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To Study the Properties of Polypropylene Fibers on Fresh & Hardened Stage of Concrete

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Abstract-. The fundamental problem with concrete is that it tends to crack due to reduction in volume. This main problem can be solved with polypropylene fiber valuable additives for the concrete world. Since polypropylene fibers can be premixed in a conventional manner, the concept of polypropylene fiber concrete has added an extra dimension to concrete construction. These concrete additives are fibers which increase strain capacity in the critical green stage of concrete. In other word polypropylene fiber provides crack control & removes the cause of weaknesses & improves the compressive strength of concrete. In nominal lengths of 6, 12 or 20 mm, polypropylene fiber is the ideal additive for concrete mixtures in order to reduce plastic shrinkage, cracking and improve the surface properties of the concrete. A concrete mix has been designed to achieve the minimum grade of M25.The investigations on concrete contain two phases. In the first phase, to identify the effects on workability due to the addition of fibers and the in second phase mechanical strength tests on standard specimens such as compressive strength & Tensile Strength will conduct on the fibrous concrete specimens to obtain the optimum volume fraction and length of fibers. After developing the software we had used it and we come to know that it is simple in operating and gives the results in short period of time. Also we had compared the final results of manual method (IS CODE METHOD) and that of software (MIX DESIGNER) we noticed that values are at most same.Workability reduces at higher dosage of fibres compared to initial dosage used. Due to more addition of fibres, there is increase in amount of entrapped air voids due to presence of fibres and therefore increase in air content attributes in reducing workability and difficulty is observed in compaction of mixes. Compressive strength of material increases with increasing fibre content. And PRFC with 12mm cut length having dosage of 1.5% give the strength increment of 40%. Strength enhancement ranges from 12% to 40% for PFRC.Strength enhancement in splitting tensile strength due to polypropylene fibre addition varies from 5% to 23%. Split tensile strength at 28 days is approximately 50% higher than 7 day's strength.

Index Terms- Mix designer, polypropylene fiber reinforced concrete, Workability, Compressive strength, Tensile strength.

1. INTRODUCTION

Concrete is a basic material used in civil engineering construction & plays important role in civil construction industry. For every concrete work initially we need to do mix design. Mix design is the process of calculation of quantities of ingredient of concrete. The proportioning of concrete mixes consists of determination of quantities of different concrete-making materials necessary to produce concrete having the desired workability and 28-days compressive strength of concrete for a particular grade of concrete and durability requirements. Mix design can be carried out by manual method but this is tedious & lengthy method in calculation. So, to avoid such a tedious process, efforts have been made and software for mix design, named as **MIX DESIGNER**, has developed in Visual Basic software. Concrete is by nature a brittle material that performs well in compression, but is considerably less effective when in tension. Reinforcement is used to absorb these tensile forces so that the cracking which is inevitable in all high-strength concretes does not weaken the structure. In many slabs, steel mesh has been used a crude (and often ineffective) method of crack control. Latest developments in concrete technology now include reinforcement in the form of fibers, notably polymeric fibers, as well as steel or glass fibers. Fiber-reinforcement is predominantly used for crack control and not structural strengthening. It has been established that the addition of randomly distributed polypropylene fibers to brittle cement based materials can increase their fracture toughness, ductility and impact resistance. The fundamental problem with concrete is that it tends to crack due to reduction in volume. This main problem can be solved with polypropylene fiber valuable additives for the concrete world. Since polypropylene fibers can be premixed in a conventional manner, the concept of polypropylene fiber concrete has added an extra dimension to concrete construction. These concrete additives are fibers which increase strain capacity in the critical green stage of concrete. In other word polypropylene fiber provides crack control & removes the cause of weaknesses & improves the compressive strength of concrete. In nominal lengths of 6, 12 or 20 mm, polypropylene fiber is the ideal additive for concrete mixtures in order to reduce plastic shrinkage, cracking and improve the surface properties of the concrete. A

concrete mix has been designed to achieve the minimum grade of M25.The investigations on concrete contain two phases. In the first phase, to identify the effects on workability due to the addition of fibers and the in second phase mechanical strength tests on standard specimens such as compressive strength & Tensile Strength will conduct on the fibrous concrete specimens to obtain the optimum volume fraction and length of fibers. After developing the software we had used it and we come to know that it is simple in operating and gives the results in short period of time. Also we had compared the final results of manual method (IS CODE METHOD) and that of software (MIX DESIGNER) we noticed that values are at most same. Workability reduces at higher dosage of fibres compared to initial dosage used. Due to more addition of fibres, there is increase in amount of entrapped air voids due to presence of fibres and therefore increase in air content attributes in reducing workability and difficulty is observed in compaction of mixes. Compressive strength of material increases with increasing fibre content. And PRFC with 12mm cut length having dosage of 1.5% give the strength increment of 40%. Strength enhancement ranges from 12% to 40% for PFRC. Strength enhancement in splitting tensile strength due to polypropylene fibre addition varies from 5% to 23%. Split tensile strength at 28 days is approximately 50% higher than 7 day's strength.

2. OBJECTIVES

The primary objectives of this investigation were

- To make the process of mix design simple and time saving by making a Software for mix design.
- To determine the benefits of using polypropylene fiber reinforced concrete (PFRC).
- To determine the properties of the fresh concrete mixtures using fiber.
- To investigate and compare the properties of hardened concrete for control and various PFRC mixes.

3. RESEARCH METHODOLOGY

3.1 TESTS ON MATERIALS

Materials testing are the most important work in project, as it helps us to select proper material for doing project work. It helps while preparing the mix design. As the standard value should be taken for preparing the mix design so the results of material testing should be as per IS standard recommended. The materials which we had tested are cement, fine aggregate, coarse aggregate. For testing the material the standard IS codes was preferred. IS 8112-1989 was used for testing the cement material, IS 383-1970 was used for testing the fine aggregate as well as coarse aggregate. There are different tests which were conducted on the concrete ingredients are as follows.

3.1.1 Tests on Cement

Following are the tests which we had conducted on the cement.

Fineness test

Result: -Average fineness = (2+2+4)/3
= 2.66%

For ordinary Portland cement the residue retained on sieve no. 9 is not more than 10% of the total weight sample taken for test.

Standard consistency test

Result: - The standard consistency of *ordinary Portland* cement is observed to be 35%.
This percent of water i.e. standard consistency shall be used for further testing.

Initial and final setting time of cement

Result: - The initial setting time of ordinary Portland cement is observed to be 36 minutes which is greater than 30 minutes and final setting time is observed to be 560 minutes which is less than 600 minutes.

Soundness of cement

Result: - The average expansion of the cement is observed to be 3 mm. The difference between two measurements represents the expansion of cement and it should not be more than 10 mm.

3.1.2 Tests On Aggregate: -

Coarse Aggregate: - Coarse aggregates shall be supplied in the nominal sizes. For any of the nominal sizes, the proportion of other sizes, as determined by the method described in IS: 2386(Part-I)-1963 shall also be taken.

Fine Aggregate: - The grading of fine aggregates, when determined as described in IS: 2386(PartI) -1963 shall be within the limits and shall be described as fine aggregates, Grading zones I, II, III and IV.

3.1.3 Quality of water for preparing the concrete: -It is a popular belief and a yardstick that if water is fit for drinking, it is fit for making concrete. Suitability of water for concrete making is checked by comparing its seven days and 28 days strength with companion cubes made with distilled water. Water containing large quantities of chlorides may cause efflorescence and dampness. We use the water having pH value 7.0 and free from salts.

3.1.4 Polypropylene Fiber:- Polypropylene, a synthetic resin built up by the polymerization of propylene. One of the important family of polyolefin resins, polypropylene is molded into many plastic

products in which toughness, flexibility, light weight, and heat resistance are required. Polypropylene fibers are gaining in significance due to the low price of the raw polymer material and their high alkaline resistance (Keer, 1984; Maidl, 1995) Polypropylene fibre manufactured in a continuous process by extrusion of a polypropylene homopolymer resin (KeerPolypropylene fibers, produced by the fibrillation of polypropylene films, have been used in Portland cement concrete, 1984; Knapton, 2003). Properties of PFRC has shown in table no.01

TABLE 1 – Properties of PFRC

Material	**Polypropylene**
Specific Gravity	0.91
Tensile Strength	0.67 KN/mm^2
Young Modulus	4.0 KN/mm^2
Melting Point	>165^{o}C
Absorption	NIL
Bulk Density	910Kg/m^3
Fibre Cut Length	6mm, 12mm, 20mm

3.3 MIX DESIGN

Mix design is the process of calculation of quantities of ingredient of concrete. The proportioning of concrete mixes consists of determination of quantities of different concrete-making materials necessary to produce concrete having the desired workability and 28-days compressive strength of concrete for a particular grade of concrete and durability requirements. Mix design can be carried out by manual method but this is tedious & lengthy method in calculation. So, to avoid such a tedious process, an effort have been made and software for mix design, named as mix designer, has developed in Visual Basic software.

TABLE 2- Mix Design Comparison by manual method and by Software.

Ingredients	**Data**	
	By manually	**By software**
Water	191.32 liters	191.3181 liters
Cement	499.87 kg	499.875 kg
Fine aggregate	681.23 kg	681.2256 kg
Coarse aggregate	940.37 kg	940.3624 kg
Ratio of proportion	1:1.36:1.88	1:1.36:1.88

3.4EXPERIMENTAL WORK-

3.4.1 GENERAL- An experimental program was decided upon consisting of casting and testing of specimen and study of properties of concrete in Fresh & Hardened stage of Concrete by addition of Polypropylene fibers.

An experimental work was carried out as follows.

1. Workability test on PCC Specimen & PFRC Specimen.
1. Compressive test on plain cement concrete (PCC) (normal strength concrete) specimen.
2. Compressive test on Polypropylene Fiber Reinforced Concrete (PFRC) specimen.
3. Tensile test on plain cement concrete (PCC) (normal strength concrete) specimen.
4. Tensile test on Polypropylene Fiber Reinforced Concrete (PFRC) specimen.

Following Properties of concrete has been studied in this experimental work

1. Workability
2. Compressive strength
3. Tensile strength

4. RESULTS AND DISCUSSION

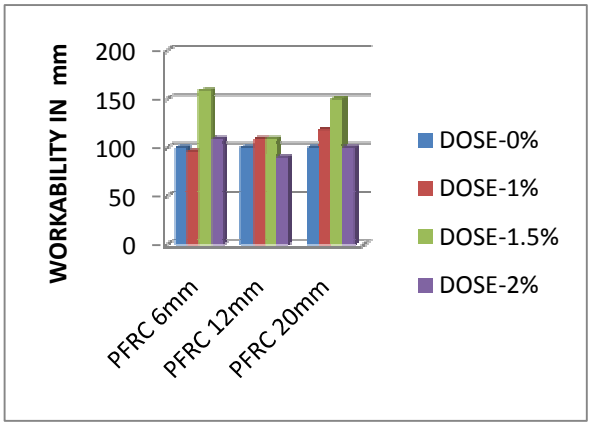
4.1 Properties of Fresh concrete:-

Workability- Workability reduces at higher dosage of fibres compared to initial dosage used. Slump value indicates that for control concrete and at 1.5% of fibre content workability is high. Workability at 2% is medium. Due to more addition of fibres, there is increase in amount of entrapped air voids due to presence of fibres and therefore increase in air content attributes in reducing workability and difficulty is observed in compaction of mixes. The fibres may also cause a finishing problem.

TABLE 3- Workability of Different dosage of PFRC

SR NO	**TYPE OF CONCRETE**	**SLUMP VALUE (mm)**
1.	Conventional Concrete	100
2.	PFRC 6mm- 1%	96
3.	PFRC 6mm- 1.5%	160
4.	PFRC 6mm- 2%	110
5.	PFRC 12mm- 1%	110
6.	PFRC 12mm- 1.5%	115
7.	PFRC 12mm- 2%	90
8.	PFRC 20mm- 1%	120
9.	PFRC 20mm- 1.5%	150
10.	PFRC 20mm- 2%	100

Chart 1- Results & Comparison of Workability with Different Dosage of PFRC



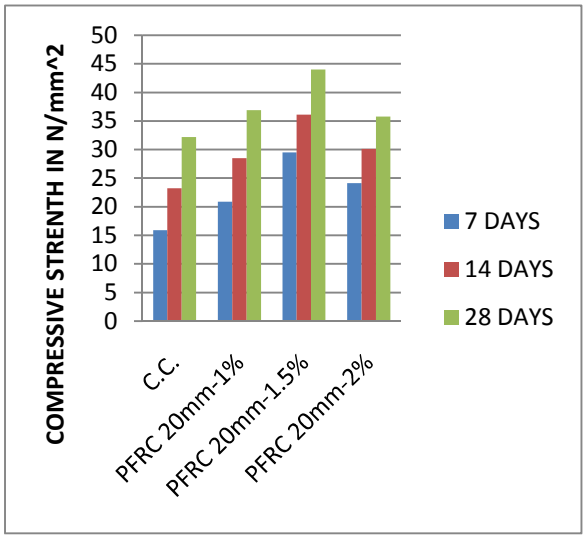
4.2Compressive Strength

In general, the improvement in cube strength observed in commonly used mixes due to fibre addition is small. The addition of polypropylene fibres to the mix increased the7day's, 14day's and 28 day's compressive strength of the mix with the dosage of 1.5% of 12mm PFRC cut length by 40% due the confinement provided by fibres. The compressive strength at 1.5% dosage is slightly higher than strength at 2% dosage. There is an increase in compressive strength by 12% to 40% by using Polypropylene fibre over conventional concrete. Compressive strength increases for all dosage of fibres than conventional concrete Reason is that due to confinement provided by fibre bonding characteristics of concrete increases and hence compressive strength increases with the increases in the fibre content.

TABLE 4- Result of Compressive Strength test

SR NO	TYPE OF CONCRETE	AVERAGE COMPRESSIVE STRNGTH(N/mm^2)		
		7DAYS	14DAYS	28 DAYS
1.	Conventional Concrete	15.89	23.22	32.19
2.	PFRC 6mm-1%	17.11	21.55	31.44
3.	PFRC 6mm-1.5%	20.67	29.78	41.34
4.	PFRC 6mm-2%	16.78	28.34	36.11
5.	PFRC 12mm-1%	22.45	29	36.34
6.	PFRC 12mm-1.5%	34.78	39.67	45
7.	PFRC 12mm-2%	21.23	34.45	38.78
8.	PFRC 20mm-1%	20.89	28.5	36.92
9.	PFRC 20mm-1.5%	29.5	36.11	44
10.	PFRC 20mm-2%	24.12	30.12	35.78

CHART 2 – Compressive strength for 20mm fiber cut length



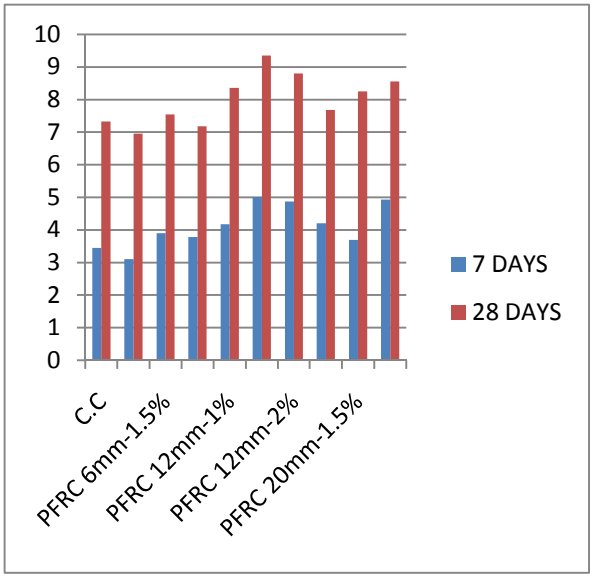
4.3 Split Tensile Strength

The split tensile strength varies from 3 MPa to 4.25 MPa for 7 days and 7.48 MPa to 9.2 MPa for 28 days. Test results shows maximum 23% increases in split tensile strength at 28 days. Split tensile test does not give perfect estimation about direct tensile strength due to mixed stress field and fibre orientation but its failure pattern gives good idea about ductility of the material. Failure patterns of splitting tensile test indicate that specimens after first cracking do not separate unlike the concrete failure. Large damage zone is produced due to closely spaced micro cracks surrounding a splitting plane. Fibre bridging mechanism is responsible for such enhanced ductile failure patter.

TABLE 5- Results of Split tensile strength

SR NO	TYPE OF CONCRETE	AVERAGE TENSILE STRENGTH (N/mm^2)	
		7DAYS	28 DAYS
1.	Conventional Concrete	3.45	7.33
2.	PFRC 6mm- 1%	3.1	6.95
3.	PFRC 6mm- 1.5%	3.9	7.54
4.	PFRC 6mm- 2%	3.78	7.18
5.	PFRC 12mm- 1%	4.17	8.36
6.	PFRC 12mm- 1.5%	5.01	9.35
7.	PFRC 12mm- 2%	4.87	8.8
8.	PFRC 20mm- 1%	4.2	7.68
9.	PFRC 20mm- 1.5%	3.69	8.25
10.	PFRC 20mm- 2%	4.93	8.56

CHART 03- Comparison chart based on tensile strength



5. CONCLUSIONS

- The software we had developed and used for the mix design & it gives the results same as that obtained by manual method in very short period of time and in simple manner.
- Polypropylene fibres dose not disperse properly in the mixing water. Addition of fibres to dry mix was found to be more practical.
- Workability reduces at higher dosage of fibres compared to initial dosage used. Slump value indicates that for control concrete and at 1.5% of fibre content workability is high. Workability at 2% is medium.
- Compressive strength of material increases with increasing fibre content. And PRFC with 12mm cut length having dose of 1.5% give the strength increment of 40%. Strength enhancement ranges from 12% to 40% for PFRC.
- Strength enhancement in splitting tensile strength due to polypropylene fibre addition varies from 5% to 23%. Split tensile strength at 28'days is approximately 50% higher than 7 day's strength.
- During the test it was visually observed that the PFRC specimen has grater crack control as demonstrated by reduction in crack widths and crack spacing.

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