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Effect of Manufactured Sand with Steel Fibre and Polypropylene on Strength Properties of Concrete

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Abstract: The scarcity of natural sand necessitates the use of alternate materials to replace it. This experiment investigates manufactured sand, a readily sourced industrial by - products waste material in India, as an alternative to natural sand, which is traditionally utilized as fine aggregate in concrete construction. In this present work the attempt has been made to study the effect of manufactured sand by partially replacing fine aggregate in concrete with addition of steel fibre and also polypropylene fibre separately. Strength properties such as compressive (7& 28 days) and tensile strength (28 days) along with fresh concrete properties; workability is determined. This test carried on referral concrete of grade M35; the concrete mixes were made using Portland pozzolana cement, and also replacing fine aggregate by 15, 30, 45, 60 and 75 percent of manufactured sand. After optimization of percentage replacement of fine aggregate by M-sand, further we made concrete Mixes using steel fibres at rate of 0.50, 0.75, 1 and 1.25 percent and also concrete mixes were made with polypropylene fibre at rate of 0.5kg/m^3, 1kg/m^3, 1.5kg/m^3, 2 kg/m^3 and various mechanical properties were investigated. The result concluded that M-sand is suitably replace the natural river sand at optimum limit and addition of fibre reinforcement also improves the compressive, flexural and tensile strength of concrete specimens however addition of polypropylene fibre and steel adversely affect the workability.
Keywords: m-sand, steel fibre, polypropylene fibre, abrasion.

I. INTRODUCTION

Concrete is most widely used construction material for any developing country. For the large-scale infrastructural development need of aggregates such as coarse and fine aggregate is quite high. In India fine aggregate used in concrete mix is generally natural river sand, which excavated from river bed hence force the river to change river course, erode the river bank and leads to loss of vegetation on the river bank and flood also. And it also disturbs habitat for aquatic animals and micro-organism also, which affects the ground water recharge. That's why need for alternate material of river sand is very urgent [1]**.** The features and physical properties of the aggregates utilized have an impact on constructability and long-term performances. Due to the high cost of transportation from natural sources, common river sand (RS), which is the most frequently used fine aggregate in the manufacturing of concrete, is expensive. Environmental issues are also brought about by the widespread depletion of these sources. Even if some of the individual aggregate sizes do not fulfill grading or other physical qualities typically specified, economy and sustainability goals are better met if durable, locally accessible aggregates can be employed [2]. Due to its capacity for void filling as well as the fact that its sharp edges offer a better bond with cement than natural sand's rounded particles, artificial sand has a higher strength. The compressive strength was gradually raised when natural sand was replaced with M-Sand up to an ideal replacement level of 60%, and then it was gradually dropped. Compressive strength of concrete made with 60% M-Sand substitution is 17% higher than that of standard concrete [3]**.** The elimination of the micro fines represents a wasted aggregate resource and leads to a disposal problem for producers. In addition, the elimination of the micro fines often produces a harsh mix that does not finish well, leading to the necessity of adding natural sand for increasing workability [4]**.** Experimental studies have already compared M-sand concrete's compressive strength to that of regular concrete. The researchers' finding suggests, according to the outcome, that natural sand will replace M-sand in 50 percent, the compressive strength is increased by 5.7 percent and when 100 percent M-sand used in place of natural sand, strength improved by 7.03 percent, although the concrete in this situation becomes Very harsh in blending [5]**.** According to the experimental findings, concrete with M-sand replacement has a 30 percent increase in compressive strength for M30 grade, a 19 percent increase for M40 grade, and an 18 percent increase for M50 grade concrete up to 60 percent replacement of M-sand. As the percentage of M-sand is increased further, the strength decreases [6]**.** In this investigation after finding the optimum content of M-sand, further experimental analysis has been carried out using steel fibre and polypropylene fibre. Various research studies were carried out to analyze the properties and the effect of these fibres in concrete matrix.

For many years, the idea of employing fibres to enhance the mechanical properties of concrete has been known. Applications in structural engineering have been using it more and more.

Compressive, tensile, and shear strengths, flexural toughness, durability, and impact resistance are all improved by the addition of fibres. The type and quantity of fibres introduced affect the mechanical properties of fibre-reinforced concrete. About 40 years ago, steel fibre reinforced concrete (SFRC) research and design increased. Steel fibres come in a variety of varieties. Size, shape, and surface morphology all vary. These fibres' mechanical characteristics range from tensile strength to the level of mechanical anchoring to their capacity for stress absorption and dispersion. As a result, they have varying effects on concrete characteristics [7]. The ability of steel fibre reinforced concrete to withstand cracking is one of its key characteristics. As a result, under flexural loading, SFRC's extensibility and tensile strength have enhanced. Even after substantial fracture, the fibres keep the matrix together. Compared to regular concrete, it exhibits substantial post-cracking ductility. The features of steel fibre reinforced concrete that increase its ability to absorb energy and endure frequently applied shock or impact loading are a result of its transformation from a brittle to a ductile kind of material. Steel fibre reinforced concrete is now replacing conventional concrete constructions in various structural applications. Therefore, ensuring the quality of such structures requires careful consideration of the content, kind, and distribution of fibre [8]. Examine the impact of employing coarse recycled concrete aggregates (RCAs) as a substitute for natural coarse aggregate on the initial, mechanical, and long-term performance of concrete reinforced with steel fibre. Tests were conducted to examine each mix's slump, density, compressive and splitting tensile strengths, flexural behavior, surface hardness, surface abrasion resistance, water absorption, and sorptivity. Eighteen distinct concrete mixes with RCA contents of 0%, 50%, and 100% and steel fibre contents of 0%, 1%, and 2% were prepared. They came to the conclusion that gains in concrete's compressive, splitting tensile and flexural strength, flexural toughness, surface hardness, and abrasion resistance, as well as decreases in absorption and sorptivity, are less significant when compared to those from 0% to 1%. This might be as a result of less uniform steel fibre dispersion in concrete mix with V_f of 2% relative to that with V_f of 1% [9]. While reinforced specimens' compressive failure modes significantly vary from fragile to ductile, uniaxial compressive testing demonstrated how the presence of fibres has less of an impact on a material's compressive strength. Due to the action of the fibres bridging, the cubic specimens did not crush but maintained their integrity throughout the test. A numerical comparison was done based on the outcomes of the direct tensile test. The homogenization process and the dual extreme principles in terms of displacements and stresses are used by the model to obtain the upper and lower bounds on SFRC tensile strength. The ultimate strain was higher for long fibre specimens in experimental tests while the maximum tensile strength increased for short fibre specimens [10]. On other hand synthetic fibre such as polypropylene is also influencing the mechanical properties of concrete mix in a positive manner. Many previous researches had done to experimentally investigate the effect of polypropylene fibre on the concrete mix using various admixtures like silica fume and fly ash as partial replacement of cement to reduce the requirement of cement. By preventing water from separating from freshly laid concrete, polypropylene fibre added to concrete improves cement hydration. Later, in a more developed concrete, the fibres seal any potential cracks and lessen the possibility of concrete deterioration. Compressive strength was consistently increased as polypropylene fibre content rose from 0.2 to 0.5 percent in the mixes. When compared to the reference samples, the compressive strength of fibrous specimens with 0.5 percent fibre at 91 days of age enhanced by 15% [11]. Researchers' studies revealed that while concrete liquefaction decreased with increasing fibre volume, compressive strength, tension strength, and bending strength rose. By reducing permeability and the quantity of concrete shrinkage and expansion, which can have a substantial impact on the tenure of the structure, the inclusion of polypropylene fibres had delayed the onset of the degradation process [12].

Based on the above literature, this study is focused on the experimental analysis of the effect of M-sand along with steel fibre and polypropylene fibre separately. Need of using M-sand is to minimizing the requirement of river sand and inclusion of these fibre is aimed to enhanced the mechanical properties of concrete. Experimental setup was prepared to gain the compressive, tensile and flexural strength of concrete specimens. The concretes were put through a variety of tests to see how well they performed, comprising slump, compressive strength, splitting tensile strength, and flexural behavior.

II. MATERIAL PROPERTIES

A. Cement

Portland pozzolana cement by Ultratech used in this concrete mix, having requirements confirming to IS 1489.1:1991 [13]. All tests of cement properties performed in laboratory as per IS 4031.1988.

B. Aggregates

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete. the aggregate is classified as fine aggregate and coarse aggregate.

1) *Fine Aggregate:* Fine aggregate used in this investigation are natural river sand and M-sand. Sieve Analysis as per IS 383:2016 of both fine aggregate is confirming classification of fine aggregate in Zone II given in figure 1. specific gravity and water absorption of river sand were 2.65 and 1.4% and for M-sand these values were 2.68 and 1.62% respectively [14].

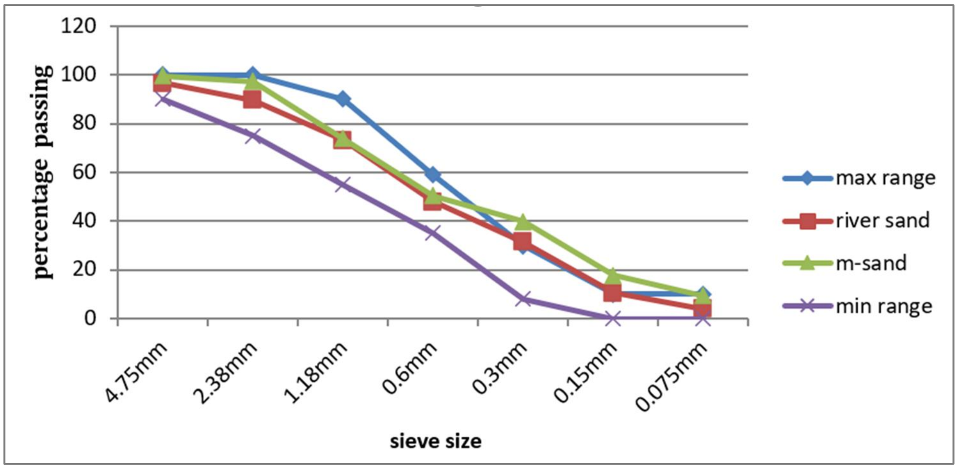

Fig. 1: sieve analysis of river sand and m-sand

2) *Coarse Aggregate:* Coarse aggregate used for the main matrix of the concrete. Natural coarse aggregate of size 20mm and 10mm were used in this investigation and tested as per IS 2386-1963 [15]. Specific gravity of coarse aggregate was found 2.7 and water absorption was 1%.

C. Fibres

1) *Steel Fibre:* Hooked end steel fibre used in this study and the following parameters for hooked end steel fibres shown in table I & figure 2.

TABLE I
SPECIFICATIONS OF STEEL FIBRE

Specifications	Value
Length	30mm
Least dimension	0.60mm
Aspect ratio	60
Density	7850kg/m^3

Fig. 2: End hooked steel fibre

2) *Polypropylene Fibre:* Mono-filament fibre of 24mm in length was used in this experiment from the JOGANI IMPEX LLP.

Fig. 3: 24mm monofilamental polypropylene fibre

D. Super Plasticize

Sikka viscocrete 5207 NS used in this concrete mix with specific gravity of 1.12.

III. EXPERIMENTAL PROCEDURE

Initially all materials were tested to fulfill the desired requirements as per IS code such as cement testing and particle size analysis of coarse and fine aggregate including specific gravity and water absorption of all aggregates. To investigate the mechanical properties of concrete such as compressive, tensile and flexural strength, including fresh concrete properties such as workability, concrete specimens are divided in four groups. One for conventional concrete, second was for replacing river sand by M-sand by 15%,30%,45%,60%,75%. After finding the optimum percentage of M-sand, two another group of specimens were casted, one with the varying dosage of steel fibre and second with the polypropylene fibre. Cubes of $150mm^3$, cylinders of 100mm diameter and 200 mm length and beams of 150mm×150mm×700mm were casted for compressive, tensile and flexural testing respectively. Total 84 cubes, 42 cylinders and 42 beams were casted with different fraction of M-sand, steel fibre and polypropylene. Concrete mix was prepared as per IS 10262:2019 for M35 grade of concrete and material proportion given in table 2[16].

Fig. 4: compressive testing machine

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TABLE II
CONCRETE MIX DESIGN AS PER IS 10262:2019

Groups	MS %	RS %	V_f %	Cement (kg/m^3)	Water (kg/m^3)	w/c	CA (Kg/m^3)	M-sand (kg/m^3)	R-sand (kg/m^3)	Steel fibre (kg/m^3)	Poly Propylene (kg/m^3)	SP (kg/m^3)
A_{MS0}	0	100	-	389.26	172.42	0.39	1221.253	-	665.306	-	-	3.89
B_{MS15}	15	85	-		172.64			99.58	565.51	-	-	
B_{MS30}	30	70	-		172.86			199.16	465.71	-	-	
B_{MS45}	45	55	-		173.07			298.74	365.92	-	-	
B_{MS60}	60	40	-		173.28			398.32	266.12	-	-	
B_{MS75}	75	25	-		173.50			497.90	166.33	-	-	
$C_{MS60SF0.5}$	60	40	0.5		173.28			398.32	266.12	39.25	-	
$C_{MS60SF0.75}$	60	40	0.75		173.28			398.32	266.12	58.875	-	
$C_{MS60SF1.0}$	60	40	1.0		173.28			398.32	266.12	78.50	-	
$C_{MS60SF1.25}$	60	40	1.25		173.28			398.32	266.12	98.125	-	
$D_{MS60PP0.5}$	60	40	-		173.28			398.32	266.12	-	0.5	
$D_{MS60PP1.0}$	60	40	-		173.28			398.32	266.12	-	1.0	
$D_{MS60PP1.5}$	60	40	-		173.28			398.32	266.12	-	1.5	
$D_{MS60PP2.0}$	60	40	-		173.28			398.32	266.12	-	2.0	

Abbreviation: V_f –steel fibre volume fraction, MS- m-sand, SF- steel fibre, CA-coarse aggregate, SP-super plasticizer.
Casted specimens were poured in water for curing. Cubes were tested after 7days and 28 days for compressive test using CTM. Cylinders and beams are tested after 28 days for split tensile and flexural loading.

IV. RESULTS AND DISCUSSION

A. *Workability*

The workability of the concrete was determined using the Slump cone test. The Slump Test measures the consistency of fresh concrete before it sets. It is a test performed to check the workability of freshly made concrete; and therefore, the ease with which concrete flows. In this study, a slump test was carried out on every batch of freshly mixed concrete conforming to IS-1199-1959 [17].

As per the results obtained, slump value decreases as M-sand percentage increases in concrete mix because of rough surface texture and angularity of M-sand particles as shown in figure 5.

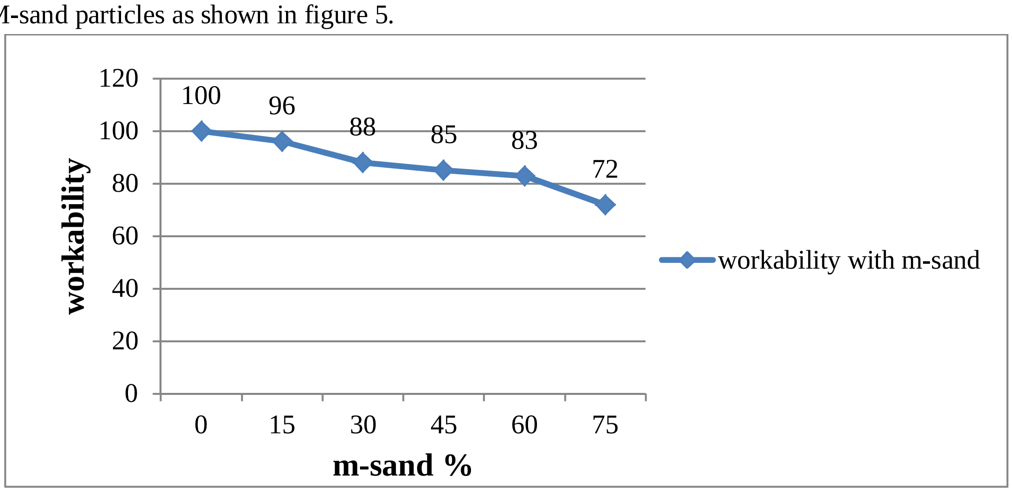

Fig. 5: workability of concrete with various percentage of m-sand.

And for the mix batches of concrete with steel fibre, workability also adversely affected by the increasing volume fraction of steel fibre due to interlocking mechanism of steel fibre shown in figure 6. In case of polypropylene fibre reinforced concrete, slump value decreases due to the significant frictional resistance created between the concrete particles and polypropylene fibre. Slump value for all mix batches with polypropylene are given in figure 7.

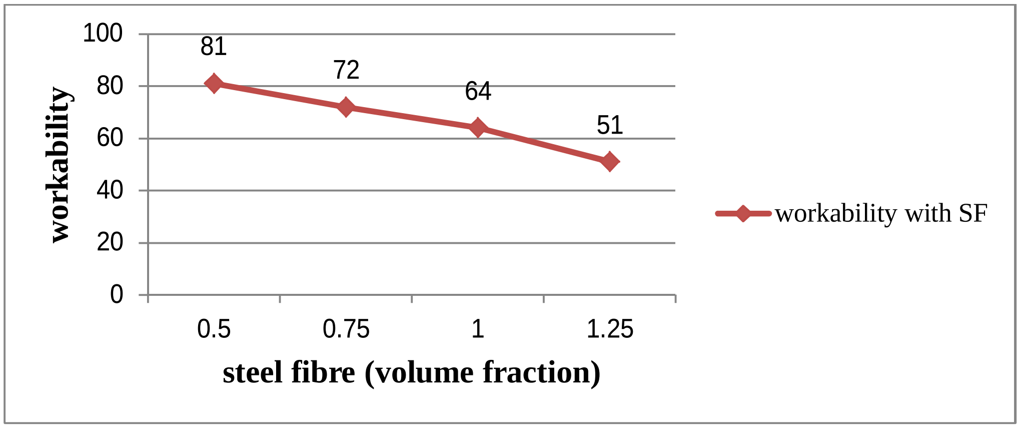

Fig. 6: workability of concrete with 60% m-sand and steel fibre

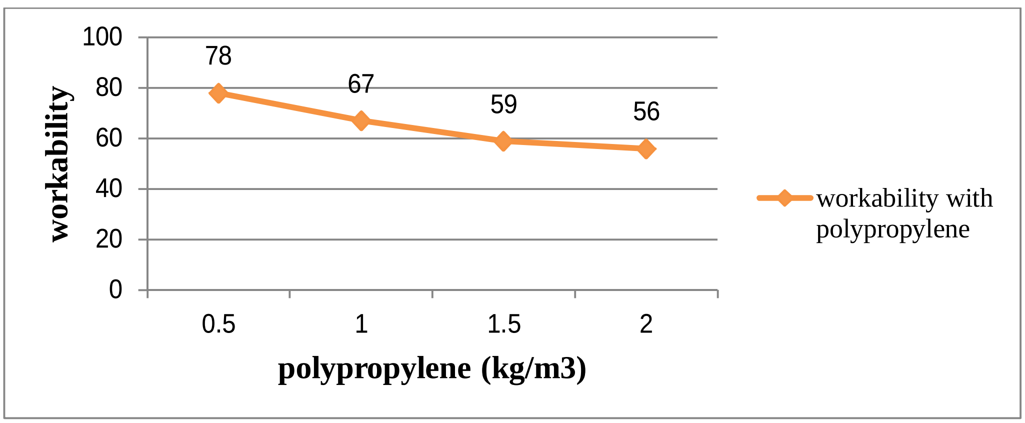

Fig. 7: workability of concrete with 60% m-sand and polypropylene fibre

B. Compressive Strength

Cubes of $150mm^3$ were tested using CTM at 7 days and 28 days after curing as per IS 516:1959 [18]. Results for compressive strength of group A and B for conventional concrete and partially replaced by m-sand are given in figure 8. There is 17% increase in compressive strength was seen with 60% replacement. And beyond this compressive strength decreases.

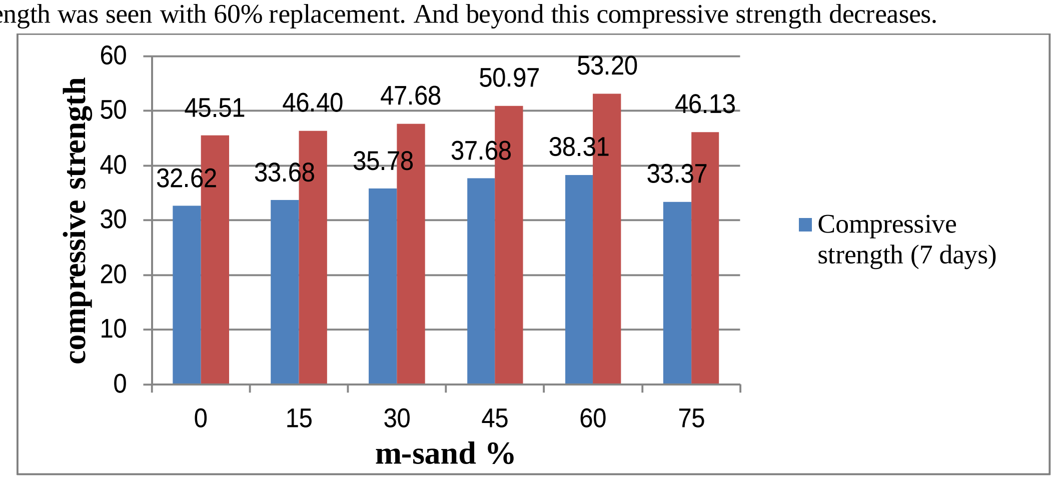

Fig. 8: compressive strength of concrete with varying percentage of m-sand

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It clarifies that the optimum content of m-sand for concrete mix is 60%. And in the second phase of the investigation, varying dosage of steel fibre and polypropylene were used with the optimum content of m-sand. Compressive strength of group C and D for different volume fraction of steel fibre and polypropylene are given in figure 9 & 10**.**

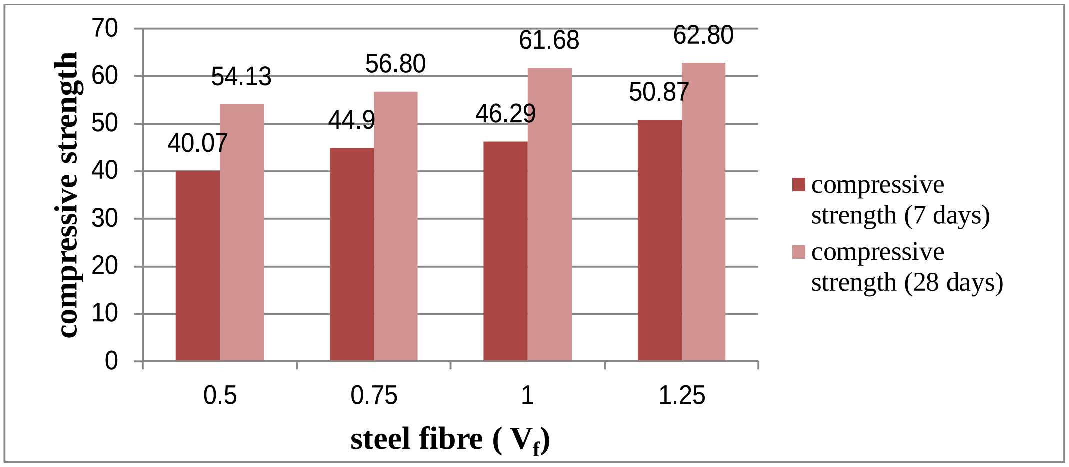

Fig. 9: compressive strength of concrete with 60% m-sand and various fraction of steel fibre

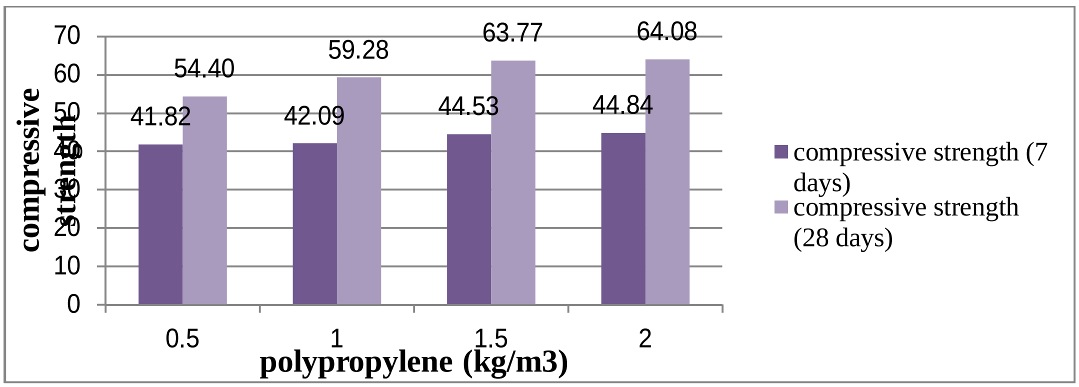

Fig. 10: compressive strength of concrete with 60% m-sand & various dosage of polypropylene fibre

C. Split Tensile Strength

Split tensile strength of concrete was determined by testing the cylindrical specimens in universal testing machine as per IS 5816:1999 [19]**.** Tensile strength increased with the increased percentage of m-sand, and found maximum at 60 % replacement as shown in figure 11.

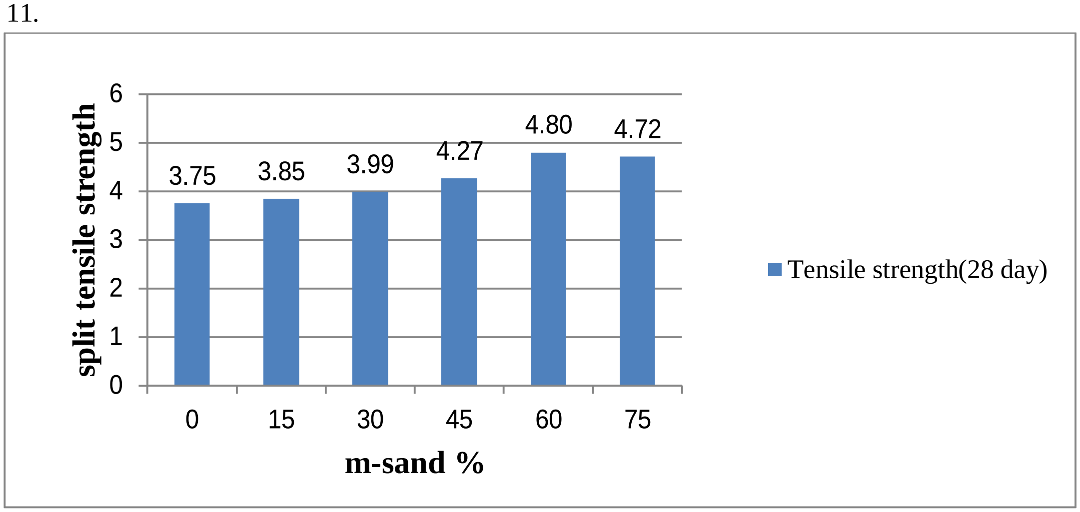

Fig. 11: split tensile strength of concrete with various percentage of m-sand

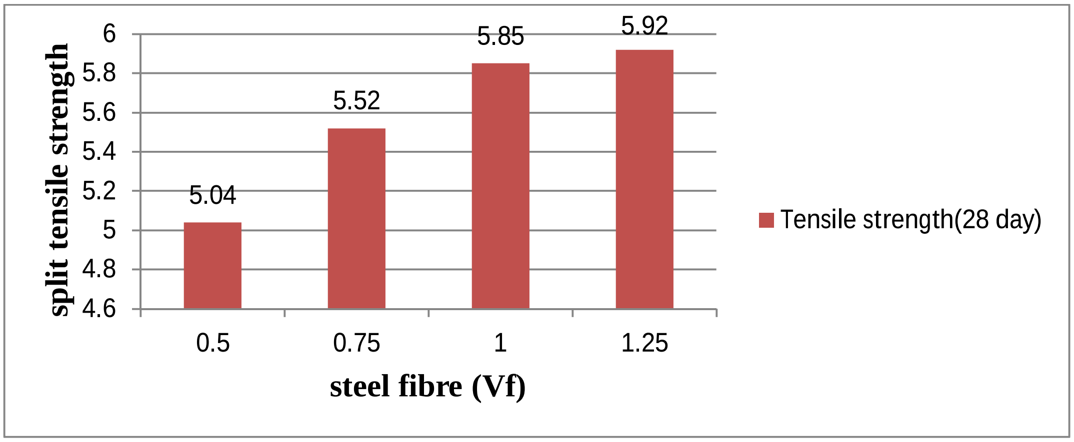

Fig. 12: split tensile strength of concrete with 60% m-sand and various fraction of steel fibre

Further addition of steel fibre also increases tensile strength more efficiently as compare to polypropylene fibre, but there is also slight increase was shown in split tensile strength using polypropylene with range of 1.5 to 2 kg/m^3.

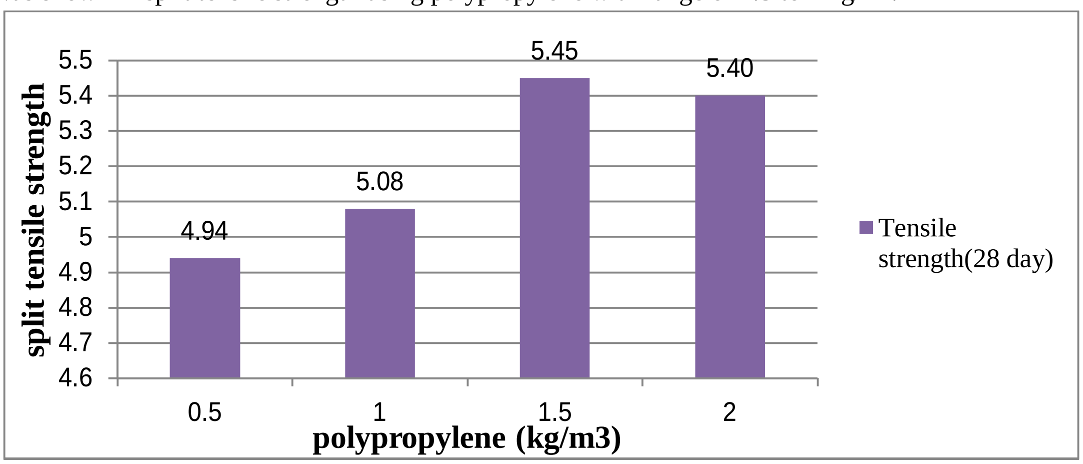

Fig. 13: split tensile strength of concrete with 60% m-sand and various dosage of polypropylene fibre

D. Flexural Strength

Flexural strength test was performed using four-point loading machine as per IS 516:1959. Prism specimens of 150mm×150mm×700mm were tested after 28 days. As test results shown in figure 14, flexural strength with 60% m-sand is maximum, and beyond this content flexural strength was decreased.

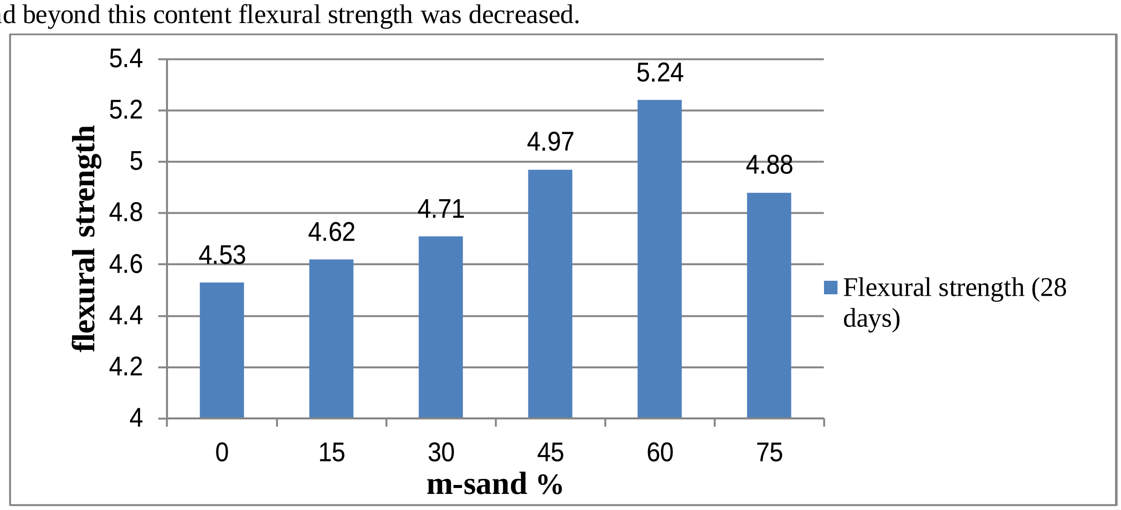

Fig. 14: flexural strength of concrete with various percentage of m-sand

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Addition of steel fibre with 60% m-sand shows proportional relation with flexural property of concrete. Strength increased marginally from 0 to 1% of steel fibre, after that raise is not more efficient. Using steel fibre, flexural strength found slightly better increase from 0 to 1% as compare to 1 to 1.25% of steel fibre as shown in figure 15.

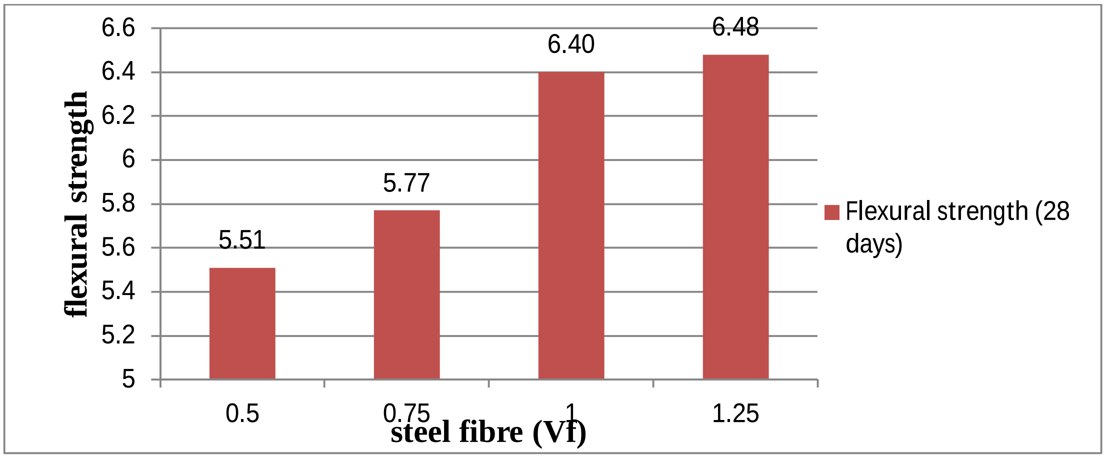


Fig. 15: flexural strength of concrete with 60% m-sand and various fraction of steel fibre

Polypropylene fibre delayed the failure and cracks are minor as compare to conventional concrete by bridging the crack-width. Polypropylene at the rate of 1.5 to 2 kg/m^3 shows the better response also in terms of flexural strength.

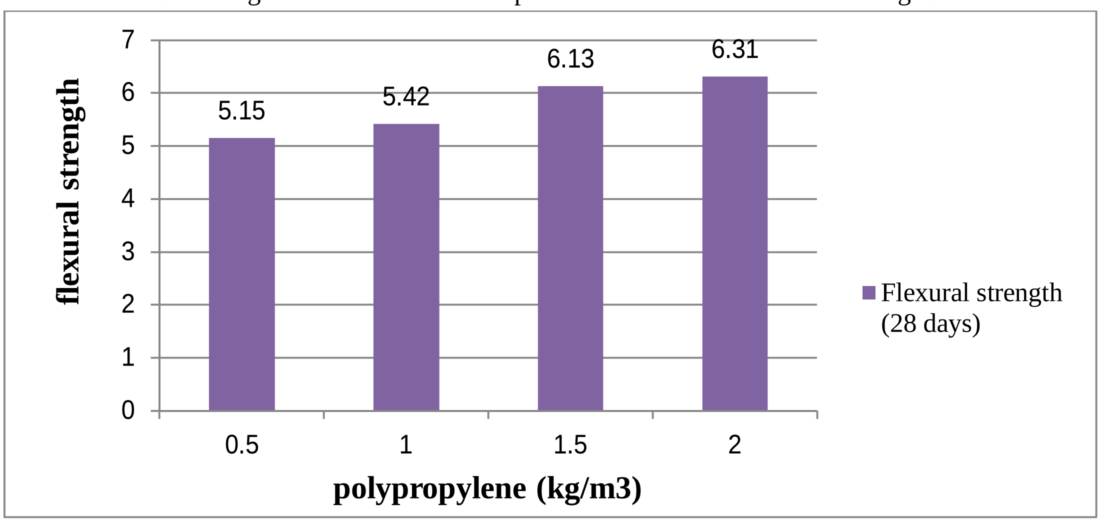


Fig.16: flexural strength of concrete using 60% m-sand with polypropylene.

V. CONCLUSION

The following conclusions are derived as a result of the research done on concrete mixes.

1) Compressive strength increased by 17% up to 60% replacement by m-sand, and after that it starts to decrease. Split tensile strength, flexural strength also shows the same trend, thus optimum dosage of m-sand is 60% by weight of fine aggregate.
2) Surface roughness of m-sand particles reduced the workability, but up to 60% content of m-sand, workability was within range for normal concrete.
3) Addition of steel fibre shows the better increase in compressive, split tensile and flexural strength from 0 to 1% of steel fibre content. Steel fibre content more than 1% does not improve mechanical properties more efficiently.
4) According to the findings of tests on strength properties, the volume ratios of polypropylene fibres had proportional relationship with the compressive, flexural and tensile strength of concrete, and specimens with 1.5 kg/m^3 and 2 kg/m^3 showing the highest strength values.
5) Even though each fibre reduces the crack width by bridging the gap, but polypropylene fibre made the failure more ductile than steel fibre.

REFERENCES

[1] M.R. Lokeswaran and C. Natarajan, "Study on the Properties of Cement Concrete Using Manufactured Sand," *Adv. Struct. Eng. Mater. Vol. Three*, pp. 1619–2647, 2015, doi: 10.1007/978-81-322-2187-6.

[2] B. Li, G. Ke, and M. Zhou, "Influence of manufactured sand characteristics on strength and abrasion resistance of pavement cement concrete," *Constr. Build. Mater.*, vol. 25, no. 10, pp. 3849–3853, 2011, doi: 10.1016/j.conbuildmat.2011.04.004.

[3] D. R. N. U. T. Shanmugapriya, "Strength and durability studies on concrete made with manufactured sand," *Int. J. Appl. Eng. Res.*, vol. 10, no. 02, pp. 1919–1924, 2015, [Online]. Available: http://www.ripublication.com/ijaer.ht

[4] N. Ahn and D. W. Fowler, "An Experimental Study On The Guidelines For Using Higher Contents Of Aggregate Microfines In Portland Cement Concrete," *Int. Cent. Aggregates Res.*, p. 435, 2001, [Online]. Available:https://repositories.lib.utexas.edu/bitstream/handle/2152/35392/102-1F.pdf?sequence=2&isAllowed=y

[5] N. V. Wayal, A S, "Effects of Manufactured Sand on Compressive Strength and Workability of Concrete," *Int. J. Struct. Civ. Engineeing Res.*, vol. 2, no. 4, pp. 228–232, 2013

[6] B. Vijaya and S. Senthil Selvan, "Comparative study on the strength and durability properties of concrete with manufactured sand," *Indian J. Sci. Technol.*, vol. 8, no. 36, pp. 1–7, 2015, doi: 10.17485/ijst/2015/v8i36/88614.

[7] chuanbo wang, "Experimental investigation on behaviour of steel fibre reinforced concrete," *dessertation, Univ. canterbury*, vol. 59, 2006.

[8] K. Holschemacher, T. Mueller, and Y. Ribakov, "Effect of steel fibres on mechanical properties of high-strength concrete," *Mater. Des.*, vol. 31, no. 5, pp. 2604–2615, 2010, doi: 10.1016/j.matdes.2009.11.025.

[9] G. Kaplan, O. Y. Bayraktar, A. Gholampour, O. Gencel, F. Koksal, and T. Ozbakkaloglu, "Mechanical and durability properties of steel fibre-reinforced concrete containing coarse recycled concrete aggregate," *Struct. Concr.*, vol. 22, no. 5, pp. 2791–2812, 2021, doi: 10.1002/suco.202100028.

[10] R. S. Olivito and F. A. Zuccarello, "An experimental study on the tensile strength of steel fibre reinforced concrete," *Compos. Part B Eng.*, vol. 41, no. 3, pp. 246–255, 2010, doi: 10.1016/j.compositesb.2009.12.003.

[11] M. Nili and V. Afroughsabet, "The effects of silica fume and polypropylene fibres on the impact resistance and mechanical properties of concrete," *Constr. Build. Mater.*, vol. 24, no. 6, pp. 927–933, 2010, doi: 10.1016/j.conbuildmat.2009.11.025.

[12] S. Kakooei, H. M. Akil, M. Jamshidi, and J. Rouhi, "The effects of polypropylene fibres on the properties of reinforced concrete structures," *Constr. Build. Mater.*, vol. 27, no. 1, pp. 73–77, 2012, doi: 10.1016/j.conbuildmat.2011.08.015.

[13] IS 1489:1991-part I, "Portland-pozzolana cement-specification," Bureau of Indian Standards, New Delhi,India, 1991.

[14] IS:383:2016, "Coarse and Fine Aggregate for Concrete-Specification," Bureau of Indian Standards, pp. 1–21, January, 2016.

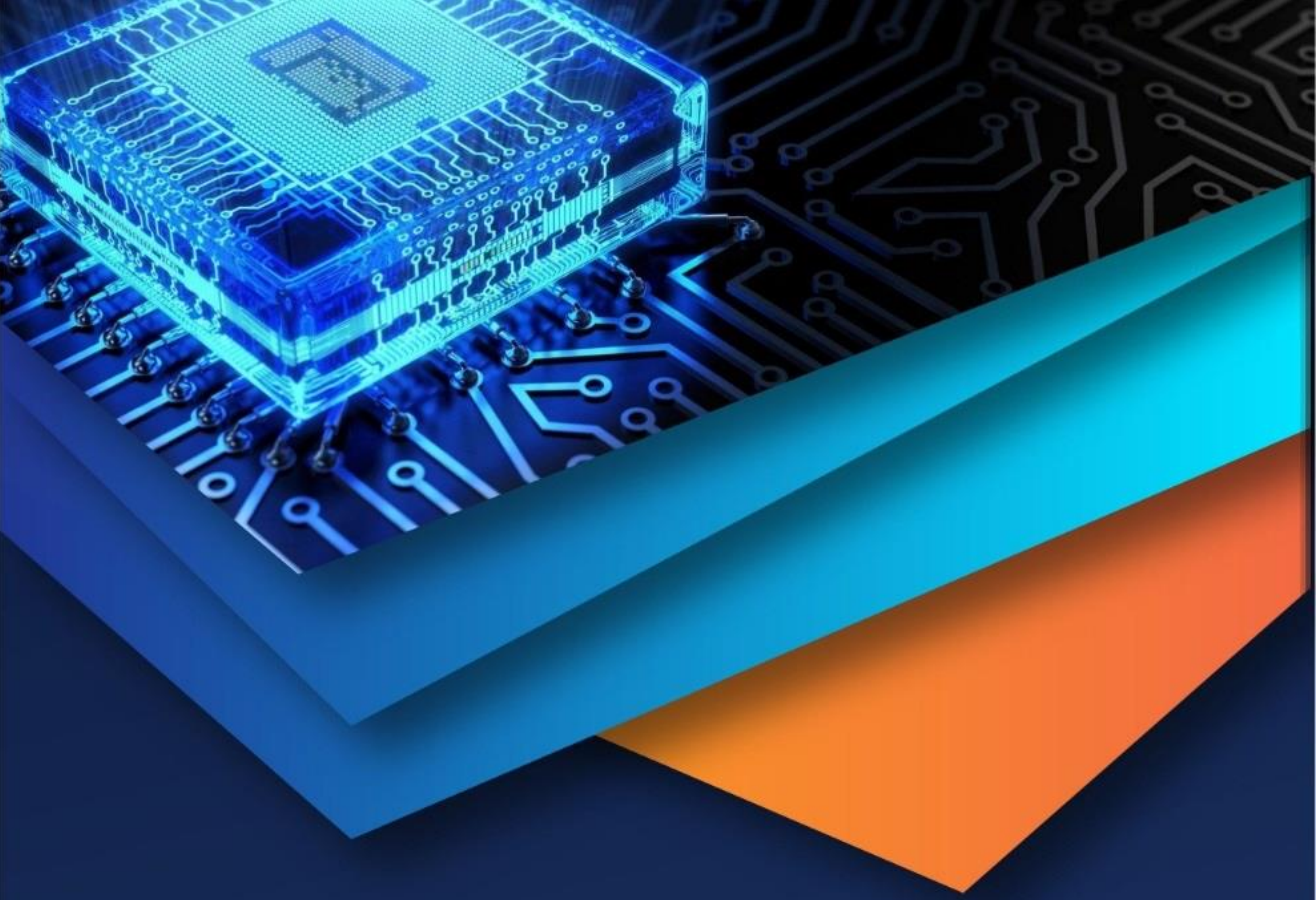
[15] IS:2386:1963-Part I, "Method of test for aggregate for concrete. Part I - Particle size and shape.," Bureau of Indian Standards,(Reaffirmed 2002), 1963.

[16] IS 10262:2019, *Concrete Mix Proportioning-Guidelines*, Bureau of Indian Standards, January 2019.

[17] IS 1199:1959, *method of sampling and analysis of concrete*, Bureau of Indian Standards, vol. 1, no. 1. 1959. doi: 10.2174/18722105130103.

[18] IS 516:1959, "Method of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi, India," pp. 1–30, 1959.

[19] IS 5816-1999, "Splitting tensile strength of concrete- method of test," Bureau of Indian Standards, pp. 1–14, 1999.



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