Study on the Properties of Cement Concrete Using Manufactured Sand

M.R. Lokeswaran and C. Natarajan

Abstract Fine and coarse aggregate constitute about 75 % of total volume of concrete. The most commonly used fine aggregate is natural river sand. Nowadays the demand for river sand is increasing due to its lesser availability. Sand quarrying has resulted in scarcity and poses environmental problems such as loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as affects agriculture. So there is an immediate need to control the sand quarrying and provide a sustainable replacement of river sand. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. Manufactured sand in concrete not only acts as replacement for concrete but also leads to the development of eco-friendly construction as well as reduction in cost of construction. Manufactured sand offers viable alternative to natural sand and it is purposely made fine aggregate produced by crushing and screening or further processing. This experimental investigation was performed to evaluate the grading and strength properties of M20 grade of concrete mixes, in which natural sand was replaced with manufactured sand. The properties of river sand and manufactured sand such as specific gravity, sieve analysis, fineness modulus and water absorption were determined through test as per IS 383-1970 and compared. Specimens were cast to compare the strength properties of concrete with river sand and manufactured sand as fine aggregate. Specimens for compressive strength, tensile strength and flexural strength were casted and tested up to failure to evaluate the strength properties of concrete at the age of 7 and 28 days. Test results showed that the grading of manufactured sand fall in the Zone II gradation as per the specifications provided in IS 383-1970. Test results showed that there is only a marginal decrease in compressive strength, splitting tensile strength and flexural strength for M20 concrete mixes on ages of 7 and 28 days in comparison to the river sand concrete

M.R. Lokeswaran (✉) · C. Natarajan
National Institute of Technology, Tiruchirappalli, India
e-mail: lokescivil@gmail.com

C. Natarajan
e-mail: nataraj@nitt.edu

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but the strength is more than the target mean strength for which the mix was designed. These studies reveal that the test results are in conformation with the river sand concrete and hence manufactured sand can be used as fine aggregate in concrete.

Keywords Manufactured sand · Sustainable replacement · Concrete · Fine aggregate · Strength

1 Introduction

The global consumption of natural sand is very high, due to the extensive use of concrete or mortar.

Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete and cement mortar. The most commonly used fine aggregate is natural river sand. Fine and coarse aggregate constitute about 75 % of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate forms the main matrix of concrete or mortar [1].

Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table are few examples [2, 3].

Manufactured sand offers viable alternative to natural sand and it is purpose made fine aggregate produced by crushing and screening or further processing i.e. washing, grading, classifying of quarried rock, cobbles, boulders or gravels from which natural fine aggregate had been removed [3].

Now a day's sand is becoming a very scarce material, in this situation research began for inexpensive and easily available alternative material to natural sand. Some alternatives materials have already been used as a part of natural sand e.g. fly-ash, slag limestone and siliceous stone powder are used in concrete mixtures as a partial replacement of natural sand [4, 5]. However, scarcity in required quality is the major limitation in some of the above materials. Now a day's sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly [6].

Based on review, work is carried out on strength properties of cement concrete with full replacement of natural sand by manufactures sand. Also strength of cement concrete is determined for ages of 7 and 28 days.

2 Material Properties

(i) Cement
The ordinary Portland cement was classified into three grades, namely 33 grades, 44 grades and 53 grades depending upon the strength of cement at 28 days when tested as per IS 4031-1988. If 28 days strength is not less than 53 N/mm^2, it is called 53 grade cement. In this research M20 concrete is selected for the study, 43 grade (OPC) cement has been used for this research.

(ii) Fine Aggregate
Natural river sand with fraction passing through 4.75 mm sieve and retained on 60 µm sieve is used and will be tested as per IS 2386. The sieve analysis of fine aggregates is presented in Table 1 and the grading zone is shown in Fig. 1.

(iii) Coarse aggregate
Coarse aggregates of maximum size of 20 mm we used and the physical properties will be tested as per IS 2386-1963.

Table 1 Sieve analysis of fine aggregates

IS sieve designation	River sand % passing	Manufactured sand % passing
4.75 mm	97.25	98.52
2.36 mm	94.01	77.83
1.18 mm	80.65	57.24
600 µm	61.61	47.65
300 µm	26.46	31.51
150 µm	4.32	13.37
Fineness modulus	2.35	2.63
Specific gravity	2.65	2.52

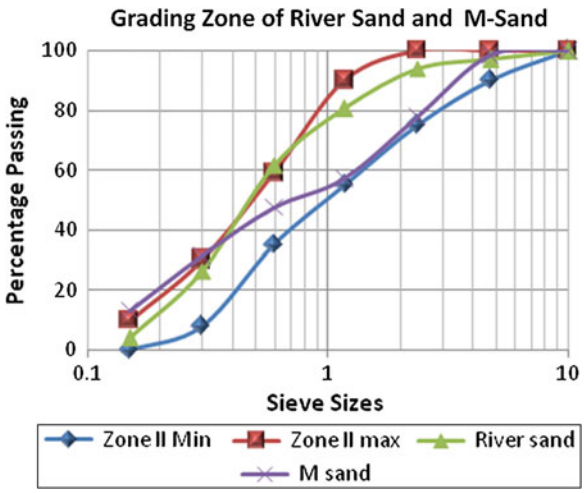


Fig. 1 Grading of fine aggregates

Table 2 Mix design ratio of concrete

Type of concrete	Cement	F.A.	C.A.	W/C
Normal concrete	1	1.660	2.90	0.5
M-sand concrete	1	1.648	2.90	0.5

3 Experimental Investigation

The mix ratio is prepared for M20 grade concrete for both conventional sand and also M-Sand. Detailed mix ratio of each grade of concrete is given in Table 2. The cube sizes of (150 × 150 × 150) mm Specimen are prepared for compressive strength. The cylinder of height 30 cm and 15 cm diameter are prepared for tensile strength. The specimens of size (100 × 100 × 500) mm are used for flexural strength test. The specimens are tested for 7 and 28 days. Totally there are 12 cubes, 12 cylinders and 12 flexural beams casted. All the specimens are de-moulded after 24 h, and curing is done in water for 7 and 28 days.

4 Results and Discussion

(a) **Compressive Strength of Concrete**
The compression test was conducted as per IS 516-1959. Compressive strength of concrete mixes made with and without manufactured sand was determined at 7 and 28 days. The test results are given in Table 3 and Fig. 2. The strength of manufactured sand concrete with respect to their compressive strength at the age of 7 and 28 days was 92 and 98 % of M20 grade when compared to same grade of conventional concrete. Therefore, the ultimate strength were taken at the peak load which was considered to represent the material strength of the manufactured sand concrete. Figure 2 shows the gradual and good increase of compressive strength of manufactured sand concrete when but marginally low strength compared to controlled concrete specimens. The variation in fine aggregate has affected the concrete to a minimal extent. Since the properties of the fine aggregate are similar to that of the river sand, the compressive strength was not influenced predominantly.

(b) **Split Tensile Strength of Concrete**
The split tensile test was conducted as per IS 516-1959. Tensile strength of concrete mixes made with and without manufactured sand was determined at 7 and 28 days. The test results are given in Table 4 and Fig. 3. The strength of manufactured sand concrete with respect to their tensile strength at the age of 7 and 28 days was 92 and 94 % of M20 grade when compared to same grade of

Table 3 Average compressive strength value

Tested on	Normal concrete	Manufactured sand concrete
7th day	19.07	17.63
28th day	31.03	30.44

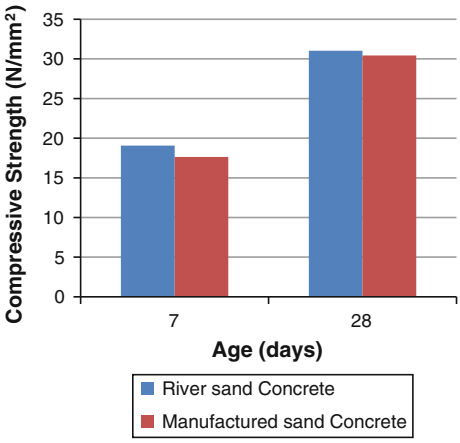


Fig. 2 Compressive strength versus age

Table 4 Average tensile strength value

Tested on	Normal concrete	Manufactured sand concrete
7th day	2.30	2.11
28th day	3.07	2.87

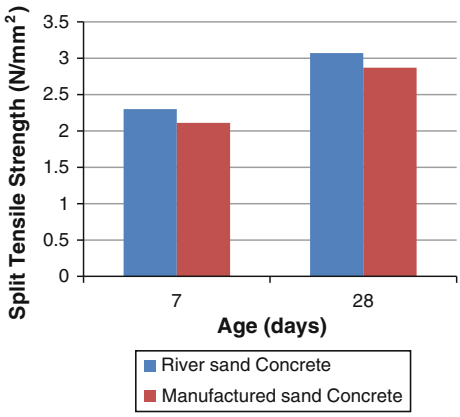


Fig. 3 Split tensile strength versus age

conventional concrete. Therefore, the ultimate strength were taken at the peak load which was considered to represent the material strength of the manufactured sand concrete. Figure 3 shows the gradual and good increase of tensile strength of manufactured sand concrete but marginally low strength when compared to controlled concrete specimens. The discussions for the behaviour of the compressive strength of the concrete with manufactured sand holds good for the results of splitting tensile strength of the concrete.

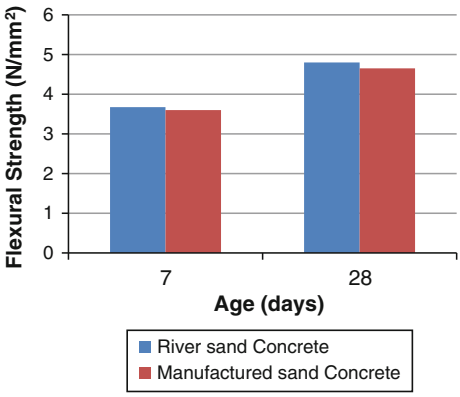
(c) **Flexural Strength of Concrete**

The flexure test was conducted as per IS 516-1959. Flexural strength of concrete mixes made with and without manufactured sand was determined at 7

Table 5 Average flexural strength value

Tested on	Normal concrete	Manufactured sand concrete
7th day	3.675	3.60
28th day	4.8	4.65

Fig. 4 Flexural strength versus age



and 28 days. The test results are given in Table 5 and Fig. 4. The strength of manufactured sand concrete with respect to their flexural strength at the age of 7 and 28 days was 98 and 97 % of M20 grade when compared to same grade of conventional concrete. Therefore, the ultimate strength were taken at the peak load which was considered to represent the material strength of the manufactured sand concrete. Figure 4 shows the gradual and good increase of flexural strength of manufactured sand concrete but marginally low strength when compared to controlled concrete specimens. The presence of more micro fines in manufactured sand is responsible for the very less decrease in flexural strength, when compared to the splitting tensile strength and compressive strength values of concrete.

5 Conclusions

- From the research following conclusions were obtained Compressive strength, Splitting tensile strength and Flexural strength of Manufactured sand concrete specimens were in conformation with the control concrete specimens at all the ages.
- The concrete containing manufactured sand had strength higher than the target mean strength, for which the mix design was made.
- The decrease in 7 days strength of concrete to the conventional concrete was more in comparison with the 28 days strength, which implies there is good increase in strength of concrete with age.

- From this experimental investigation, it was also observed that replacement of natural sand by manufactured sand will reduce the strength of concrete marginally.
- The effect of the specific gravity, grading and fineness modulus on the compressive and splitting tensile strength of concrete was considerably low, since the difference of the aggregate properties of manufactured sand was moreover similar to the river sand.
- The presence of more fines in manufactured sand gave good flexural strength results at 7 and 28 days on comparison with compressive and splitting tensile strength of concrete. But the presence of fines did not increase the flexural strength of manufactured sand concrete more than the conventional concrete.
- From the following studies, we can conclude that manufactured sand is a good alternative for river sand in concrete.

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