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EFFECT OF POLYPROPYLENE AND STEEL FIBRES ON COMPRESSIVE STRENGTH OF CONCRETE

M.Veera Reddy

Professor, Department of Civil Engineering, KITS Warangal, India

Abstract: Concrete is the most widely used construction material due to its inherent properties. In recent years, researchers have focused to reduce the brittleness of concrete. One way of improving the ductile behaviour of concrete is the addition of fibres to the concrete. In this study, the strength properties of Hybrid fibre reinforced concrete (HFRC) have been presented. The workability and compressive strength are studied for different proportions HFRC like 0%, 0.5%, 1.0%, 1.5%, and 2.0% by volume of concrete and in each proportion the polypropylene fibres (ppf) and steel fibres (stf) are added in the ratio of 100:0, 75:25, 50:50 to get hybrid fibres. It is found that the workability and strength reduced due to increase of polypropylene fibre content.

Keywords—Hybrid fibre reinforced concrete (HFRC), Polypropylene fibres, Steel fibres, Compressive strength, Stress-Strain.

I. INTRODUCTION

Fibre reinforced concrete (FRC) is a concrete containing fibrous materials which increase its structural integrity. FRC contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, and natural fibres each of which lends varying properties to the concrete. In addition, the character of fibre reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities. In a hybrid, two or more different types of fibres are rationally combined to produce a composite that derives benefits from each of the individual fibres and exhibits a synergistic response. The hybrid combination of metallic and non-metallic fibres offers potential advantages in improving concrete properties as well as reducing the overall cost of concrete production.

A. Hybrid Fibre Reinforced Concrete (HFRC):

A composite can be termed as hybrid if two or more types of fibres are rationally combined into common matrix to produce a composite that drives benefits from each of the individual's fibres and exhibits a synergetic response.
Addition of short discontinuous fibres plays an important role in improvement of mechanical properties of Concrete. It increases elastic modulus; decreases brittleness controls cracks initiation and its growth and propagation. Deboning and pull out of the fibre require more energy absorption, resulting in a substantial increase in the toughness and fracture resistance of the materials to the cyclic and dynamic loads.

B. Polypropylene Fibre:

Polypropylene fibres were first suggested as an admixture to concrete in 1965 for the construction of blast-resistant buildings for the US Corps of Engineers. The fibre has subsequently been improved further and at present, it is used either as short discontinuous fibrillated material for the production of fibre reinforced concrete or a continuous mat for production of thin sheet components. Since then the use of these fibres has increased tremendously in the construction of structures because the addition of fibres in concrete improves the toughness, flexural strength and tensile strength as well as failure mode of concrete. Polypropylene twine is cheap, abundantly available, and like all manmade fibres of a consistent quality of the material remains a larger handicap for the seismic and other applications where flexible behaviour is essentially required. Recently, however, the development of polypropylene fibre-reinforced concrete has provided a technical basis for improving these deficiencies.

C. Steel Fibre:

Steel fibres can be defined as discrete, short length of steel having ratio of its length to diameter (i.e. aspect ratio) in the range of 20 to 100 and that are sufficiently small to be easily and randomly dispersed in fresh concrete mixing conventional mixing procedure. The random distribution results in a loss of efficiency as compared to conventional rebar's, but the closely spaced fibres improve toughness and tensile properties of concrete and help to control cracking. In many situations, it is prudent to combine fibres in for cement with conventional steel reinforcement to improve performance.
Steel fibre is the most popular type of fibre used as concrete reinforcement. Initially, Steel Fibres are used to prevent/control plastic and drying shrinkage in concrete. Further research and development revealed that addition of SFs in concrete

significantly increases its flexural toughness, the energy absorption capacity ductile behaviour prior to the ultimate failure, reduced cracking, and improved durability.

II. LITERATURE REVIEW

Rajendra P. Mogre, Dr.Dhananjay K. Parbat:-They studied on "use of polypropylene fibre" from their study they concluded that replacement of natural sand with artificial sand is fissile and behaviour and strength of reinforced concrete will improve. Also, the use of polypropylene fibre will enhance the strength and behaviour of reinforced concrete also improves resistance against impact loading and fire. Polypropylene filers have a positive impact on ultimate strength of heated beams. For a heating duration of 4.5 hours, the residual ultimate strength is larger than the corresponding strength of beams without polypropylene filers by more than 60 %. No sudden failures are observed in all beams containing polypropylene fibres.

James E. Shoenberger, Joe G. Tom: - They studied on Polypropylene fibre reinforced concrete and they concluded that improved impact resistance with increasing volumes of fibres and mentioned that the Polypropylene fibre reinforced concrete mixture does provide reductions in permeability provided that the water-cement ratio remains below 0.5. Increased percentages of fibres further decreased the permeability provided the mixture remained workable. The study indicates a reduction in plastic shrinkage with increasing amounts of fibres. The polypropylene fibres decrease plastic shrinkage provided the water-cement ratio remains below 0.5. 4. Wear resistance of PFRC has not been widely studied, but one study found an increase in the wear resistance with increasing fibre contents. Found an increase in the wear resistance with increasing fibre contents.

Mehul and Kulkarni:- They studied on fibrillated polypropylene fibre of length 12.0mm diameter 34 microns and low density 0.9 kN/m3 in percentage of 0.5,1.0 and 1.5 in the high strength concrete super plasticizer sp430 was used they observed compressive strength of concrete increased with the addition of fibres.

Hsie:-He studied on flexural strength of macro polypropylene fibre reinforced concrete. These had a diameter of 1mm, length 60 mm, tensile strength 320Mpa, Young's modulus 5.88Gpa. Plane concrete showed a brittle failure. Whereas the ppf fibres slightly increased the maximum flexural strength to 5.5Mpa at the same deflection point i.e., at 0.05 mm.

Brown: - He studied on long term properties of virgin polypropylene fibres in concrete under a reactive environment where poly propylene was exposed to an ionic environment of sodium and chloride ions created by salt water at different temperatures of 71 degrees centigrade and -7 degree centigrade for six months.The tensile properties of fibres remain unchanged.

SaeedAhmed:-He studied the effects of fibre on the addition of various proportions of polypropylene fibre on the properties of concrete. An experimental program was carried out to explore its effects on compressive, tensile, flexural, shear strength and plastic shrinkage cracking. The author concludes that the addition of polypropylene fibres at low values actually increases the 28 days compressive strength but when the volumes get higher than the compressive strength decreases from original by 3 to 5%. The tensile strength increases about 65% to 70% up to 0.40% after which it decreases. There is about 80% increase in flexure strength by adding 0.20% fibres in concrete after which strength starts reducing with further increment in fibre ratios

Thamilselvi:-He studied that the strength of concrete cubes, cylinders and prisms cast using M20 grade concrete and reinforced with steel and polypropylene fibres. Which possess high flexural strength and high durability when compared to fibre reinforced concrete with conventional concrete. This hybrid form enhances the strength, durability and acts as a crack arrester. This is more economical than normal reinforced concrete.

III. Experimental Investigation

A. Cement

Cement used in the experimental work is ordinary Portland cement confirming to IS: 4031-1998. The physical properties of cement obtained on conducting appropriate tests which are given in the Table below

TABLE I
Properties of Cement

Tests	Results
Standard Consistency	34%
Fineness	5%
Specific Gravity	3.03
Initial Setting Time	65 minutes

B. Steel Fibres

Typically steel fibres have equivalent diameters of 0.15mm to 2.0 mm and length from 7.0 mm to 75.0mm.aspect ratio generally ranges from 20 to 100. In present work steel fibres used are of diameter 0.55mm with length 30mm and aspect ratio 55.

C. *Polypropylene Fibres*

The fibres used were fine polypropylene mono filaments. It is available in three different sizes i.e., 6mm, 12mm, and 24mm. In this project 12 mm fibres are used.

D. Fine Aggregate

The fine aggregate used in the experiment conforms to zone III as per the specifications of IS 383:1970

TABLE II
Properties of Fine Aggregate

Tests	Results
Specific Gravity	2.4
Bulk Density	1.57gm/cm^3
Grading Zone	III
Fineness modulus	2.8
Porosity	34.2%
Void Ratio	0.52

E. Coarse Aggregate

The coarse aggregate used for the work is of 20mm size .the sieve analysis of combined aggregate confirms to the specifications of IS 383:1970 for graded aggregates.

TABLE III
Properties of Coarse Aggregate

Tests	Results
Specific Gravity	2.72
Bulk Density	1.5gm/cm^3
Void Ratio	0.88
Porosity	50.5%
Fineness Modulus	7.5

F. Water

Clean portable tap water available in the laboratory which satisfies drinking standards, is used for preparation and curing of specimens.

G. *Chemical Admixture*

In this work Conplast sp430 is used which acts as High performance, super plasticizing admixture having Specific gravity: 1.20.

Mix Design

In this work mix design is done as per IS: 456-2000 and IS: 10262-2009 for M20 grade concrete

TABLE IV
Mix Design of M20 Grade Concrete

Materials	Cement	Fine aggregate	Coarse aggregate	Water (lit.)
Quantity (kg/m^3)	345	690	1205	162
Proportions	1	2.0	3.5	0.47

Mix Designation

For experimental work M20 grade of concrete was considered. In this the hybrid fibres are added in different proportions like 0%, 0.5%, 1.0%, 1.5%, and 2.0% by volume of concrete. In each proportion the polypropylene and steel fibres added in the ratio of 100:0, 75:25, and 50:50 are combined to get hybrid fibres.

IV. RESULTS

To study effect Polypropylene and steel fibers on compressive strength of cubes, number of cubes were cast and tested. The experimental results are presented in the following tables.

TABLE: V
Compressive Strength & workability of specimens with 100% ppf

S.no	% of Fibre	PolyPropylene (%)	Steel (%)	Slump(mm)	Compressive Strength (N/mm²)
1	0	0	0	120	30.95
2	0.5	0.5	0	50	33.97
3	1.0	1.0	0	50	36.0
4	1.5	1.5	0	30	30.35
5	2.0	2.0	0	20	28.36

TABLE VI
Compressive Strength & workability of specimens' with75%ppf +25%stf

S.no	% of Fibre	PolyPropylene (%)	Steel (%)	Slump (mm)	Compressive Strength(N/mm²)
1	0	0	0	120	30.95
2	0.5	0.375	0.125	100	37.27
3	1.0	0.75	0.25	60	37.93
4	1.5	1.125	0.375	50	30.52
5	2.0	1.5	0.5	40	28.34

TABLE VII
Compressive Strength & workability of specimens' with50%ppf +50%stf

S.no	% of Fibre	PolyPropylene (%)	Steel (%)	Slump (mm)	Compressive Strength (N/mm²)
1	0	0	0	120	30.95
2	0.5	0.25	0.25	120	33.7
3	1.0	0.5	0.5	120	34.93
4	1.5	0.75	0.75	90	28.54
5	2.0	1.0	1.0	70	27.83

IV. CONCLUSIONS

1. The compressive strength is reducing due to addition of poplypropylene fibre.
2. The workability of concrete is reducing as polypropylene fibre content increasing.
3. Brittle nature of failure is controlled due to addition of fibers.

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