International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | Apr -2017 www.irjet.net p-ISSN: 2395-0072

Experimental study on Polypropylene Fiber Reinforced Concrete Using Manufactured Sand as Fine Aggregate

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Abstract – *Concrete is a fundamental unit for the infrastructural development of an entire world and is a most commnly used building material for its sustainability, versatility, durability and economy. Concrete is a mixture of cement, sand and aggregate with water. In present situation the availability of natural sand is being decreasing day by day due to its high consumption. Scarcity of natural sand has uplifted the need for its substitute. Manufactured sand is one such excellent alternative material to replace natural sand. Manufactured sand is purpose made crushed aggregate processed by separation, washing, crushing and srubbing. Polypropylene fibres are used in a concrete to enrich the resistance against cracks and to strengthen the concrete. This paper enhances the experimental results of compressive strength, split tensile strength and flexural strength of fiber reinforced concrete with a partial replacement of manufactured sand with variant proprotions (0%, 20%, 40%, 60%, 80% and 100%) and addition of fixed proportion(1% of weight of cement) of polypropylene fibers.*

***Key Words*: Manufactured sand, polypropylene fiber, fiber reinforced concrete, compressive strength, split tensile strength and flexure strength.**

1. INTRODUCTION

Concrete is well known for its high compressive strength. It is weak in tension, for this reason it is being reinforced with the materials that are strong in tension. Fibre is one such material that increases the tensile behaviour of the concrete. Fiber reinforced concrete increases the properties such as toughness, flexural strength and tensile strength, impact strength and resistance to failure mode of concrete. Polypropylene fiber increases the resistance against crack and strengthens the concrete. India is a developing country, major constructional activities or infrastructure growth is rapid in current situation. To meet the requirements for constructional activities throughout the country, concrete plays a very significant role. Natural sand is one of the important ingredient in concrete, is becoming scarce and expensive due to its increase extraction from river beds causing serious threat to environment and society. Hence for upcoming sustainable construction an alternative for natural sand is must. It has incited many engineers to look for alternative materials that are cheaper, easily available and possessing similar characteristics to that of natural sand. Fly ash, slag, lime stone and siliceous stone powder are already in use as alternative materials to natural sand. The alternative material used should satisfy technical requisites of fine aggregate and should be available abundantly with effective cost. Usage of artificial sand helps to overcome environmental problems and protect the river bed against erosion also sustain as filter for ground water.

1.1 Fiber reinforced concrete

Fiber reinforced concrete is a resulting material obtained by mixing Portland cement, aggregate and incorporating discrete discontinuous fibers. Use of fiber reinforced concrete in constructional activities has been increasing tremendously due to its property of enhancing the tensile property of the concrete. Some of the commonly used fibers are asbestos fibers, carbon fibers, organic fibers, glass fibers, steel fibers, plastic fibers. Polypropylene fiber is one of the commonly used fiber, due to its easily availability and cheap cost and its consistent quality. For number of reasons the concrete develops cracks. One of the main reason is weakness of the material to resist tensile forces. This crack leads to the structural damage of concrete. Hence to increase the tensile behavior of the concrete, polypropylene fibers are used in present investigation.

A.P.Sathe, A.V.Patil (2013) state that durability of concrete improves and addition of polypropylene fibers greatly improves the fracture parameters of concrete. Polypropylene fiber reduces number of joint and reduce repair due to subsequent damage. Workability of polypropylene fiber concrete was found to decrease with increase in the polypropylene fiber content.

Saman Khan, Roohul Abad Khan, Amadur Rahman Khan, Misbahul Islam, Saman Nayal (2015) carried out their investigation on polypropylene based fiber reinforced

concrete. They concluded that the samples with added polypropylene fiber of 1% and 1.5% showed better result and the increase compressive strength due to fiber percentage was due to fiber and aggregate bonding and not due to cement paste bonding. The fibers where acting as anchors between the cement paste, the fine aggregates and coarse aggregate which results in increased durability of concrete before failure.

Yajurveda Reddy M, D. V. Swetha(2015) in their experimental investigation showed that manufactured sand is best alternative in terms of strength and durability. The 60% replacement of natural sand by manufactured sand showed higher compressive strength, split tensile strength and flexural strength.

2. RESEARCH SIGNIFICANCE

The main objective of present investigation is to study the properties of fibre reinforced concrete by replacing the fine aggregate by manufactured sand at different percentages (0%, 20%, 40%, 60%, 80%, and 100%) with addition of polypropylene fibres. The study was carried out on M30 grade concrete with 0.45 water cement ratio.

3. MATERIALS

3.1 Cement

In the present investigation Portland pozzolana cement of 53 grade was used conforming to IS 8112-1989. The specific gravity of cement was found to be 3.15.

Table -1: Physical properties of cement

Sl. no	Particulars	Experimental result	As per IS 8112-1989
1	Specific gravity	3.15	3.15
2	Normal consistency	35%	—
3	Setting time Initial set Final set	 100min 250min	 30 min minimum 600 min maximum
4	Temperature during testing	Room temperature	Room temperature

3.2 Water

In this investigation the preparation of specimens and curing of specimens are done with portable tap water.

3.3 Fine aggregate

In the present investigation natural sand and manufacture sand is used as fine aggregate. The sand used for experimental programme was locally procured and conformed to Indian standard specification IS:383-1970. Specific gravity of fine aggregate was found to be 2.55 and fineness modulus was found to be 3.18.

3.3.1 Manufactured sand

Manufactured sand was used as partial replacement of fine aggregate. It was collected from R.N.Shetty crushers. The manufactured sand were tested as per IS:383-2016. Specific gravity was found to be 2.8 and fineness modulus was found to be 3.92.

Table2: Physical characteristics of river sand and manufactured sand

Sl. No	Properties	River sand	Manufactured sand
1	Shape	Spherical particle	Cubical particle
2	Gradation	Cannot be controlled	Can be controlled
3	Impurities i. Marine products ii. Oversized materials iii. Clay & silt	 2-4% 6-10% 5-20%	 Nil Nil Nil
4	Specific gravity	2.3-2.7	2.5-2.9
5	Water absorption	1.5-3.1	2.4%
6	Ability to hold surface moisture	Up to 10%	Up to 10%
7	Grading zone	Generally zone II & III	Can be controlled to obtain zone II
8	Fineness modulus	2.2-2.8	2.3

3.4 Coarse aggregate

Locally available coarse aggregate having the maximum size of 20mm down size was used in our work. The aggregate were tested as per IS:2386-(1963). It was collected from

Anand stone crushers. Specific gravity of coarse aggregate was found to be 2.86 and fineness modulus was found to be 4.75.

Table 3: Physical properties of coarse aggregate

SI. no	Particulars	Experimental result
1	Specific gravity	2.86
2	Bulk density(kg/liters) Compacted condition Loose condition	 1.52 1.38
4	Fineness modulus	4.75

3.5 Polypropylene fibers

Addition of polypropylene fibers to the concrete increases the resistance against micro cracks due to shrinkage during curing. In this experimental work fibrillated fiber length is 12mm. The fibers were collected from Dolphin floats Pvt.Ltd. Pune. The dosage of polypropylene fibers is 0.9 kg/m^3 of concrete.

3.6 Plasticizer

Kemiplast-600 plasticizer manufactured by suraksha system inc. Banglore was used in this experiment. It increases the workability of concrete mix and lowers the water requirement that leads to a concrete of higher compressive strength and improve durability.

Table4: Properties of super plasticizer

Physical properties	Colorless to slightly hazy yellowish liquid
Chemical contents	Melamine resin
PH	7-8
Density	1.23±0.02grams/cc
Chloride contents	nil

3. 7 Mix design

The mix design in this investigation was designed as per the guidelines specified in IS 10262-2009 for M_{30} grade concrete with 0.45 water cement ratio. Concrete mixtures with different proportions of manufactured sand replacement (0%, 20%, 40%, 60%, 80% and 100%) were casted with fixed amount of polypropylene fibers (1% weight of cement). The materials of each mix are shown in table 5.

3.8 Experimental procedure

With the mix proportion of 1:1.88:3.3 which corresponds to M_{30} grade concrete with water cement ratio 0.45 the test specimens were prepared. The standard cube specimen of 150mm*150mm*150mm was used to determined the compressive strength of concrete. Cylinder of size 150mm diameter and 300mm height and beam specimen of size 100mm*100mm*500mm were used for testing split tensile strength and flexural strength respectively

3.8.1Compressive strength

In order to find compressive strength, cubical shaped specimens of dimensions (150×150×150mm) were prepared. These specimens are tested in CTM machine having capacity of 2000KN as per IS 516-1959.

Fig 1: Testing of cube specimen for compressive strength

3.8.2 Split Tensile Strength

In order to find tensile strength, cylindrical shaped specimens of dimensions (150mm diameter and 300mm length) were prepared. These specimens are tested in CTM machine having capacity of 2000KN as per IS5816-1999.

Fig 2: Testing of cylindrical specimen for tensile strength

3.8.3Flexural strength

In order to find flexural strength, beam shaped specimens of dimensions (100×100×500mm) were prepared. These specimens are tested in UTM machine and test is carried out by two points loading system in 100mm effective span and as per IS 516-1959.

Fig3: Testing of beam for flexural strength

4. RESULTS AND DISCUSSION

The compressive strength results of different mixes are given by fig4. In the present investigation compressive strength of concrete produced by replacing natural sand by manufactured sand with addition of polypropylene fibre is goes on increasing up to 60% replacement of M-sand after that it decreases as the percentage of M-sand increases. The percentage increase in the compressive strength at this 60% replacement of M-sand found to be 35.61% as seen in table 6 and fig4. Similarly for split tensile strength increases up to 100% replacement of M-sand. The increased percentage of split tensile strength for 100% replacement of M-sand found to be 24.94% which is shown in table6 and fig5. For flexural strength also 60% replaced manufactured sand concrete possess higher strength compare to all other mixes. The increased percentage of flexural strength found to be 19.46% which is shown in table6 and fig6.

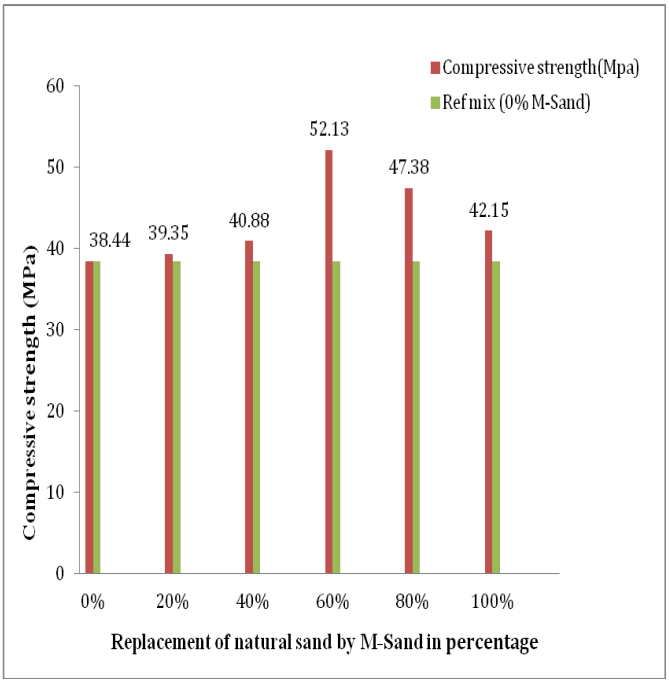

Fig4: Variation in Compressive strength of concrete

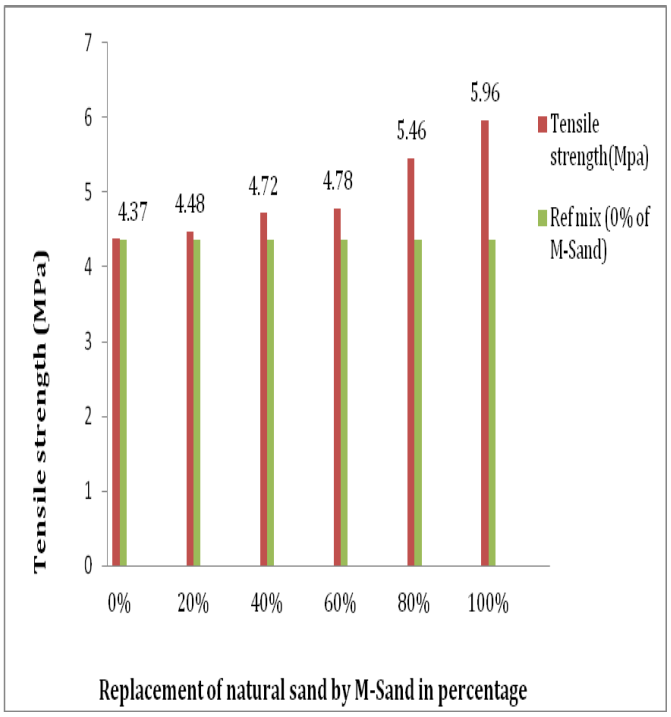

Fig 5: Variation in split tensile strength of concrete

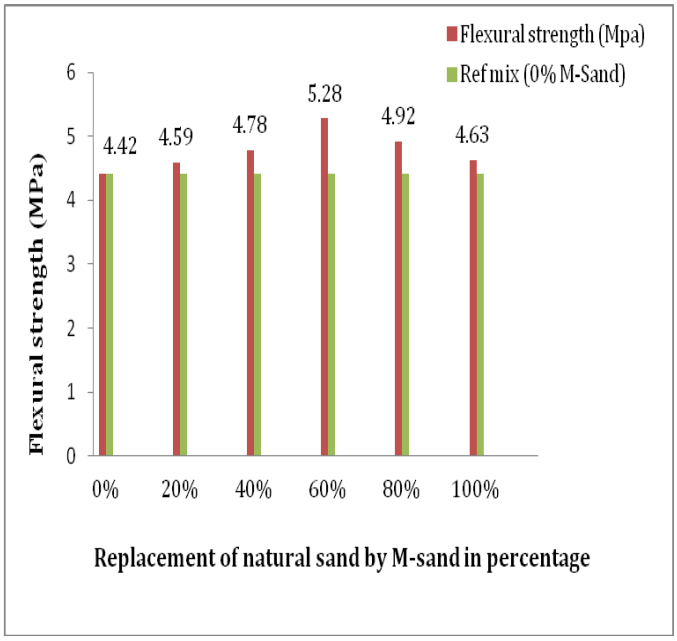

Fig6: Variation in Flexural strength of concrete

5. CONCLUSION

Based on the test results from table 2, following conclusions are drawn

1) Concrete produced by replacing natural sand by manufactured sand with addition of 1% of polypropylene fibres imparts higher compressive, flexural and split tensile strengths due to sharp edges and better interlocking of M-sand particles and good bonding with other materials.
2) The compressive strength of 60% replaced manufactured sand concrete with 1% of polypropylene fibres is 35.61% more than reference mix (0% replaced mix).
3) The split tensile strength of 100% replaced manufactured sand concrete is 24.94% more than the split tensile strength of reference mix.
4) The flexural strength of 60% replaced manufactured sand concrete is 19.46% more than the flexural strength of reference mix.
5) The result of experimental work proves that river sand can partially replaced with manufactured sand(up to 60%) and addition of polypropylene fibres does not have any adverse impact on mechanical characteristics of concrete.
6) Workability of concrete decreases with increase in polypropylene fibre content. The problem of low tensile strength can be outcome by addition of polypropylene fiber to concrete.

Table 5: Concrete Mix Details

S.No	Cement (kg)	Fine aggregates		Coarse aggregate 20mm down (Kg)	Water (litres)	Super plasticizer (Kemiplast-600 in Kg)	Polypropylene fibers (Kg/m^3)
		Natural sand (Kg)	M-sand (Kg)				
Mix A (0% M –sand, Ref mix)	372	700.13	---	1228.19	196.66	5.58	3.72
Mix B(20%M-sand)	372	560.10	153.75	1228.19	201.92	5.58	3.72
Mix C(40% M - sand)	372	420.07	307.5	1228.19	199.02	5.58	3.72
Mix D (60% M-sand)	372	280.05	461.26	1228.19	200.21	5.58	3.72
Mix E (80% M-sand)	372	140.03	615.01	1228.19	201.37	5.58	3.72
Mix F (100% M-sand)	372	---	768.77	1228.19	202.58	5.58	3.72

Table 6: Test Results of concrete

Replacement of natural sand by manufactured sand in %	Compressive strength (MPa)	Increase of compressive strength w.r.t ref. mix in %	Split tensile strength (MPa)	Increase of tensile strength w.r.t ref. mix in%	Flexural strength (MPa)	Increase of flexural strength w.r.t ref. mix in %
Mix1(0%M-sand,1% PF) Ref.mix	38.44	0.00	4.37	0.00	4.42	0.00
Mix 2(20% M-sand,1% PF)	39.34	2.34	4.48	2.52	4.59	3.85
Mix 3(40% M-sand,1% PF)	40.88	6.35	4.72	8.00	4.73	7.01
Mix 4(60% M-sand,1% PF)	52.13	35.61	4.78	9.38	5.28	19.46
Mix 5(80% M-sand,1% PF)	47.38	23.25	5.46	24.94	4.92	11.31
Mix 6(100% M-sand,1% PF)	42.16	9.67	5.96	36.38	4.63	4.75

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