EXPERIMENTAL STUDY OF HIGH PERFORMANCE CONCRETE USING FIBERS

Mrs. vandana shah, Prof K R Ghadge.
Student.ME Structure,. Professor
CIVIL,
Sanmati college of EnggWashim

*Abstract :*High performance concrete (HPC) has been a promising material for many decades. Development of new high performance concrete types has a great success within the last few years. The experimental results of testing mechanical and durability properties of different high performance concrete types with steel fiber & Polypropylene fiber are presented. Advantage and disadvantage of these concrete types are critically commented with the aim to find the optimum practical application of different high performance concrete types.Concrete is one of the most extensively used construction material in the world. It is attractive in many applications because it offers considerable strength at a tentatively low cost.When the general performance of concrete is substantially higher than that of normal type concrete, such concrete is regarded as high performance concrete (HPC).

1.1. INTRODUCTION

High-performance concrete is defined as concrete combinations of performance and uniformity requirements that cannot always be achieved by using conventional constituents and normal mixing, placing, and curing practices. High-performance concrete was introduced into the industry, it had widely used in large scale concrete construction that demands high strength, high flow ability, and high durability. A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete.

HPC is a construction material which is used in increasing volumes due to its long term performance & better mechanical & durability properties than cement concrete. HPC possess invariably high strength, reasonable workability & negligible permeability compared to CC., preparation of HPC requires lower water binder ratio (w/b) & higher cement content. The HPC permits the use of reduced sizes of structural member, increased building height in congested areas & early removal of formwork.

Fiber Reinforced Concrete:-Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers.

Steel Fiber [(1)]: -Steel fibers are available unperforated, corrugated or with wide end for better bending. The fibers can placed single or in the form of mats. The main fields of application of steel fibers are gunned concrete, tunnel constructions & high loaded industrial floors. The addition of steel fiber increases the tensile strength of normal & high strength concrete. It also has positive effects on the tension stiffening behavior, the formation of cracks the tightness & long -term deformations.

- **Properties of Concrete Improved by Steel Fibers**

Below are some properties that the use of steel fibers can significantly improve:

- **Flexural Strength:** Flexural bending strength can be increased of up to 3 times more compared to conventional concrete.
- **Fatigue Resistance:** Almost 1.5 times increase in fatigue strength.
- **Impact Resistance:** Greater resistance to damage in case of a heavy impact.
- **Permeability:** The material is less porous.
- **Abrasion Resistance:** More effective composition against abrasion and spalling.
- **Shrinkage:** Shrinkage cracks can be eliminated.

ADVANTAGES OF HPC

The advantages of using high strength high performance concretes often balance the increase in material cost. The following are the major advantages that can be accomplished.

1) Reduction in member size, resulting in increase in plinth area/useable area and direct savingsin the concrete volume.
2) Reduction in the self-weight and super-imposed DL with the accompanying saving due to smaller foundations.
3) Reduction in form-work area andcostwith the accompanying reduction in shoring and stripping timedue to high early-age gain in strength.
4) Construction of High –rise buildings with the accompanying savings in real-estate costs in congested areas.
5) Reduced axial shorteningof compression supporting members.
6) Reduction in the number of supports and the supporting foundationsdue to the increase in spans.

POLYPROPYLENE FIBER(3)

In the past several years, an increasing number of contractors have placed concrete containing polypropylene fibres. Fibre manufacturers have promoted the material as a practical alternative to the use of welded wire fabric for control of shrinkage and temperature cracking. They cite the ease with which fibres' can be added to concrete and also state that adding fibres reduces shrinkage, inhibits shrinkage cracking, reduces permeability and improves impact and abrasion resistance. There is, however, conflicting data concerning the effects of polypropylene fibres' on the properties of concrete. This article reviews some of the suggested applications for concrete reinforced with fibres and surveys recent studies concerning properties of the fibre- reinforced concrete. We limited our survey to data obtained from tests on concretes containing either 1.5 or 1.6 pounds of collated fibrillated polypropylene fibres per cubic yard of concrete. These are dosage rates recommended by the two major polypropylene fibre manufactures. Results of the testing are fragmentary because there have been a limited number of tests and test conditions investigated. Few of the studies involved field mixing of the concrete containing fibres.

. NECESSITY OF HPC

1) It increases the tensile strength of the concrete.

2) It reduces the air voids and water voids the inherent porosityof gel.

3) It increases the durability of the concrete.

4) Fibers such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibers have a significant influence on the creep performance of rebar/tendons**.**

5) 5) Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fiber and the concrete as the

matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized.

6) It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties.

.METHODOLOGY

There has been significant interest & development in the use of short discrete & continuous fiber reinforcement for improving the pre- & post- cracking behavior of cementing composites concrete. Fiber reinforced polymer or sometimes also referred to as fiber reinforced plastics are increasingly accepted as an alternative for uncoated & epoxy-coated steel reinforcement for pre-stressed & non-pre stressed concrete applications.

CLASSIFICATION:

Based on Characteristic Strength: (16)

Based on Characteristic Strength (28-days) strength of concrete following classification has been suggested. Characteristic Strength of Concrete

Classification	28-day compressive strength
Ordinary Concrete (OC)	10 to 20 Mpa
Standard / Normal concrete (NC)	25 to 55 Mpa
High performance concrete(HPC)	60 to 100 Mpa
Very High performance concrete(VHPC)	100 to 150 Mpa
Exceptional Concretes(EC)	>150

Placing of Concrete

The fresh concrete was placed in the moulds by trowel. It was ensured that the representative volume was filled evenly in all the specimens to avoid segregation, accumulation of aggregates etc. While placing concretes, the compaction in vertical position was given to avoid voids in moulds.

TESTS FOR COMPRESSIVE STRENGTH OF CONCRETE

Size of Specimen: 150×150×150mm

Age at Test — Tests shall be made at recognized ages of the test specimens, the most usual being 7& 28days.

Procedure — In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so uniform seating may be obtained.

The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

TEST REPORT

1 Compressive Strength for Plain Concrete Grade:-M40

Curing days	Plain concrete (N/mm^2)
7	35.35
28	50.05

Compressive Strength Test After addition of Fiber:

Size of cube 150×150×150 mm Grade of concrete: M-40I.S.:516:1959

Testing of compressive strength

for 0.6% Polypropylene Fiber

Sr. No.	Wt. of Specimen (kg)	Age At Testing	Crushing Load observed on Machine (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	**2**	**3**	**4**	**5**	**6**
1	8.782	7 Days	900	40.00	
2	8.920	7 Days	970	43.21	**41.82**
3	8.837	7 Days	950	42.26	
1	8.867	28 Days	1240	55.24	
2	8.842	28 Days	1190	52.90	**53.96**
3	8.858	28 Days	1210	53.76	

for 0.9% Polypropylene Fiber

Sr. No.	Wt. of Specimen (kg)	Age At Testing	Crushing Load observed on Machine (KN)	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm2)
1	2	3	4	5	6
1	8.955	7 Days	960	42.77	
2	8.974	7 Days	950	42.23	44.48
3	8.880	7 Days	1090	48.44	
1	8.920	28 Days	1200	53.30	
2	9.020	28 Days	1440	64.00	59.11
3	8.914	28 Days	1350	60.03	

for 1.5% Polypropylene Fiber

Sr. No. 1	Wt. of Specimen (kg) 2	Age At Testing 3	Crushing Load observed on Machine (KN) 4	Compressive Strength (N/mm2) 6	Average Compressive Strength (N/mm2) 7
1	8.780	7 Days	1010	44.90	
2	8.864	7 Days	1020	45.36	44.62
3	8.910	7 Days	980	43.60	

	8.982	**28 Days**	1550	68.88	67.26
2	8.892	28 Days	1560	69.34	
3	8.808	28 Days	1430	63.57	

for 0.6 % Steel Fiber

Sr. No.	Wt. of Specimen (kg)	Age At Testing	Crushing Load observed on Machine (KN)	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm)2
1	2	3	4	5	6
1	8.652	7 Days	990	44.20	44.51
2	8.654	7 Days	1000	44.44	
3	8.701	7 Days	1010	44.89	
1	8.860	28 Days	1280	56.90	55.25
2	8.763	28 Days	1230	54.68	
3	8.905	28 Days	1220	54.20	

for 0.9 %Steel Fiber

r. No.	Wt. of Specimen (kg)	Age At Testing	Crushing Load observed on Machine (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	8.683	7 Days	1030	45.80	**45.05**
2	8.640	7 Days	1000	44.44	
3	8.742	7 Days	1010	44.93	
1	8.880	28 Days	1250	55.58	**56.45**
2	8.874	28 Days	1190	52.90	
3	8.920	28 Days	1370	60.88	

Sr. No.	Wt. of Specimen (kg)	Age At Testing	Crushing Load observed on Machine (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm)^2
1	8.852	7 Days	1000	44.44	**44.60**
2	8.830	7 Days	1000	44.44	
3	8.700	7 Days	1010	44.92	
1	8.963	28 Days	1150	51.11	**53.05**
2	8.900	28 Days	1230	54.68	
3	8.885	28 Days	1200	53.35	

Compressive Strength after addition of fiber:-

Sr. No.	ID Mark	7 Days	28 Days
1	T-1(0.6%PP)	41.82	53.96
2	T-1(0.9%PP)	44.48	59.11
3	T-1(1.5%PP)	44.62	67.26
4	T-3(0.6%SF)	44.51	56.45
5	T-3(0.9%SF)	45.05	56.45
6	T-3(1.5%SF)	44.60	53.05

After Addition Of Polypropylene Fiber

Sr. No.	Particulars	Quantity	Rate	Cost
1	PlainConcreteM40	$1m^3$	3643/-	3643/-
2	P.P. (0.6%)	2.6kg	270/kg	702/-
TOTAL				$4345/m^3$
3	PlainConcreteM40	$1m^3$	3643/-	3643/-
4	P.P. (0.9%)	3.6kg	270/kg	972/-
TOTAL				$4615/m^3$
5	PlainConcreteM40	$1m^3$	3643/-	3643/-
6	P.P. (1.5%)	6.6kg	270/kg	1782/-
TOTAL				$5425/m^3$
7	PlainConcreteM40	$1m^3$	3643/-	3643/-
8	P.P. (1.8%)	7.92kg	270/kg	2138/-
TOTAL				$5781/m^3$

After Addition Of Steel Fiber

Sr. No.	Particulars	Quantity	Rate	Cost
1	PlainConcreteM40	$1m^3$	3643/-	3643/-
2	S.F. (0.6%)	2.6kg	66/kg	172/-
TOTAL				$3815/m^3$
3	PlainConcreteM40	$1m^3$	3643/-	3643/-
4	S.F. (0.9%)	3.6kg	66/kg	238/-
TOTAL				$3881/m^3$
5	PlainConcreteM40	$1m^3$	3643/-	3643/-
6	S.F. (1.5%)	6.6kg	66/kg	436/-
TOTAL				$4079/m^3$
7	PlainConcreteM40	$1m^3$	3643/-	3643/-

RESULTS AND DISSCUSSION

Average Experimental results for **Polypropylene Fiber** are as follows:

Age/% Fiber	0.6%	0.9%	1.5%
7	41.82	44.48	44.62
28	53.96	59.11	67.26

Graph-4.1 Compressive strength Vs % Fiber Content

Average Experimental results for **Steel Fiber** are as follows:

Age/% Fiber	0.6%	0.9%	1.5%
7	44.51	45.05	44.60
28	55.25	56.45	53.05

Graph-4.3 Compressive strength Vs % Fiber Content

CONCLUSIONS

Following are the conclusion based on experimental results

1. Compressive Strength increase by about 34% when 1.5% PP fibres are used and its cost after addition of 1.5%PP increase by 48%compare to plain concrete.
2. Compressive strength increase by about 13% when 0.9% SF is used its cost after addition of 0.9%SF increase by 7% compare to plain concrete. Therefore it is more effective.

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