Effect of Manufactured Sand on Mechanical Properties of Concrete

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Abstract - *Natural river sand was the cheapest sand readily available. But excessive mining increased the demand for sand and had lead to the ecological imbalance. Now the sand available contains very high amount of silt and clay which holds dampness and reduces the strength of concrete. Though the researchers suggest M-sand for construction purposes, it has not fully come to practice. Also the property of M-sand available in different places varies. Hence after going through several works, full replacement of river sand with M-sand in concrete has been carried out. For this study M-sand from three different localities were collected and tested. M_{20} mix is adopted as grade of concrete and water cement ratio 0.45 is followed. Three variants of samples containing different M-sand are casted. Workability and Mechanical properties have been examined. Slump tests showed that river sand is highly workable than the M-sand. On comparing their Mechanical Properties, concrete containing M-sand obtained from Karur showed 10.71%, 12.15% and 8.22% increase in Compressive Strength, Split Tensile Strength and Flexural Strength when compared to the conventional concrete at the end of 28 days curing.*

***Key Words*: M-sand, three localities, full replacement, Compressive Strength, Split Tensile Strength, Flexural Strength.**

1. INTRODUCTION

The real estate and infrastructure sectors of Tamil Nadu are experiencing sand shortage, which has halted numerous building projects across the city. It has affected all building projects, including government ones like the Metro Rail. The sand shortage and its volatile price escalation is a major cause for concern in the real estate and infrastructure sectors which posed a massive drawback. Due to the growth of construction industry and major infrastructure projects, there is a huge demand for sand as a building material. This leads to acute shortage of river sand for the construction purpose. Excessive Sand Mining has adversely affected the environment. This led to ban on mining of river sand. Tamil Nadu High Court has proposed an order on 29th November 2017, that within a period of 6 months all the river sand quarries should be closed and no new quarries shall be opened. Hence Tamil Nadu Government encouraged importing sand from Foreign countries like Malaysia, Dubai etc., but these sand does not confirm to the IS codal specifications. Also it is considered to contain organic impurities. Out of 300 M-sand manufacturers in Tamil Nadu only 10 companies provide proper quality M-sand, verified by PWD. About 35,000 loads of sand is the daily requirement in Tamil Nadu for construction. But only 2,000 loads are being manufactured by the authorized 10 M-sand quarries. To cope up with the crisis, developers are now finding other alternatives. M-sand is an alternative solution for demand of river sand and in future most of the construction project will be fully dependent on M-sand. Hence it is important to study its properties and its behavior in concrete. Also it is obtained naturally from the rock. So it should be known whether any variations are there between M-sand from different quarries as each quarry follows its own method for manufacturing of M-sand. Hence different samples of M-sand from the nearby locality is considered and used for the experiment. The project is aimed to focus on the following objectives: (1) To recommend the use of M-sand for construction purposes to meet the demanding crisis of river sand, (2) To fully replace river sand with M-sand, (3) To conduct tests to find out their Compressive Strength, Split Tensile Strength and Flexural Strength of the concrete.

2. MATERIALS USED

Materials used in this study are (i) Portland Pozzolana Cement (ii) M-sand (collected from Karur, Padalur and Pudukottai) (iii) Blue granite crushed stone aggregate. All these materials are locaaly available.

Three samples of m-sand were collected from Karur, Pudukottai and Padalur. The material properties of Portland Pozzolana Cement, M-sand and coarse aggregates are tested according the codal provisions and are given in the table 1, 2 and 3 respectively. The results obtained are therein checked with the nominal values.

Table -1: Properties of Cement

S.No.	Properties	Results	Nominal values as per IS 1489-1991
1	Standard Consistency	30%	26%- 33%
2	Initial setting Time (minutes)	75	Minimum 30
3	Final setting Time (minutes)	190	Maximum 600

Table -2: Properties of M-sand

S.No	Properties	M-sand			Nominal values as per IS 383-1970
		Karur	Pudukottai	Padalur	
1	Fineness Modulus	2.75	2.89	2.97	2.2-3.2
2	Specific Gravity	2.73	2.81	2.75	2.4-2.9
3	Grading Zone	II	II	II	-
4	Maximum Size	4.75mm	4.75mm	4.75mm	-

Table -3: Properties of Coarse Aggregate

S.No.	Test Particulars	Coarse aggregate	Nominal values as per IS 2386 -1963
1	Specific Gravity	2.85	2.5 to 3.0
2	Water absorption (%)	0.36	< 0.6
3	Grading Zone	II	-
4	Maximum size	20 mm	-

3. PREPARATION OF CONCRETE SPECIMENS

M_{20} grade of concrete is used in the test [2] with a water cement ratio of 0.45 [3] according to IS 456-2000. The specimens were prepared in the following size moulds: (i) Cube - 150mm x 150mm x 150mm (ii) Cylinder - 150 mm diameter and 300 mm height (iii) Prism - 100mm x 100mm x 500mm [4]. Specimens were cast with conventional concrete and also with three M-sand. After 24 hours the moulds are removed and curing is done.

4. CONCRETE TESTING

4.1 Slump Cone Test

The slump cone test is used to assess the horizontal free flow of in the absence of obstructions [5]. Mould is the shape of a truncated cone with internal dimensions 200 mm diameter at the base, 100mm diameter at the top and a height of 300 mm. Concrete is poured in three layers and the cone is lifted in an upward direction. The difference in height of cone to the remaining concrete gives the slump value. Table 4 gives the slump values.

Table -4: Slump Values of Concrete

M-sand	Karur	Pudukottai	Padalur	River sand
Slump values (mm)	65	60	45	75

4.2 Compressive Strength Test

The Compressive test is used to determine the hardness of a cubical specimen of concrete. After curing the concrete cube specimen is surface dried for 24 hours. Then the Compressive tests are taken in the Compression Testing Machine as per IS 516-1959. Using (1) the Compressive Strength is calculated.

Compressive Strength =Load at Failure / Area (1)

Area = 150x150 mm^2

Table 5 gives the values of Compressive Strength.

Table -5: Compressive Strength

S.No.	M-sand	Compressive Strength (N/mm^2)		
		7days	14days	28days
1	Karur	18.34	23.87	29.8
2	Pudukottai	16.12	21.3	26.12
3	Padalur	15.04	19.63	25.18
4	River sand	16.59	21.68	26.6

4.3 Split Tensile Strength Test

The Tensile Strength is determined either by direct tensile tests or by indirect tensile tests such as split cylinder tests. In Split Tensile Test, cylinders after 28 days were removed from the curing tank and was left to dry for 24 hours after that cylinder is placed in Compression Testing Machine for testing as per IS 5816-1999. Split Tensile Strength of cylinder is calculated using (2).

Split Tensile Strength = $2P/\pi DL$ (2)

Where, P – Load at failure (kN)

D – Diameter of the cylinder = 150 mm

L – Height of the cylinder = 300 mm

Table 6 gives the values of Split Tensile Strength.

Table -6: Split Tensile Strength

S.No.	M-sand	Split Tensile Strength (N/mm^2)		
		7days	14days	28days
1	Karur	1.98	2.35	3.14
2	Pudukottai	1.86	2.13	2.74
3	Padalur	1.83	2.10	2.37
4	River sand	1.85	2.10	2.80

4.4 Flexural Strength Test

Flexure test is carried as per IS 516-1999, a standard plain concrete beam rectangular cross section is simply supported and subjected to third point until failure. For two point loading at the top and simply supported bottom, the flexural strength of the prism is obtained from (3).

$$F_r = 3PL/4bd^2 \quad (3)$$

Where,

F_r= Flexural Strength of specimen in N/mm^2

P = Maximum load in N applied to the specimen

d = Measured diameter of the specimen in mm and

b = Measured width of the specimen in mm

The values F_r are tabulated in the table 7.

Table -7: Flexural Strength

S.No.	M-sand	Flexural Strength (N/mm²)		
		7days	14days	28days
1	Karur	3.05	5.31	7.5
2	Pudukottai	2.93	4.69	6.37
3	Padalur	2.65	4.15	5.55
4	River sand	2.96	5.05	6.93

5. DISCUSSION

5.1 Slump Cone Test

The concrete having Karur, Pudukottai and Padalur M-sand has 15.4%, 25% and 66.7% lesser workability than that of M-sand. Also Karur M-sand concrete has 8.33% and 44.44% higher slump values than the Pudukottai and Padalur M-sand.

5.2 Compressive Strength Test

When compared with the conventional concrete, Karur M-sand showed 9.56%, 9.16% and 10.71% increase in Compressive Strength for 7 days, 14 days and 28 days curing. Pudukottai and Padalur M-sand has 1.8% and 5.33% lesser Compressive Strength than that of the conventional concrete for 28 days curing.

The three M-sands when compared altogether, the M-sand obtained from Karur region showed 12.73% and 16.61% higher Compressive Strength than the M-sand obtained from Pudukottai and Padalur during 28 days curing period. Chart 1 shows that the Compressive Strength of the M-sand of type I obtained from Karur has good results.

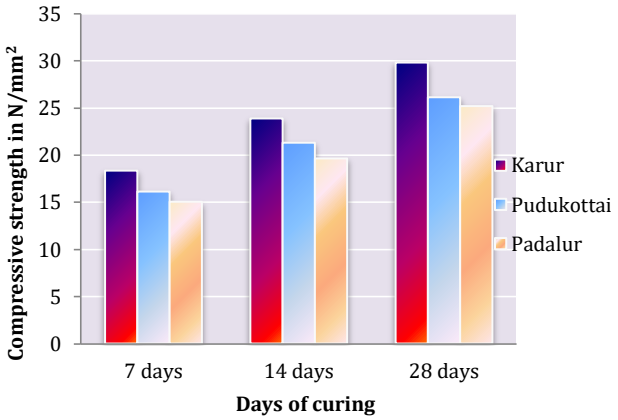

Chart -1: Compressive Strength of M-sand - Comparison

5.3 Split Tensile Strength Test

The results of Tensile Strength can be seen from Chart 2. On comparing the Tensile Strength results of Karur M-sand with that of the conventional concrete, it showed 7%, 11.9% and 12.15% higher Tensile Strength than conventional concrete during 7 days, 14 days and 28 days curing. When the conventional concrete is compared with the concrete having Pudukottai and Padalur M-sand, at the end of 28 days curing period, it possess 2.19% and 18.14% lesser Tensile Strength than that of the conventional concrete respectively.

The Split Tensile Strength of the concrete having M-sand obtained from Karur is 14.6% and 32.49% higher than that of the concrete having Pudukottai and Padalur M-sand, after 28 days of curing.

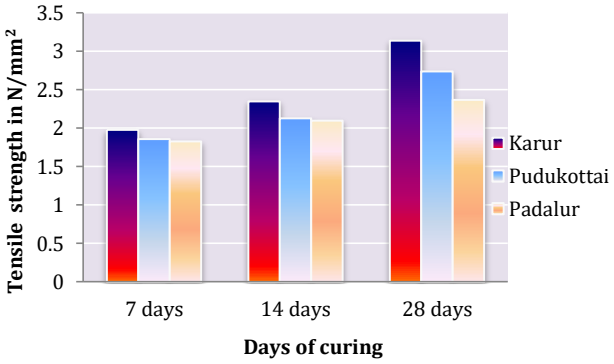

Chart -2: Split Tensile Strength of M-sand – Comparison

5.4 Flexural Strength

On comparing the results obtained, it is seen that when compared with the conventional concrete, Karur M-sand shows 3.05%, 5.15% and 8.22% increase in Flexural Strength for 7 days, 14 days and 28 days curing. Pudukottai and Padalur M-sand has 8.08% and 19.91% lesser Flexural Strength than that of the conventional concrete.

The three M-sands when compared altogether, the M-sand obtained from Karur region shows 15.07% and 26% higher Flexural Strength than the M-sand obtained from Pudukottai and Padalur during 28 days curing period. Chart 3 shows the comparison of Flexure Strength on concrete at 7days, 14 days and 28 days.

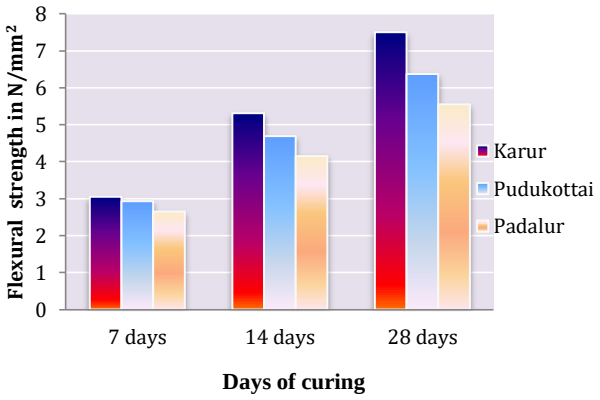

Chart -3: Flexural Strength of M-sand - Comparison

6. CONCLUSION

i. M-sand obtained from Karur region showed 12.73% and 16.61% higher Compressive Strength than the M-sand obtained from Pudukottai and Padalur during 28 days curing period.

ii. When compared with the conventional concrete, Karur M-sand showed 9.56%, 9.16% and 10.71% increase in Compressive Strength for 7 days, 14 days and 28 days curing.

iii. On comparing the Tensile Strength results of Karur M-sand concrete with the conventional concrete, it showed 7%, 11.9% and 12.15% higher Tensile Strength than conventional concrete for 7 days, 14 days and 28 days.

iv. The Split Tensile Strength of the concrete having M-sand obtained from Karur is 14.6% and 32.49% higher than that of the concrete having Pudukottai and Padalur M-sand, after 28 days of curing.

v. Karur M-sand showed 3.05%, 5.15% and 8.22% increase in Flexural Strength than the conventional concerete for 7 days, 14 days and 28 days curing. Pudukottai and Padalur M-sand has 8.08% and 19.91% lesser Flexural Strength than that of the conventional concrete.

vi. Karur M-sand concrete has 8.33% and 44.44% higher slump values than the Pudukottai and Padalur M-sand.

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