0	-2
For increase in compaction factor 0.90-0.80=0.1	3	0
Sand confirmed to zone2	0	0
TOTAL	3	-2

There for sand content as percentage of total aggregate by absolute volume
→ 35-2=33
Required water content →186+(3÷100)*186=191.6 lit/cu.m
f)Determination of water content
w/c ratio =0.5
water= 191.6 lit
cement=191.6/0.5= 383kg
The cement content is adequate for mild exposure condition.
g)Determination of coarse and fine aggregates

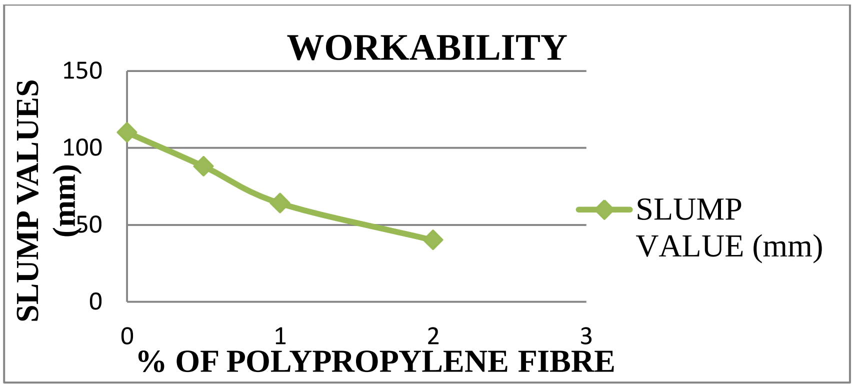
Water :	Cement :	fine aggregate :	coarse aggregate
191.6 :	383 :	573 :	1110
0.0 :	1 :	1.50 :	2.90

h) Actual quantities required for mix=per bag of cement

Cement= 50kg
Sand = 75kg
Coarse aggregate=145kg
60% of 20mm=87kg
40% of 12mm=58 kg

Table 7: Results Of Various Proportions

PERCENTAGE OF FIBRE	HEIGHT OF SLUMP
0	110 mm
0.5	88mm
1	64mm
2	40mm



Graph 1: Graph Showing Obtained Slump Values

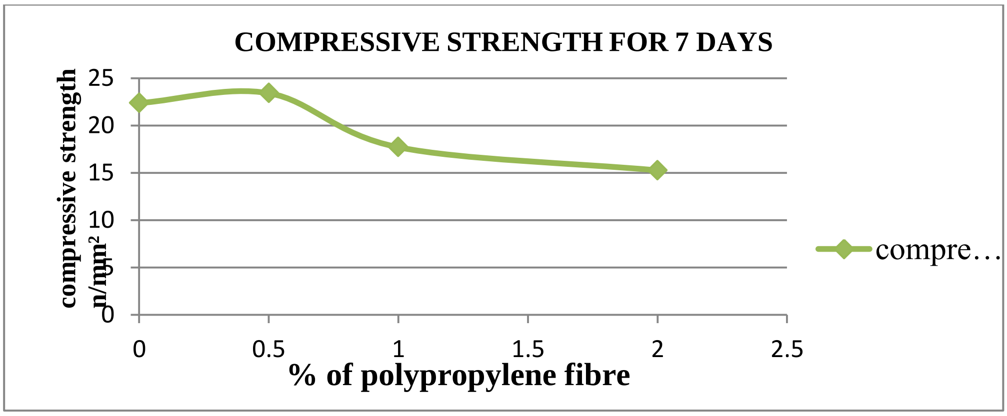
4. RESULTS AND CONCLUSIONS

4.1 RESULTS:

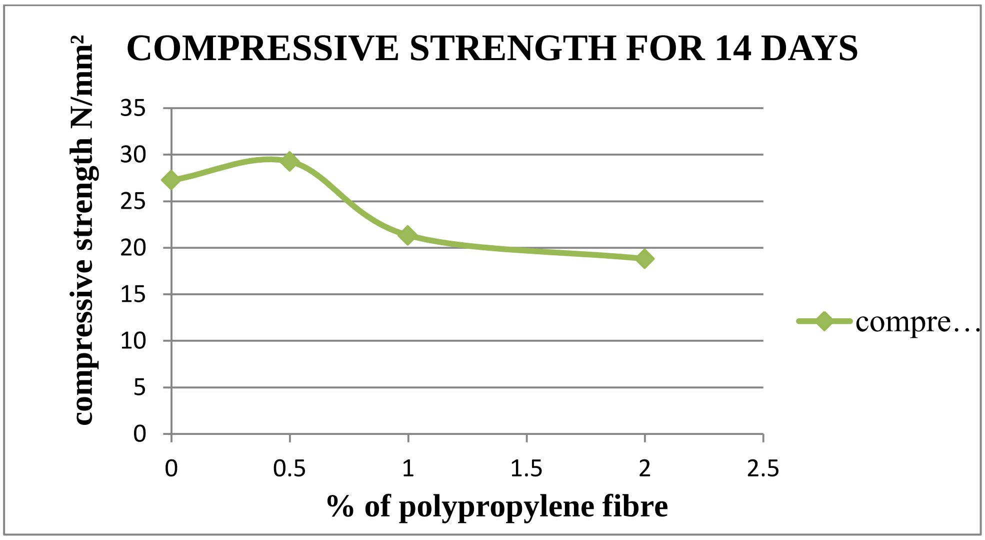
Table 4.1: Compressive Strength Values

Description	CUBE NO	COMPRESSIVE STRENGTH (N/mm^2)		
		7Days	14Days	28Days

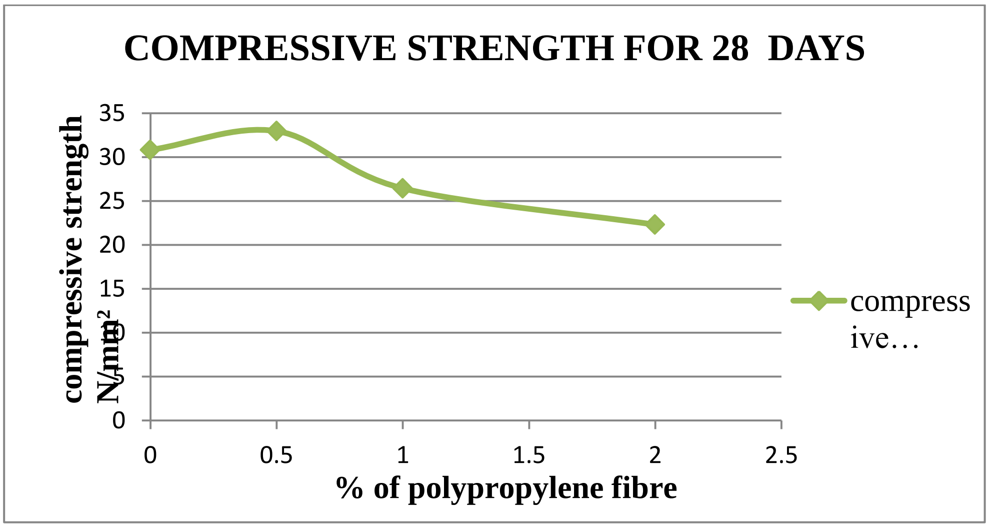
0% of Fibre	1	22.22	27.11	30.67
	2	23.11	28.00	31.56
	3	21.78	26.67	30.22
		Avg =22.37	**Avg** =27.26	**Avg**=30.82
0.5% of Fibre	1	23.56	29.11	33.11
	2	22.44	28.44	34.67
	3	24.22	30.22	31.11
		Avg =23.41	**Avg** =29.26	**Avg** =32.96
1% of Fibre	1	17.11	20.44	26.00
	2	18.44	21.33	26.22
	3	17.56	22.22	27.11
		Avg =17.70	**Avg** =21.33	**Avg** =26.44
2% of Fibre	1	16.22	18.22	22.67
	2	15.78	19.33	21.78
	3	13.78	18.89	22.44
		Avg =15.26	**Avg** =18.81	**Avg** =22.30



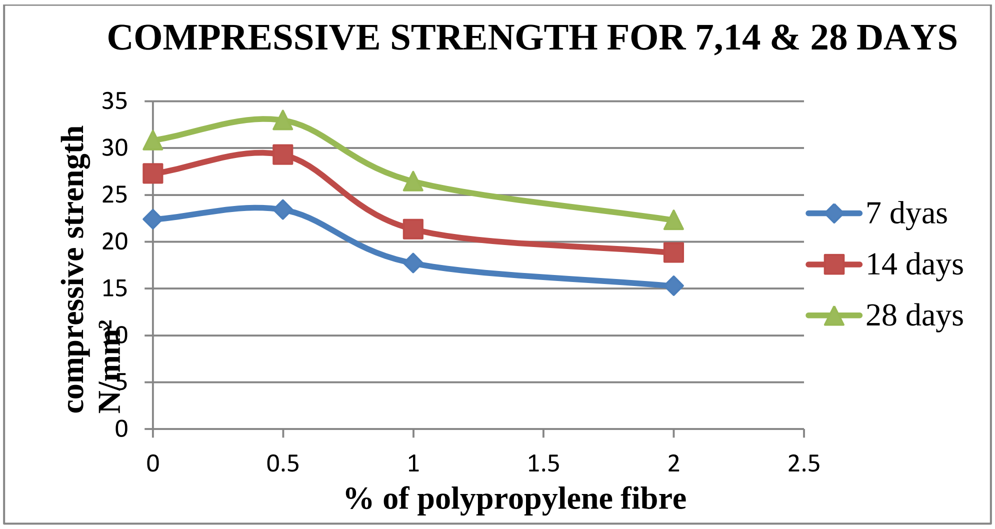
Graph 4.1: Graph Showing Compressive Strength For 7 Days



Graph 4.2: Graph Showing Compressive Strength For 14 Days



Graph 4.3: Graph Showing Compressive Strength For 28 Days



Graph 4.4: Graph Showing Compressive Strength For 7, 14 & 28 Days

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5. CONCLUSION

The versatility and applications of polypropylene fibres in different fields is discussed in detail. The polypropylene fibres reduce early age shrinkage and moisture loss of the concrete mix even when low volume fractions of polypropylene used.

It was concluded that the increasing percentage volume of fibre added into the concrete would lead the workability decreased. Compressive strength of concrete increases with increase in fibre dosage up to 0.5%, then it starts decreasing. So the optimum percentage fibre content found from research is 0.5%.As per the current demand of construction industry new types of concrete are to be invented, which will satisfy the problems observed in traditional concrete. In this approach polypropylene reinforced concrete (PPFRC) will be a good substitute to meet the present demand of construction industry.

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