International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 09, September-2018

STRENGTH AND DURABILITY OF CONCRETE ON REPLACING FINE AGGREGATE WITH MANUFACTURED SAND

[1] Gariki Sagar, [2] Dr. Shaik Yajdani

[1] M.Tech, Department Of Civil Engineering, Andhra University College of Engineering, Visakhapatnam, India.
[2] Associate Professor, Department of Civil Engineering, Andhra University College of Engineering, Visakhapatnam, India

Abstract: In this present work, M25 grade of concrete is used as reference mix. The fine aggregate (natural sand) was replaced with percentages 0%, 20%, 40%, 60%, 80%, and 100% of manufactured sand by weight. Tests were performed to evaluate the workability characteristics of fresh concrete, Compressive, Split Tensile and Flexural strength were determined at the age of 7days, 28days, 56days, and 91days respectively. Durability of the concrete was tested by immersing the specimens in 1% Hydrochloric acid solution for 91 days.

Keywords: Manufactured Sand, Natural sand, Concrete, Durability, Replacement, Compressive strength, Split tensile strength, Flexural strength, and workability.

1. Introduction

For the construction of any structure, we know that river sand is very important as it plays a major role. Due to the excessive usage of river sand, a situation of scarcity of river sand has arised. Now researchers have to find a solution to this problem. After several experiments, researchers have come to a conclusion that manufactured sand can be a substitute for river sand. Manufactured sand is advantageous in many ways such as workability, ease of transportation from the site, reduction in cost of construction, achievement of higher strengths etc. Hence, in this thesis work manufactured sand has been considered as the main component.

2. Literature Review

1. M.Adams Joe et al (2013) 'Experimental Investigation on the Effect of M-Sand in High Performance Concrete' had proposed the natural river sand was the least expensive resource of sand. The silt and clay show in the sand decrease the strength of the concrete and holds dampness. A couple of choices have come up for the business to count on of which manufactured sand or M-sand, as it was called, was observed to be the more appropriate individual to supplant river sand. Utilization of MS can radically lessen the cost since, as river sand, it does not include contaminations and wastages was nil as it is create with present day innovation and machinery. The reason for this examination was tentatively explore the impact of MS in structural concrete by supplanting river sand and build up a high performance concrete. The examination done by utilizes few tests, which incorporate workability test, compressive test, tensile test, and flexural test.

2. P Daisy Angelin et al (2015) 'Durability Studies on Concrete with Manufacturing Sand As A Partial Replacement of Fine Aggregate In HCL Solution' had anticipated that manufactured sand was individual among such materials to supplant river sand which can be utilized as an option fine aggregate in mortars and concrete. An endeavor had been completed in the current analysis to talk about the properties of concrete for example, workability and compressive strength of concrete, which was set up by supplanting natural sand with artificial sand at various substitution levels (0%, 20%, 40%, 60%, 80% and 100%). The outcomes had anticipated that supplanting of natural sand with manufactured sand in order of 60% deliver cement of acceptable workability and compressive strength. Durability of the concrete was additionally tried through immersing the cubes in 5% hydrochloric acid solution.

3. M.Manoj Pravarly and S.Mahesh (2017) focused on achieving high performance characteristics of concrete by comparing M80 and M90 grades. The strength, workability and Durability properties for both grades are compared by varying the percentages of ROBOSAND with natural sand by 0%, 25%, 50%, 75% and 100% together with fly ash of 20% replacement in cement. The compressive strength, split tensile strength and flexural strength are compared for both grades and results are tabulated and the optimum percentages are concluded.

4. Prasanna K and Anandh K S (2017) conducted experiments on M60 grade concrete with fine aggregate replacement proportion 0%, 25%, 50%, 75% and 100%. The properties such as compressive strength, split tensile strength and ultrasonic pulse velocity are determined from cubes and cylinders cast with manufactured sand procured from kundrathur

IJTIMES-2018@All rights reserved

and river sand taken from Araniar basin. The replacement of 75% natural sand by manufactured sand recommended as this proportion gives comparatively better results in special concrete such as high performance concrete. Hence the manufactured sand can be used in high performance without any doubt which will also improve the environment as well as sustainability of construction industry.

3. Experimental Investigation

3.1 Materials Used

3.1.1 Cement

Ordinary Portland cement of 53 grade conforming to IS: 12269-2013, Ultra Tech Cement brand was used. Physical properties of cement are shown in Table 1.

3.1.2 Fine Aggregate (River Sand)

The locally available river sand passing through 4.75 mm sieve and retained on 600 µ sieve, conforming to Zone-II of IS 383-1970 has been used as fine aggregate. Physical properties of fine aggregate are shown in Table 2.

3.1.3 Manufactured Sand

Manufactured sand used in this work was brought from SS ROCK PRODUCTS, SURVEY NO: 303/304, KUNCHANGI VILLAGE, VISAKHAPATNAM-531032, and is conforming to Zone-II of IS 383-1970. The physical properties of manufactured sand are shown in table 3.

3.1.4 Coarse Aggregate

Conventional coarse aggregate was used from an established quarry satisfying the requirement of IS 383-1970. The locally available crushed granite stone is used as coarse aggregate. The tests conducted on coarse aggregate are tabulated in Table 4.

Table 1- Physical Properties of Cement

S.NO.	Property	Value
1.	Specific Gravity	3.11
2.	Fineness of cement (By sieving)	3.2%
3.	Standard Consistency	31%
4.	Setting Time i) Initial setting time	115 min
	ii) Final setting time	223 min
5.	Compressive Strength i) 3 Days ii) 7 Days iii) 28 Days	20.93 N/mm^2 36.54 N/mm^2 56.28 N/mm^2

Table 2- Physical properties of fine aggregate

S.NO.	Property	Value
1.	Grading of Sand	Zone II as per IS 383
2.	Specific Gravity	2.61
3.	Bulk Density i) Loose State ii) Compacted State	1554.9 Kg/m^3 1697 Kg/m^3
4.	Fineness Modulus	2.87
5.	Water Absorption	1.20%

Table 3- Physical properties of Manufactured Sand

S.NO.	Property	Value
1.	Grading of Sand	Zone II as per IS 383
2.	Specific Gravity	2.65
3.	Bulk Density i) Loose State ii) Compacted State	1664 Kg/m^3 1898.07 Kg/m^3
4.	Fineness Modulus	2.52
5.	Silt Content	3.57%

IJTIMES-2018@All rights reserved

Table 4- Physical properties of Coarse Aggregate

S.NO.	Property	Value
1.	Specific Gravity	2.81
2.	Bulk Density i) Loose State ii) Compacted State	 1557.33 Kg/m^3 1751.70 Kg/m^3
3.	Water absorption	0.59%
4.	Flakiness Index	12.54%
5.	Elongation Index	23.07%
6.	Crushing Value	21.01%
7.	Aggregate Impact Value	21.35%
8.	Fineness Modulus	6.80

3.1.5 Super plasticizer

The super plasticizer used in the study was FOSROC Conplast SP 430.

3.1.6 Mix Proportion

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete of having certain minimum workability, strength and durability as economically as possible. The M25 grade concrete Mix design is made as per IS10262:2009. The table 5 below shows the mix design.

Table 5- Mix Proportions

Water (Liters)	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)
165.6	360	697.80	1270.98 (762.588+508.392) (60%+40%)
0.46	1	1.938	3.530

4. Test Procedure

4.1 Slump cone Test

Slump cone test is a preliminary test conducted to determine the workability. In this thesis, slump test was conducted on the mix containing cement, fine aggregate, manufactured sand and coarse aggregate. The mix was prepared according to the proportions obtained from mix design. The prepared mix was then placed in slump cone in three layers with simultaneous tamping with a tamping rod for each layer. The slump cone is lifted and the change in slump is observed. The change in slump is measured with a steel rule and is noted down.

4.2 Compaction Factor Test

Compaction factor test is another test conducted to determine the workability of the prepared mix. In this test the mix is poured into the upper hopper of the compaction factor apparatus, and then the lever is pulled, which makes the mix fall down in to the lower hopper and then in to the cylinder under the action of gravity. Now the cylinder is weighed and the weight is noted down. The cylinder is now placed on the vibrator table and then compacted. The cylinder is again weighed and the weight of fully compacted cylinder is noted down. The compaction factor is found out with the help of the formula below.

$$\text{Compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weihght of fully compacted concrete}}$$

4.3 Vee-Bee Consistometer Test

In this test, the mix is placed in the cone in three layers with simultaneous compaction. After the cone has been removed the circular glass plate attached to the apparatus is placed on the mix. The machine is switched on and the stopwatch is started. The time taken for the cone shaped to mix to transform into a cylindrical shaped mix is noted down. This time recorded is known as Vee-Bee time.

4.4 Compressive Strength Test

In this test, the cubes that have been cast in the cubical mould of dimensions 150mmx150mmx150mm, placed in curing tank for 7, 28, 56, and 91 days and then dried until it is free from moisture are tested in a compression testing machine. The cubes are placed in the machine and then load is applied until failure. The load obtained is recorded and the compressive strength is calculated using the formula below. Figure 1 depicts the placing of concrete cube in compression testing machine.

$$\text{Compressive strength} = \frac{P}{A} \text{ (N/mm}^2\text{)}.$$

Where,

P = load applied to the specimen.

A = Cross-sectional area of cube on which the load is applied (150mm x 150mm)

Fig.1. Testing of cube

4.5 Splitting Tensile Strength

In this test, cylinders of dimension 150mm x 300mm have been cast in cylindrical moulds, placed in curing tank for 7, 28, 56 and 91 days and dried until free from moisture. These cylinders are placed in the testing machine and the load is applied until failure. The ultimate load is recorded and then the splitting tensile strength is calculated according to the formula given below. The placing of the cylinder in the testing machine is depicted in Fig 2.

$$F_t = \frac{2P}{\pi \, x \, D \, x \, L} \text{ N/mm}^2$$

Where, P= Maximum load applied to the specimen.
D = Cross sectional dimension of cylinder on which load is applied.
L = Length of specimen in mm.
F_t = Split tensile strength. (N/mm^2)

Figure 2. Testing of Cylinder

4.6 Flexural Strength

In this test, prisms of dimensions 500mm x 100mm x 100mm were cast in the appropriate moulds, placed in curing tank for 7, 28, 56 and 91 days, and then dried until free form moisture. Before the testing of these prisms, two lines with a gap of 5 cm from each of the ends are drawn. Now from this 5 cm lines, two more lines with a gap of 13.33 cm are drawn. This is for the purpose of three point loading. The prism is placed in the testing machine and then load is applied on the roller plate placed on the lines drawn on the prism. The prism is loaded until failure and the ultimate load is recorded.

The flexural strength is calculated with the help of the formula given below. Fig 3 depicts the placing of the prism in the universal testing machine.

$$F_b = P\, x \frac{L}{B\, x\, D\, x\, D} \text{ N/mm}^2 \text{ (when tensile crack length is greater than 13.33cm)}$$

$$F_b = \frac{3Pa}{B\, x\, D\, x\, D} \text{ N/mm}^2 \text{ (when tensile crack length is between 11.0cm to 13.33cm)}$$

Where,
F_b = Flexural strength of the specimen.
P = maximum load applied to the specimen.
L = Length in mm of the span on which the specimen was supported.
B = width of the specimen.
D = depth of specimen.

Figure 3. Testing of Prism

4.8 Durability

Durability is defined as the ability of concrete to withstand factors of weathering, abrasive actions, and exposure to freeze and thaw characteristics. In this thesis main focus was given to the resistance of concrete with manufactured sand towards acid attack. HCl was chosen for the test as it causes leaching in concrete structures and it is the major concern.

4.8.1 Hydrochloric Acid Attack on Concrete:

Hydrochloric acid is very aggressive in nature. The reaction given below causes leaching of calcium hydroxide from the cement that has been set. The concrete specimens were exposed to 1% HCl concentration. 1% diluted HCl is prepared and to make 30 litres solution of 1% concentrated HCl, the stock solution required is 675ml.

$$CaOH_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

5. DISCUSSION OF TEST RESULTS

5.1 Workability

The values of Slump cone test, Compaction factor and Vee-Bee time obtained from present investigation are presented in Table 6, 7 & 8 respectively. The Slump cone test and Compaction factor are decreasing, and Vee-Bee time is increasing as the quantity of manufactured sand is increasing.

Table 6- Workability in terms of Slump Cone test

Grade of Concrete	M25					
Percentage Replacement of Manufactured Sand	0%	20%	40%	60%	80%	100%
Slump (mm)	53	47	40	37	31	25
Percentage of Admixture required for Slump (25-75mm)	0%	0.5%	0.6%	0.7%	0.8%	0.9%

Table 7- Workability in terms of Compaction Factor test

Grade of Concrete	M25					
Percentage Replacement of Manufactured Sand	0%	20%	40%	60%	80%	100%
Compaction Factor	0.96	0.95	0.93	0.91	0.89	0.87

Table 8- Workability in terms of Vee-Bee time

Grade of Concrete	M25					
Percentage Replacement of manufactured sand	0%	20%	40%	60%	80%	100%
Vee-Bee Time (sec)	10.20	11.10	12.03	14.3	15.89	17.21

5.2 Compressive strength

The results of compressive strength are obtained and are presented in table 9. The variation of compressive strength with respect to manufactured sand content is shown in figure 4.

Table 9- Compressive Strength Values

Age in days	0%M-Sand MPa	20%M-Sand MPa	40%M-Sand MPa	60%M-Sand MPa	80%M-Sand MPa	100%M-Sand MPa
7	22.64	24.95	26.18	28.35	27.02	26.12
28	32.93	34.36	36.71	38.86	37.08	36.37
56	35.41	37.39	39.87	41.43	40.26	39.12
91	37.62	39.37	41.51	43.18	42.28	41.08

From the graphs we can observe that the 60% replacement of natural sand by manufactured sand gives more strength than any other replacement. For M25 grade concrete the compressive strength is of order 0%, 4.34%, 11.47%, 18%, 12.60%, 10.44% for 0%, 20%, 40%, 60%, 80% and 100% replacement of manufactured sand.

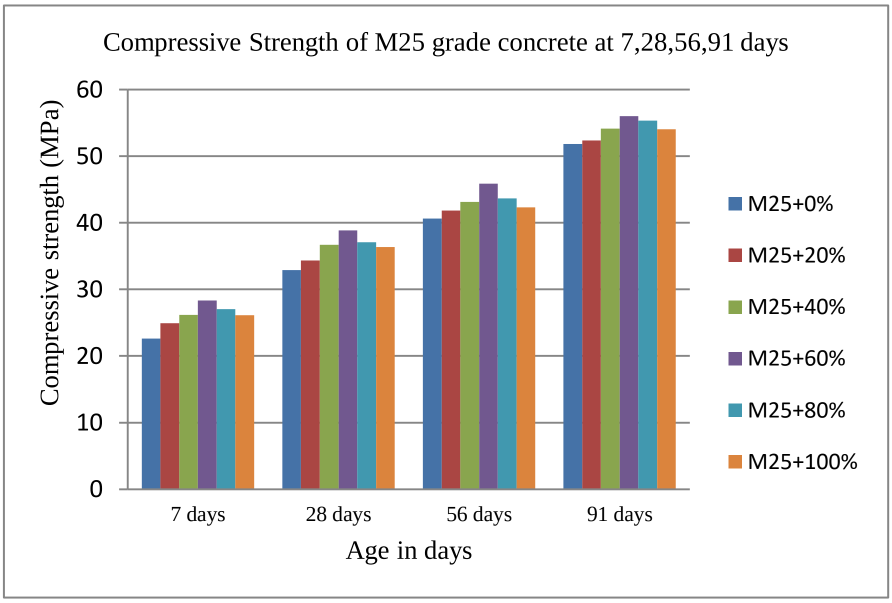

Figure 4. Variation of Compressive strength for M25 grade of concrete

IJTIMES-2018@All rights reserved

5.3 Split Tensile strength

The results of split tensile strength are obtained and are presented in table 10. The variation of split tensile strength with respect to fiber content is shown in figure 5.

Table 10- Split Tensile Strength Values

Age in Days	0% M-Sand MPa	20% M-Sand MPa	40% M-Sand MPa	60% M-Sand MPa	80% M-Sand MPa	100% M-Sand MPa
7	2.14	2.58	2.98	3.15	2.92	2.86
28	2.85	3.22	3.55	3.79	3.41	3.32
56	3.16	3.50	3.64	3.91	3.63	3.58
91	3.22	3.57	3.72	3.89	3.75	3.63

From the graphs we can observe the 60% replacement of natural sand by manufactured sand gives more strength than any other replacement. For M25 grade concrete the split tensile strength is of order 0%, 12.98%, 24.56%, 32.98%, 19.64%, 16.49% for 0%, 20%, 40%, 60%, 80%, 100% replacements.

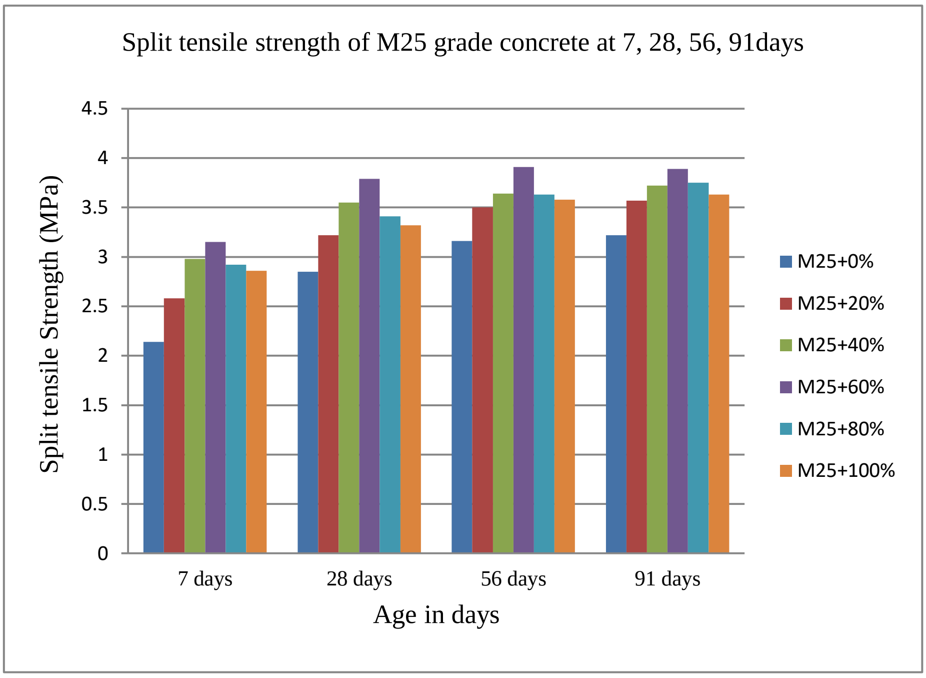

Figure 5. Variation of Split tensile strength for M25 grade concrete

5.4 Flexural Strength

The results of flexural strength are obtained and are presented in table 11. The variation of flexural strength with respect to fiber content is shown in figure 6.

Table 11- Flexural Strength Values

Age in days	0% M-Sand MPa	20% M-Sand MPa	40% M-Sand MPa	60% M-Sand MPa	80% M-Sand MPa	100% M-Sand MPa
7	4.68	5.11	5.36	5.68	5.41	5.31
28	5.79	6.02	6.25	6.78	6.41	6.28
56	6.10	6.48	6.82	6.98	6.70	6.61
91	6.31	6.61	6.94	7.06	6.87	6.75

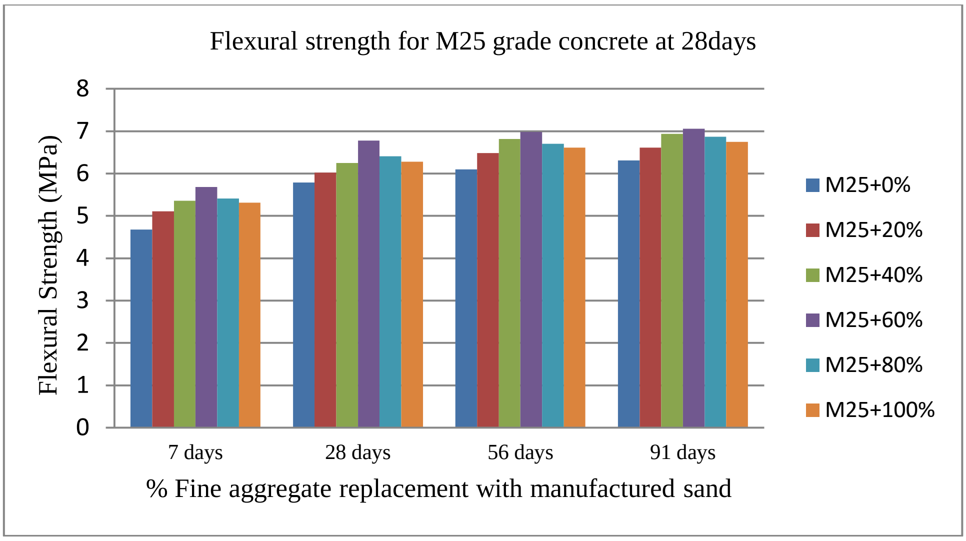

Figure 6. Variation of flexural strength with M25 grade concrete

5.5 Compressive Strength of Acid treated Specimens

The comparison of 28 days compressive strength with 91 days acid treated compressive strength with the increase in quantity of manufactured sand for M25 grade concrete were tabulated in the table 12 and is shown in fig.7

Table 12- Compressive strength of acid treated M25 grade cubes

Type	0% M-sand MPa	20% M-sand MPa	40% M-sand MPa	60% M-sand MPa	80% M-sand MPa	100% M-sand MPa
Before Acid Treatment	37.6	39.3	41.51	43.18	42.28	41.08
After Acid Treatment	35.21	37.71	39.31	41.52	40.22	38.88

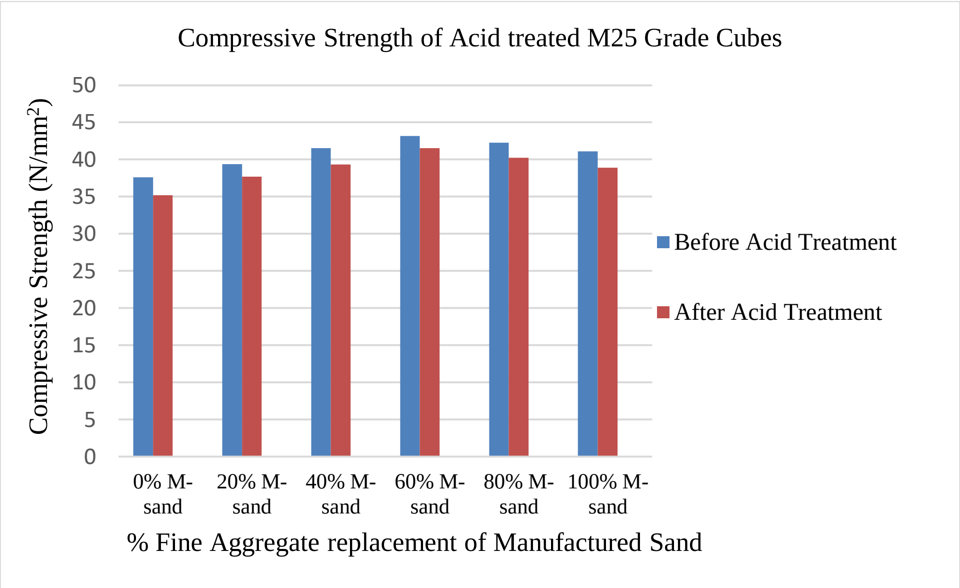

Figure 7. 91 days Acid treated compressive strength

5.6 Split tensile strength of Acid treated Specimens

The comparison of 28 days split tensile strength with 91 days acid treated split tensile strength with the increase in quantity of manufactured sand for M25 grade concrete were tabulated in the table 13 and is shown in fig.8.

Table 13- Split Tensile strength of acid treated M25 grade cylinders

Type	0% M-sand MPa	20% M-sand MPa	40% M-sand MPa	60% M-sand MPa	80% M-sand MPa	100% M-sand MPa
Before Acid Treatment	2.85	3.22	3.55	3.79	3.41	3.32
After Acid Treatment	2.72	3.08	3.37	3.65	3.28	3.17

From the graphs we can see that the 60% replacement of natural sand by manufactured sand gave more resistance to acid treatment than any other replacement. For M25 grade concrete the decrease in Split tensile strength is of order 4.56%, 4.34%, 5.01%, 3.69%, 3.81%, 4.51% for 0%, 20%, 40%, 60%, 80%, 100% replacements respectively.

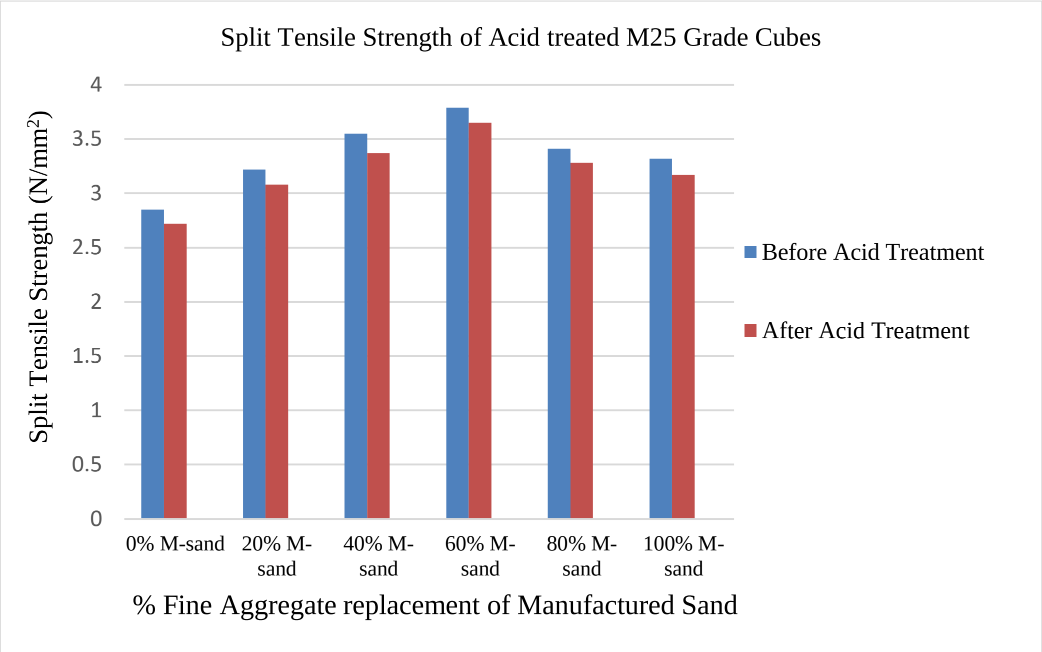

Figure 8. 91 days acid treated Split tensile strength

5.7 Flexural Strength of Acid Treated Specimens

The comparison of 28 days flexural strength with 91 days acid treated flexural strength with the increase in quantity of manufactured sand for M25 grade concrete were tabulated in the table 14 and is shown in fig.9.

Table 14- Flexural strength of acid treated M25 grade prisms

Type	0% M-sand MPa	20% M-sand MPa	40% M-sand MPa	60% M-sand MPa	80% M-sand MPa	100% M-sand MPa
Before Acid Treatment	5.79	6.02	6.25	6.78	6.41	6.28
After Acid Treatment	5.53	5.77	5.91	6.56	6.10	5.96

From the graphs we can see that the 60% replacement of natural sand by manufactured sand gave more resistance to acid treatment than any other replacement. For M25 grade concrete the decrease in flexural strength is of order 4.49%, 4.15%, 5.44%, 3.24%, 4.83%, 5.09% for 0%, 20%, 40%, 60%, 80%, 100% replacements respectively.

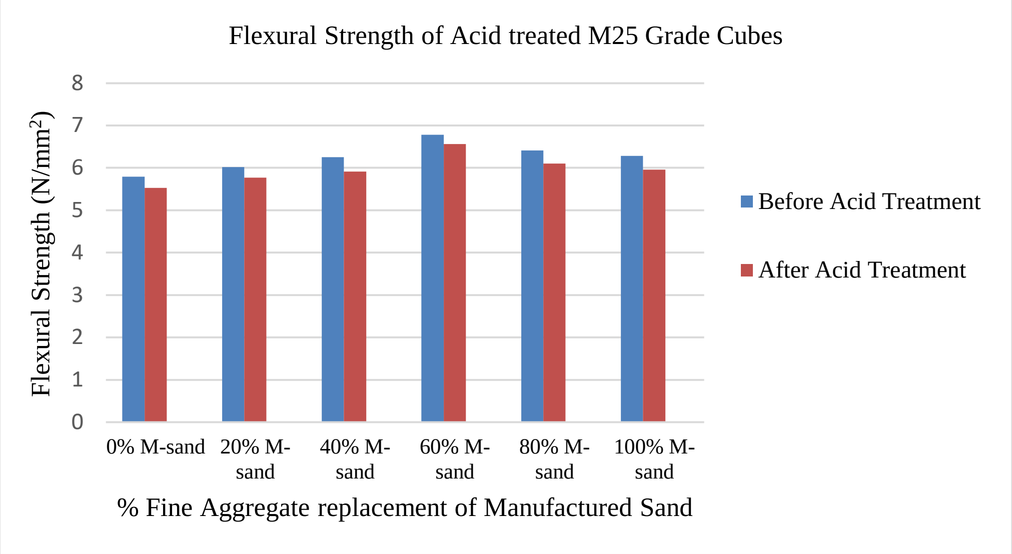

Figure 9. 91 days acid treated flexural strength

6. Conclusions

1. The manufactured sand can be used as a best alternative material for partial replacement of natural sand as fine aggregate and gives more compressive strength in order of 4.34% to 17.8% for M25 grade concrete than conventional concrete.

2. The slump in terms of Vee-Bee time increases with increase in percentage replacement of manufactured sand.

3. It is observed that 60% replacement of natural sand by manufactured sand is giving better compressive strength for M25 grade concrete compared to other proportions of mixes.

4. It is observed that 60% replacement of natural sand by manufactured sand is giving better split tensile strength for M25 grade concrete compared to other proportions of mixes.

5. It is observed that 60% replacement of natural sand by manufactured sand is giving better flexural strength, for M25 grade concrete compared to other proportions of mixes.

6. It is observed that 60% replacement of natural sand by manufactured sand is giving better resistance to acid attack for M25 grade concrete compared to other proportions of mixes.

References

[1]. Adams Joe M, Maria Rajesh A, Brightson P, Prem Anand M. Experimental Investigation on the Effect of M-Sand in High Performance Concrete, American Journal of Engineering Research. 2013; 2(12):46-51.

[2]. Daisy Angelin P, Ravi Kishore P. Durability Studies on Concrete with Manufacturing Sand As A Partial Replacement of Fine Aggregate In HCL Solution", International Journal of Engineering Research and Development. 2015; 11(12):44-50.

[3]. Manoj Pravarly M, Mahesh S. "Characteristic of High Performance Concrete by using ROBO Sand and Fly ash", International Journal of Scientific Engineering and Technology Research. 2017; 6(6):1015-1022.

[4]. Prasanna K, Anandh KS, kiruthiga K. Study on High Performance Concrete with Replacement of Fine Aggregate by Manufactured Sand, International Journal of Civil Engineering and Technology. 2017; 8(8):1502- 1514.

[5]. IS: 12269-2013. Specification for 53 grade ordinary Portland cement. Bureau of Indian Standards, New Delhi.

[6]. IS: 383-1970. Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian standards, New Delhi.

[7]. IS: 2386-1963 Part I to VIII. Indian standard Methods of test for aggregate for concrete. Bureau of Indian standards, New Delhi.

[8]. IS: 1199-1959. Indian standard methods of sampling and analysis of concrete. Bureau of Indian standards, New Delhi.

[9]. IS: 516-1959. Indian standard methods of test for strength of concrete. Bureau of Indian standards, New Delhi.

[10]. IS: 10262-2009 and SP 23: 1982. Recommended guidelines for concrete mix. Bureau of Indian standards, New Delhi.

[11]. Plain and Reinforced Concrete Code of Practice (Fourth Revision), IS 456:2000, Bureau of Indian Standards, New Delhi.

[12]. M.S. Shetty “Concrete technology” S.Chand and Co.Ltd, India (2009).