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# Performance Evaluation of Concrete by Replacing Natural Sand with Manufactured Sand

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**Abstract:** *In the past few decades, Infrastructure industry is growing with unprecedented rate which led to huge demand of river sand.*

*To cope this large demand mining is done at extreme level which is degrading the natural reserves of river and sand. The common River sand has become expensive due to excessive cost of transport from location of natural sources. The large scale depletions of these sources have led to ill impacts environment. In order to overcome impacts of an anthropogenic activity an alternative has to be found in order to replace sand.*

*It is a need of an hour. The manufactured sand (M-sand) has found to be economical alternative to the river sand. M-sand is obtained as a crushing of stones in required grading to be used for construction purposes as a replacement for river sand. M-sand has been used in large scale in Highways as surface finishing materials and also used in the manufacture of hollow blocks and in light weight concrete prefabricated elements.*

*In this paper study has been conducted for optimum usage of Manufactured or Artificial Sand to replacement Natural Sand in manufacturing of concrete.*

**Keywords:** *Concrete, M-Sand, Compressive strength, Artificial Sand, Environment*

## I. INTRODUCTION

Increase in demand and decrease from natural sources of fine aggregate for the production of concrete has resulted in the need to identify new source of fine aggregate.

Due to increased levels of construction expected in the forthcoming years, it is expected that fine aggregates suitable for use in concrete will become scarce or uneconomical to produce. Dwindling sand resources pose environmental problems and hence government restrictions on sand quarrying resulted in scarcity and significant increase in its cost. Sand mining from our rivers becomes objectionable.

It has now reached a stage where it is disturbing our river ecosystem of our country from total depth. With the expected shortfall in natural sands, manufactured sands offer a viable alternative to natural sand. The manufactured sand should satisfy the technical requisites like workability and strength of concrete. M-sand or manufactured sand is prepared on the quarry site by demolishing the huge parent rock into smaller sizes.

The vertical shaft impeller is the type of impact crusher which reduces the particle size of rocks smaller than 4.75mm making it suitable for use in replacement of sand for various purposes in construction. The texture and properties of M-Sand depends upon the parent rock from which it is obtained.

At the quarry site, it is washed and thus free from silt content and dust. As for the physical properties, M-Sand resembles to the natural sand except for its shape.

In the present project work, M-20 and M-30 grade concrete has been prepared by replacing the natural sand in different percentage with manufactured quarry sand. The compressive strength has been checked and result is quite promising.

## II. LITERATURE REVIEW

- A. <sup>[9]</sup>In research paper, the consumption of cement content, workability, compressive strength and cost of concrete made with Quarry Rock Dust. The mix design proposed by Nagaraj et.al shows the possibilities of ensuring the workability by wise combination of rock dust and sand, use of super plasticizer and optimum water content using generalized lysés Rule.
- B. <sup>[2]</sup>Prof. Babu K.K.et.al, Nagaraj T.S.et.al, and Narasimahan et.al. has studied “concrete mixes with artificial sand as fine aggregate gives consistently higher strength than the mixes with natural sand. The sharp edges of the particles in artificial sand provide better bond with cement than the rounded particles of natural sand resulting in higher strength. The excessive bleeding of concrete is reduced by using artificial sand.”

- C. <sup>[3]</sup>M. R. Chitlange stated that “Physical and chemical properties of quarry rock dust satisfied the requirements of code provision in properties studies. Natural river sand, if replaced by hundred percent Quarry Rock Dust from quarries, may sometimes give equal or better than the reference concrete made with Natural Sand, in terms of compressive and flexural strength studies.”
- D. <sup>[1][6]</sup>R. Ilangovana1, N. Mahendrana1 and K. Nagamanib said that “The effect of concrete with partial replacement of manufactured sand on the properties of normal strength concrete with water cement ratio of 0.45 and 28 day’s compressive, split tensile and flexural strength of 20Mpa (2900 psi) and workability (slump and compacting factor) were studied. The effect of percentage replacement of manufactured sand on strength property and workability were evaluated and compared with reference mix of 0% replacement of natural sand by manufactured sand.”
- E. <sup>[8]</sup>Priyanka A. Jadhava and Dilip K. Kulkarni said “Even though concrete with CSFA has a reduced 28 day compressive strength than river sand (Table 1), it can be adopted for construction, as the strength obtained from CSFA is considerably more than that predicted by Fig. 47 of SP: 23- 1982. Also, IS: 383- 1970 permits the use of CSFA as fine aggregate if it confirms to the requirements.”
- F. <sup>[7]</sup>P.T.Santhosh Kumar1 and K.K.Sajeevan. “In this, investigations were carried out to study the compressive strength and split tensile strength of concrete using M-sand as fine aggregate instead of river sand. And compare the results obtained from both the river sand and the M-sand. In order to achieve the strength, cement is replaced by silica fume by 15% in weight and also 1.2% weight of binder super plasticizer is added to obtain workability. The present investigations mainly focused on the M-sand properties and the strength obtained from both the river sand and m-sand. In order to solve the problem of the granite powder disposal from the industries and also to solve the raw materials shortage problem for concrete, studies are being made to utilize the M-sand in the manufacture of varieties of building and ceramics products. This investigation is also based on the comparison of the compressive strength and split tensile strength achieved by the cubes and cylinders in normal sand and M-sand.”
- G. <sup>[10]</sup>Scarcity of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is “Manufactured sand”. Though manufactured sand has been in use in concrete manufacturing in India, the percentage of its contribution is still very negligible in many parts of the country. Except in Kerala and in some pockets in Southern and Western India, real processed manufacture sand is not available and this makes manufacturing of good quality of concrete very difficult. The application of concrete meeting the specification is of paramount importance, to ensure construction of durable R.C.C. structure. Hence durable concrete covers and bears the responsibility of sustaining the entire R.C.C. structure throughout its service life. A well processed manufactured sand as partial or full replacement to river sand is the need of the hour as a long term solution in Indian concrete industry until other suitable alternative fine aggregate are developed.

### III. OBJECTIVES

This project research is carried out to serve the following objectives:

#### A. *Manufacture of Concrete*

Preparation of concrete of grade M-20 and M-30 by replacing the natural sand with manufactured quarry sand

#### B. *Compressive Strength*

Checking of compressive strength of concrete prepared by partial replacement of river sand by manufactured sand by 25% replacement from 0-100%.

#### C. *Comparison of strength*

Comparison of strength obtained in every proportion of replacement of natural sand by manufactured sand.

#### D. *Saving of Nature*

Saving the natural reserves of sand and protecting rivers from mining.

#### IV. MATERIALS

Various materials and their properties are mentioned below.

##### A. Cement

Ordinary Portland cement is used for general construction of concrete of 53 grade.

TABLE I  
CONSISTENCY OF CEMENT PASTE

Observation number	1	2	3
Weight of water added (W2) gm	108	110	116
Penetration of plunger from bottom in mm	11	09	08
% of water by weight = $W2/W1 \times 100$	27.4	28	29

##### B. Fine Aggregates

Locally available fine aggregates are used as natural sand of grading zone –II. Artificial manufactured sand is obtained from the Om Sai quarry of Chikhli.

##### C. Course Aggregates

Concrete constitutes about 70% of coarse aggregates. Coarse aggregates are obtained from locally available warehouses or from the quarry.

TABLE II  
PHYSICAL PROPERTIES OF NATURAL AND ARTIFICIAL SAND

Property	Artificial Sand	Natural Sand	Test Method
Specific Gravity	2.54-2.60	2.60	IS 2386(Part III) 1963
Bulk relative Density	1600	1460	IS 2386(Part III) 1963
Absorption (%)	1.20-1.50	Nil	IS 2386(Part III) 1963
Moisture Content (%)	Nil	Nil	IS 2386(Part III) 1963
Sieve Analysis	Zone II	Zone II	IS 383-1970

TABLE III  
SIEVE ANALYSIS RESULTS

Sample	Fineness Modulus
Coarse Aggregate (5Kg)	8.03
Artificial Sand (2Kg)	7.5
Natural Sand (2Kg)	3.07



**D. Water**

Tap water provided by Surat Municipal Corporation which was used for all concrete mix as pH value ranging from 6.2-8.2. The water-cement ratio is kept 0.45 for standard cube casting of all proportions.



Fig. 1 Artificial Manufactured Sand

**V. EXPERIMENTATION**

**A. Properties of the materials**

Cement, coarse aggregates, natural sand and manufactured sand were tested for their physical properties which are stated above. The materials tested are constituted in concrete of both M20 and M30 mixes in all the proportion of replacement of natural sand by manufactured sand in 25% increment in replacement.

**B. Manufacture of concrete**

The concrete is prepared by weighing each material according to the proportion in M-20 and M-30. Three cubes for each proportion of replacement are casted. Size of cube mould is 150mm × 150mm × 150mm.

Cubes are kept for curing of 7 days and 28 days. The temperature of water in curing tank should be 23-28°C.

The cubes are opened after its curing period and tested for the compressive strength.



Fig. 2 Concrete Cubes in Curing Tank

TABLE IV  
PROPORTIONS OF REPLACEMENT

Proportion	100% Natural Sand	75% Natural Sand 25% Manu. Sand	50% Natural Sand 50% Manu. Sand	25% Natural Sand 75% Manu. Sand	100% Manu. Sand
Compressive Strength	√	√	√	√	√

The compressive strength is to be carried out for the above proportions of replacement for both M-20 and M-30 grade of concrete as per weight batching.

## VI. RESULTS

TABLE V  
COMPRESSIVE STRENGTH

CONCRETE MIX	M-20		M-30	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
100% N	38.15	53.14	39.65	53.14
75% N – 25% M	29.62	52.10	39.22	54.50
50% N – 50% M	31.94	42.25	41.52	56.42
25% N – 75% M	33.55	45.42	43.27	56.88
100% M	40.90	55.70	45.63	59.70

N = NATURAL SAND

M = MANUFACTURED SAND

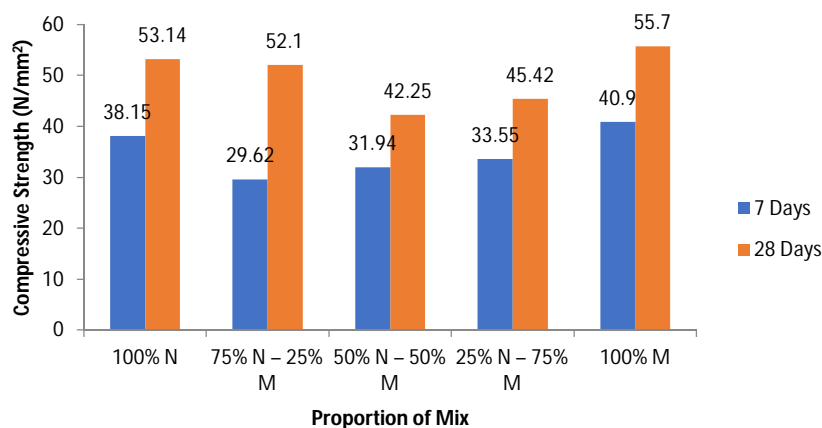


Fig. 3 Compressive strength of M-20 grade concrete

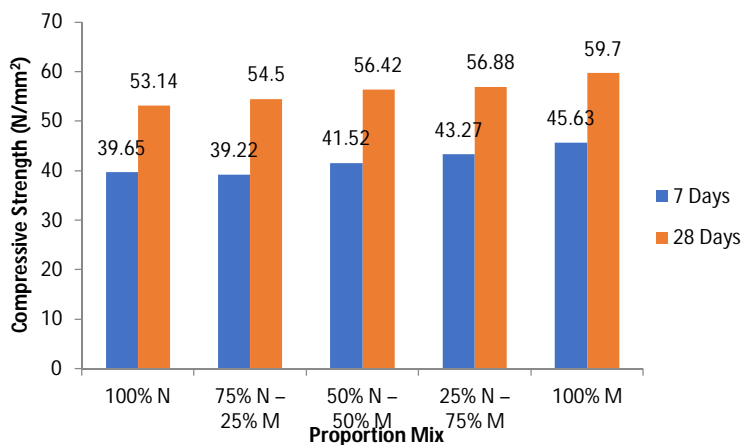


Fig. 4 Compressive strength of M-30 grade concrete

- 1) On observation of result we come to know that after 100% replacement of natural sand with M-Sand, the strength of concrete becomes greater than the concrete prepared with natural sand in the proportion of M-20.
- 2) Also we see that the strength of concrete prepared from M-sand remains lesser than the concrete prepared by natural sand.
- 3) This result is observed due to the composition of materials in concrete, if the proportion is 1:1.5:3 i.e. ratio of M-sand is more as compared to the cement, it shows positive result on complete replacement, and if the ratio is 1:0.75:1.5 i.e. ratio of cement is less as compared to cement, the result is negative.
- 4) The gradation of manufactured sand and River Sand is done and gradation chart is prepared which satisfies the gradation zone II for manufactured sand making it perfectly suitable for use in construction industry as and where natural sand is used.

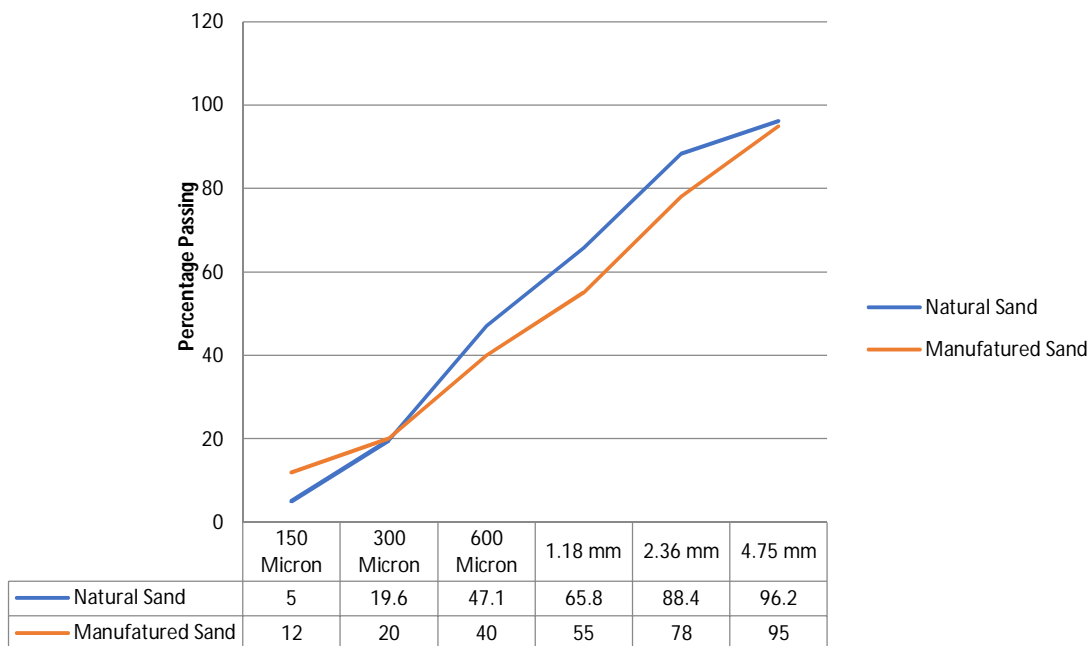


Fig. 5 Sieve Analysis of Natural and Manufactured Sand

### VII. CONCLUSION

As per above results we conclude that Manufactured Sand can be utilised to replace the Natural Sand for the manufacture of Concrete.

Partial replacement by manufactured sand gives positive results but not as much as complete replacement.

Complete replacement of natural sand by manufactured sand can be adopted for construction practices. Concrete prepared by manufactured sand shows more compressive strength.

We have been successful in proving the potentiality of Manufacture Artificial Sand for the construction purposes and the usage of this sand is already been done in various industries in Bangalore, Chennai, Mumbai and Pune.

The Optimum replacement ratio of natural sand by manufactured sand is 100%

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