ISSN: 2395-7639

International Journal of Multidisciplinary Research in Science, Engineering, Technology & Management (IJMRSETM)

(A Monthly, Peer Reviewed Online Journal)

Visit: www.ijmrsetm.com

Volume 5, Issue 4, April 2018

Strength Characteristics of High Strength Concrete Using M Sand with Fibre

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ABSTRACT: Concrete is the most widely used construction material today. Increase in construction activities have led to an increase in demand for the various raw materials in concrete, especially river sand which is the conventionally used fine aggregate. Due to increase in mining process, the availability of this river sand is becoming scarce. This led to researches on alternate materials as ingredients of concrete that are in no way inferior to the conventional materials. Manufactured sand (M-Sand) was one of the alternate materials proposed. Though manufactured sand has many advantages, one of the major areas of concern is the fine material of size 150 micron and down removed during the manufacturing process and accumulated as a waste material.

The purpose of this research is to experimentally investigate the effect of m-sand in structural concrete by replacing river sand and develop a high strength

concrete. It is proposed to determine and compare the differences in properties of concrete containing river sand and m-sand. It is also proposed to use different fibres and chemical admixtures to increase the strength and workability of concrete respectively. The investigations are to be carried out using several tests which include workability test, compressive test, tensile test, and flexural test.

KEYWORDS: Manufactured sand, Natural Sand, chemical admixture, fibers, compressive strength, flexural strength.

I.INTRODUCTION

With the world wide decline in the availability of construction sands along with the environmental pressures to reduce extraction of sand from rivers, the use of manufactured sand as a replacement is increasing. With the ban on sand mining implemented by different states, and with the increasing demand for river sand for construction works, many civil engineers have expressed the need to promote use of manufactured sand in the construction industry. As per reports, manufactured sand is widely used all around the world and technicians of major projects around the world insist on the compulsory use of manufactured sand because of its consistent gradation and zero impurity. Concrete mix design of M60 grade was done according to Indian Standard code Concrete cube; beam and cylindrical specimens were tested for evaluation of compressive, split tensile & Flexural strength respectively.

The concrete exhibits excellent strength with 100% replacement of natural sand, so it can be used in concrete as viable alternative to natural sand. A Concrete add with various percentages of different fibers used. The compressive strength of concrete obtained at the ages of 7, 28, 56, days.

RESEARCH SIGNIFICANCE

Normal concrete lacks required strength and durability which are more often required for large concrete structures such as high rise buildings, bridges and structures under severe exposure condition. Due to booming construction activities natural sand is becoming scarce due to excessive non scientific methods of mining from the river beds. For these reasons it is necessary to produce a concrete with improved high strength, with suitable materials. This research shows the effective utilization of by product fibres and M-sand in High Strength Concrete.

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1.2 MANFACTURED SAND

For aggregate produces concrete aggregate are end products while for concrete manufacturers, aggregates are raw materials to be used for concrete production. The quality of aggregates can be influenced while raw materials, gravel or rock may have characteristics which can't be modified by the production process. One extremely important factor is consistent supply of course, fine aggregate. In this regard a course aggregate produced by crushing basaltic stone and river sand is the major natural source of fine aggregate in our country. However the intense construction activity is resulting in growing shortage and price increase of the natural sand in the country in addition the aggregate and concrete industry are presently facing a growing public awareness related to environmental threats.

Therefore, looking for a viable alternative for natural sand is a must. One alternative used as replacement is the use of M sand. Due to the forecast shortfall in supply of natural sand and increased construction practices time will come when M sand will play a significant role as an ingredient in concrete production.

M sand characteristics:

When rock is crushed and sized in quarry the main aim has generally been to produce course aggregate and road construction materials. M sand is defined as a purpose made crushed fine aggregate produced from suitable source materials. Manufactured sand has been produced by variety of crushing equipments including cone crushers, impact crushers, roll crushers, road rollers etc., The raw material for M sand production is the parent mass of rock. It is based on the parent rock that the chemical, mineral properties, texture, composition of sand would change.

R-sand & M-sand.

II. EXPERIMENTAL INVESTIGATION

Materials.

The materials usually used in the concrete mix are cement, fine aggregate (M-Sand & River Sand), coarse aggregate, fibres & water. The materials used in this project for concrete mix are,

2.1Cement:

Portland Pozzolana cement of 53 Grade conforming to IS 8112 -1989**,** and the specific gravity of cement was found to be 3.15.Many tests were conducted to cement some of them are consistency tests, setting tests, etc. It was collected from **Shankar cement(IC)**, Sankari, India. The properties of cement are given in table 1.

Table 1: Properties of Cement:

SI.NO.	PROPERTY	VALUE
1	Specific gravity	3.15
2	Fineness	97.25
3	Initial setting time	45 min
4	Final setting time	385 min
5	Fineness modulus	6%

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2.2 Fine Aggregate:

M-SAND:

Fine aggregate used in this research is M- sand. The aggregates whose size is less than 4.75mm. It was collected from **RPP READY MIX PLANT**, Erode, India. The bulk density of manufactured sand was 1860 kg/m^3.

Table 2: Properties of M-Sand:

SI.NO.	Property	Value
1	Specific Gravity	2.68
2	Fineness modulus	5.2
3	Water Absorption	7.0%
4	Surface texture	Smooth

River-SAND:

Good quality natural river sand is readily available in many areas and may be easily obtained and processed. As with the gravels that they often accompany, the sand deposits may not have been laid uniformly, meaning a potential change in quality. Generally fines are classified based on size, i.e.; below 4.75mm is regarded as fine aggregate. The bulk density of river sand was 1860 kg/m^3. It was collected from **RPP READY MIX PLANT**, Erode, India.

Table 3: Properties of River-Sand:

Sl.No.	Property	Value
1	Specific Gravity	2.55
2	Fineness modulus	4.45
3	Water Absorption	6.2%
4	Surface texture	Smooth

The percentage of particles passing through various sieve were compared with natural sand and it was found to be similar. The results are presented in Table.4.

Table 4 Sieve analysis of River sand & M-Sand:

Sieve Size	R-Sand % Passing	M-Sand % Passing
4.75mm	98	99.78
2.36mm	96	87.14
1.18mm	78	63.12
600µm	51	45.75
300µm	26	25.50
150µm	7	7.98

2.3 Coarse Aggregate:

Coarse aggregate of nominal size of 20mm &12.5mm is chosen and tests to determine the different physical properties as per IS 383-1970. Test results conform to the IS 383 (PART III) recommendations. The bulk density of coarse aggregate 1691kg/m^3.

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Table 5: Properties of Coarse Aggregate:

Sl.No.	Property	Value
1	Specific Gravity	2.70
2	Water Absorption	8.0%
3	Particle Shape	Angular

2.4 Super plasticizer:

In order to improve the workability of high-performance concrete, super plasticizer in the form of Sulphonated Napthalene Polymers complies with IS 9103:1999 and ASTM C 494 type F as a high range water reducing admixture (CONPLAST SP 430) was used. This had 40% active solids in solution. The specific gravity is 1.22.It is a brown liquid instantly dispensable in water. It was collected from **High tech- chemicals**, Salem, India

Table 6: Properties of super plasticizer:

SI. NO	PROPERTIES	VALUE
1	Appearance	Brown liquid
2	Specific gravity	1.220-1.225@30°C
3	Water soluble chloride	Nil
4	Alkali content	Less than 55g.Na2O
5	Chloride content	0.2% Max
6	Air entrainment	Nil
7	Nitrate content	Nil

2.5 Fibres.
Glass fibres:

Glass fibres are made of silicon oxide with addition of small amounts of other oxides. Glass fibres are characteristic for their high strength, good temperature and corrosion resistance, and low price. Alkali resistant E-glass fibres of 12mm length, 0.014mm nominal diameter, specific gravity of 1.9 and density of 2650 kg/m3 were used.

The glass fibers used in concrete suppressed the localization of micro cracks in to macro cracks hence tensile strength increase. It improves durability of concrete by increasing the strength of concrete. The aspect ratio of Glass Fibers is 857.1. The number of fibers per 1 kg is 212 million. It was collected from **COVAI SEENU & COMPANY, Coimbatore.**

Binani **Chopped Strands** are chopped from continuous **"E" - glass fibres**. The chopped strands are free flowing and are designed to resist the rigors of compounding whilst allowing the finished moulding to develop satisfactory mechanical properties.

Table 9: Properties of E-Glass Fibre

Sl.No.	Property	Value
1	Diameter (μm)	12
2	Specific Gravity	2.60
3	Failure strain	3.0%
4	Elasticity (GPa)	80
5	Tensile strength (GPa)	2.5
6	Elongation	2.5-4.8%

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Recron 3s fibres:

Recron 3s Fibres are Engineered Micro Fibres with a unique "Triangular" cross section, used as a Secondary Reinforcement Concrete. It arrests shrinkage cracks and increases resistance to water penetration, abrasion and impact. It makes concrete homogenous and also improves the compressive strength, ductility and flexural strength together with improving the ability to absorb more energy.

Recron 3s Fibres are manufactured in an ISO 9001:2000 facility for use in concrete as a "Secondary Reinforcement" at a rate of dosage varying from 0.1% to 0.4% by volume (0.9kgs/Cu.m – 3.60kgs/Cu.m). Fibres comply with ASTMC 1116, Type 111 Fibre Reinforced Concrete.

Only 0.2-0.4% by cement RECRON 3s is sufficient for getting the above advantages.

Thus it not only pays for itself, but results in net gain with reduced labour cost & improved properties. So we can briefly summarize the advantages of Recron 3s fiber as,

- Control cracking
- Increase flexibility
- Reduction in water permeability
- Reduction in rebound loss in concrete
- Safe and easy to use

Use of uniformly dispersed Recron 3s fibres reduces segregation and bleeding, resulting in a more homogeneous mix. This leads to better strength and reduced permeability which improves the durability. It was collected from **RELIANCE INDUSTRIES LTD.Coimbatore**. The physical properties of Recron 3s fibre are given in Table 7.

Table-7: The physical properties of Recron 3s fibres:

SI.NO.	PROPERTIES	UNITS	POLYESTER *TYPE:CT2024*	POLYPROPYLENE *TYPE:CTP2424*
1	Shape		Triangular	Triangular
2	Cut Length	Mm	3/ 4.8/ 6/ 12/18/ 24	3/ 4.8/ 6/ 12/ 18/ 24
3	Effective Diameter	Microns	20-40	25-40
4	Specific Gravity		1.34 - 1.39	0.90 – 0.91
5	Melting Point	Deg.C	250 - 265	160 – 165
6	Tensile Strength	Mpa	480 - 730	320 – 490
7	Elongation (initial)	%	20 – 60	60 -90
8	Young's Modulus	Mpa	>5000	>4000
9	Alkaline Stability		Very good	Very good

Dosage rate:

- Concrete - Use 12 mm @ 909 gms per cubic metre
- Plaster - Use 6 mm @ 125gms per cement bag in 1:4 cement/sand ratio, optimize as per need.

Role of Fibres

Cracks play an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. Therefore, it is important to reduce the crack width and this can be achieved by adding different fibres to concrete.

Thus addition of fibres in cement concrete matrix bridges these cracks and restrains them from further opening. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibers. This process, apart from preserving the integrity of concrete, improves the load-carrying capacity of

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structural member beyond cracking. The major reasons for crack formation are Plastic shrinkage, Plastic settlement, Freeze thaw damage, Fire damage etc.

Fibre mechanism

Fibres work with concrete utilizing two mechanisms, the spacing mechanism and the crack bridging mechanism. The spacing mechanism requires a large number of fibers well distributed within the concrete matrix to arrest any existing micro-crack that could potentially expand and create a sound crack. For typical volume fractions of fibres, utilizing small diameter fibres or micro fibres can ensure the required number of fibres for micro crack arrest.

The second mechanism termed crack bridging requires large straight fibres with adequate bond to the concrete. This fibre type which is commonly referred to as large diameter fibres or macro fibres. Benefits of using larger fibres include impact resistance, flexural and tensile strengths, ductility, and fracture toughness.

Polypropylene fibre

Glass fibre

2.6 Water:

The water, which is used for making concrete should be clean and free from harmful impurities like oil, alkalis, acids etc. Ordinary potable water available in the laboratory was used for making and curing concrete. The quality of water was found to satisfy the requirements of IS: 456 –2000.

Table 10: Properties of water

Sl.No.	Property	Value
1	Appearance	Clear liquid
2	Corrosive action	None
3	Specific gravity	1.1
4	Flash Point	None
5	PH	7

III.MIX PROPORTIONS & MIX DESIGN

In this study, control mix A was designed as per IS 10262:1986 to achieve a target compressive strength of 60 Mpa. River sand was used to 100% replace M-sand using Portland pozzolana cement (PPC). The various fibres of 0.1%, 0.3% and 0.5% by volume fraction of concrete were used. The casted cubes are test for 7, 28, 56 days Compressive strength, Split tensile strength & Flexural strength.

Various fibres:

- Glass fibres
- Recron 3s fibres
  - Polyester - Type: CT2024.
  - Polypropylene - Type: CTP2424.

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Volume 5, Issue 4, April 2018

3.1 Mix design:

A total no. of 10 mixes were cast using different percentages of various fibres by volume of concrete. The proportion of Cement, M-sand, Coarse Aggregate, and Fibres & Water was kept same for all mixes. Various parameters used in the research are given below:

- Concrete mix ratio: 1:0.62:2.20
- Water cement Ratio: 0.30
- Fibre percentages by volume of concrete:
  - Glass fibres - 0.1%, 0.3% & 0.5%.
  - Polyester (Recron 3s) – 0.1%, 0.3% & 0.5%.
  - Polypropylene – 0.1%, 0.3% & 0.5%.
- Super Plasticizer (CONPLAST SP 430) – 1%
- Mix with 0% Fibres content was declared as control mix.

Table -11: Concrete Mix proportions:

Mix id	T	T1	T2	T3	T25	T26	T27	T28	T29	T30
Cement(kg/m^3)	600	600	600	600	600	600	600	600	600	600
FA(kg/m^3)	375	375	375	375	375	375	375	375	375	375
CA(kg/m^3)	1324	1324	1324	1324	1324	1324	1324	1324	1324	1324
Glass fibres-%	-	0.1	0.3	0.5	-	-	-	-	-	-
Polyester-%	-	-	-	-	0.1	0.3	0.5	-	-	-
Polypropylene-%	-	-	-	-	-	-	-	0.1	0.3	0.5
Conplast sp 430-%	1	1	1	1	1	1	1	1	1	1
Water (lt/m^3)	190	190	190	190	190	190	190	190	190	190

3.2 Experimental Procedure:

The specimen of standard cube of (150mm x 150mm x 150mm), cylinder (100mm dia x 200mm high) & beam (1000mm x 100mm x 100mm) were used to determine the compressive strength, tensile strength and flexural strength of concrete. Three specimens were tested for 7, 28 & 56 days with each proportion of various fibres and M-sand replacement. Totally 90 cubes, 90 cylinders and 4 beams were cast. The constituents were weighed and the materials were mixed by machine mixing. The mixes were compacted using vibrating needle.

The water binder ratio (W/B) adopted was 0.30 and weight of super plasticizer was estimated as 1 % of weight of binder .The specimens were demoulded after 24h, cured in water for 7, 28 & 56 days, and then tested for its compressive and flexural strength as per Indian Standards.

IV. RESULTS AND DISCUSSIONS

The Compressive and tensile strength of the conventional concrete are presented in Table 12

Table 12: Compressive and tensile strength of conventional concrete.

Si.No	Cube id	Compressive strength (N/mm^2)		Split tensile strength(N/mm^2)	
		7 days	28 days	7 days	28 days
1	R- sand	33.68	51.35	4.10	5.23
2	M- sand	39.88	55.33	4.62	6.86
3	Gf-0.1%	36.61	48.66	4.81	7.10
	Gf-0.3%	36.89	53.33	4.93	7.22
	Gf-0.5%	43.10	61.34	5.10	7.56

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Volume 5, Issue 4, April 2018

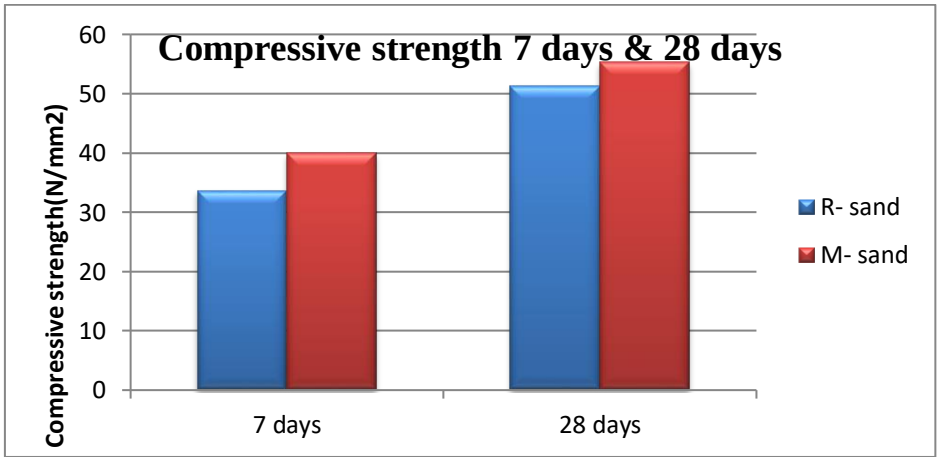
4	PP-0.1%	34.52	51.55	4.65	7.26
	PP-0.3%	34.18	49.44	5.20	7.86
	PP-0.5%	42.83	59.89	5.65	8.15
5	Rc-0.1%	33.89	50.77	5.25	7.22
	Rc-0.3%	35.79	53.62	6.12	7.66
	Rc-0.5%	44.25	61.58	6.75	7.96

4.1 Compressive strength of concrete:

Standard cube specimens are casted and tested for compressive strength after 7 days and 28 days. For preparing the specimens, the permanent steel moulds size of 150mmx150mmx150mm were used. Before mixing the concrete, the moulds were kept ready. The sides and the bottom of the mould were properly oiled for easy demoulding. After pouring concrete into the mould, Table vibrator was used to compact the concrete and then the top surface was given a smooth finish. After casting, test specimens were demoulded after 24 hours and were kept in the curing tanks until the time of test.

This test was conducted as per IS 516-1959. The cubes of standard size 150mm x150mm x150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of Compression Testing Machine (CTM) of capacity 200 tones without eccentricity and a uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The experimental result shows that the Compressive Strength of glass Fibre Reinforced Concrete was greater than Recron 3s Fibre Reinforced Concrete from 0.1%, 0..3% and 0.5% of mix from the Tables respectively; also explain from the graphs.

Graph 1: Compressive strength 7 days & 28 days



4.2 SPLIT TENSILE STRENGTH.

This is test to determine the tensile strength of cylindrical specimens. splitting tensile strength tests were carry on cylinder specimens of size 100 mm diameter and 200 mm length at the age of 7, 28, 56 days curing, using compression testing machine. To avoid the direct load on the specimen the cylindrical specimens were kept below the specimens spilt and readings were noted. The splitting tensile strength has been calculated using the following formula:

$F_1 = 2P/\Pi LD$

Where, P is the compressive load on the cylinder.

L is the length of cylinder.

D is the diameter.

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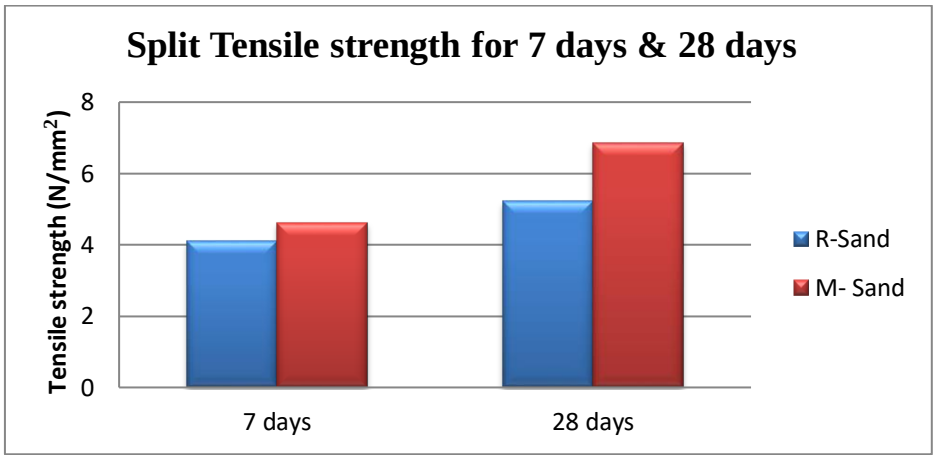
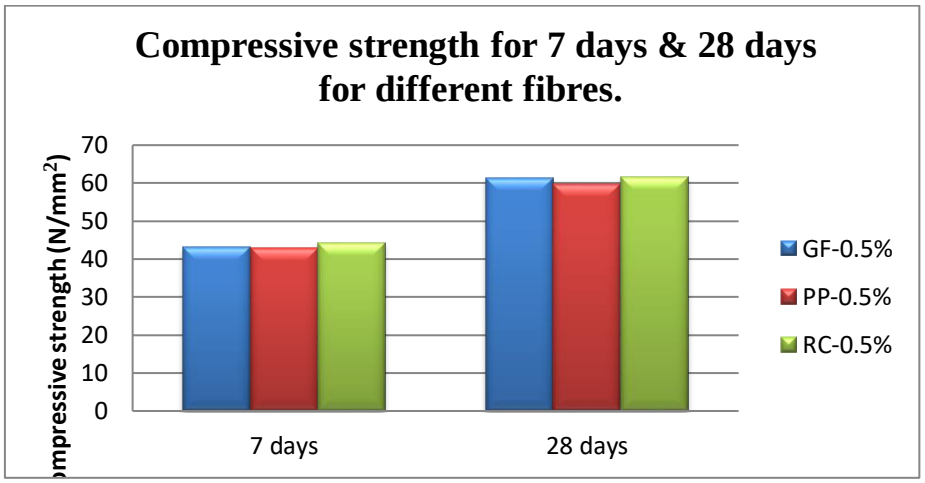
Volume 5, Issue 4, April 2018

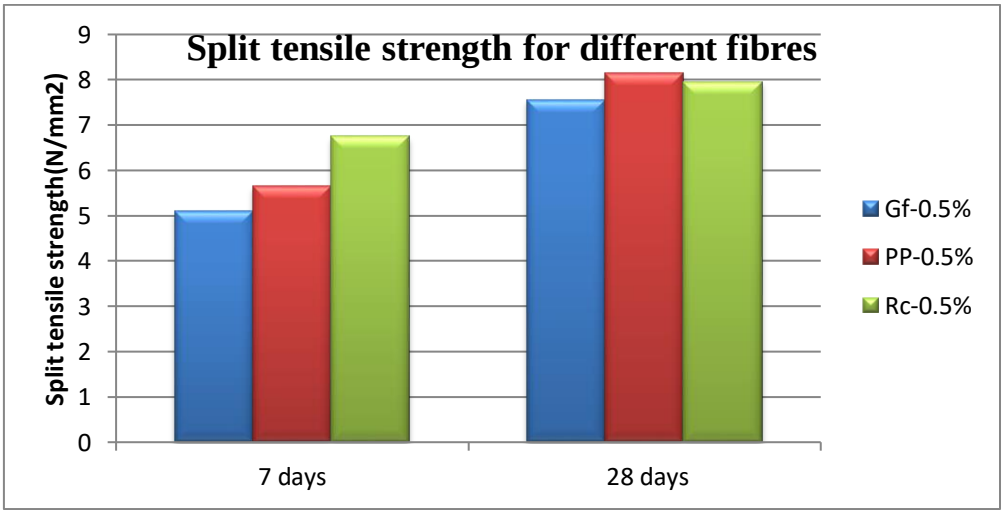
Graph 2: Split Tensile strength for 7 days & 28 days.



Graph 3: Compressive strength in 7 days & 28 days for different fibres.



Graph 4: Split tensile strength in 7 days & 28 days for different fibres.



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International Journal of Multidisciplinary Research in Science, Engineering, Technology & Management (IJMRSETM)

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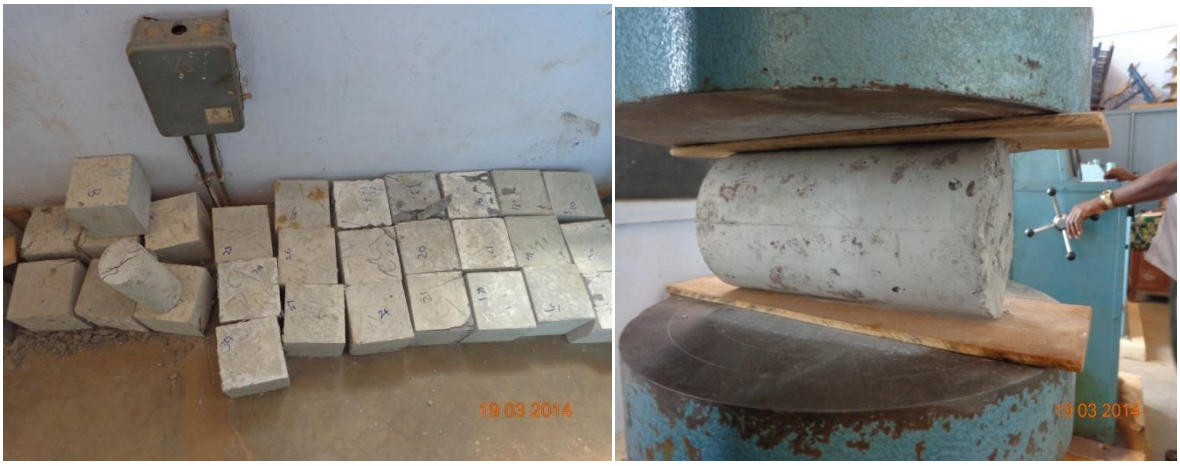
Volume 5, Issue 4, April 2018

It is observed form the graph 1 that the cube compressive strength increased up to 1.5times compare with River sand. The cube compressive strength observed as 55.33 N/mm^2 for M-sand, in the concrete curing at 28 days. However, the compressive strength for controlled mix at 28 days was observed as 51.35 N/mm^2 for River sand. For fibres using concrete cube compressive strength observed as 61.34 N/mm^2 for 0.5% of glass fibre, 59.89 N/mm^2 for 0.5% of Polypropylene fibre, 61.58 N/mm^2 for 0.5% of Recron 3s fibre

It is observed form the graph 2 that the split tensile strength increased up to 1.5times compare with River sand. The split tensile strength observed as 6.86 N/mm^2 for M-sand, in the concrete curing at 28 days. However, the tensile strength for controlled mix at 28 days was observed as 5.23 N/mm^2 for River sand. For fibres using concrete split tensile strength observed as 7.56 N/mm^2 for 0.5% of glass fibre, 8.15 N/mm^2 for 0.5% of Polypropylene fibre, 7.96 N/mm^2 for 0.5% of Recron 3s fibre.

From the Experimental investigation carried out, it was observed that when fibres are used in concrete it enhances both the compressive and split tensile strength of concrete. This trend is observed with percentages of fibres content 0.5% at all ages. On addition of Recron 3s fibre with cement matrix, the both strengths will be increased with compare other fibres would yield economical result.

Cube Testing



Tested cubes & cylinders

ISSN: 2395-7639

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Visit: www.ijmrsetm.com

Volume 5, Issue 4, April 2018

V. CONCLUSIONS

A Comprehensive study had been carried out on various journals and books related to the high strength concrete with manufactured sand and various fibres**.** All the literatures are studied in the field manufacture sand, different fibers and chemical admixture. From the results it is concluded that the M-Sand can be used as a replacement for fine aggregate. It is found that 100% replacement of fine aggregate by M-Sand give maximum result in strength aspects than the conventional concrete. The results proved that the replacement of 100% of fine aggregate by M-Sand & fibres induced higher compressive strength and higher split tensile strength. Usage of Recron 3s fibre will reduce the cost of maintenance by reducing the micro cracks and permeability and hence the strength & durability will increase. It is found that use of Recron3s fibre reduces the segregation.Thus the environmental effects, illegal extraction of sand and cost of fine aggregate can be significantly reduced.

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