

# Effect of Replacement of Manufactured sand with Natural Sand on Compressive Strength & Workability of Concrete – A Review

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**Abstract**— There is a great demand of both coarse & fine aggregates for the construction of concrete structures day by day. But Availability of natural sand is limited due to limited resources. The Government contemplating ban on dredging of River beds to quarry river sand, as part of the growing concern for environment protection. For Infrastructure development of country construction work could not be stopped. So an alternate of natural sand is necessarily required in concrete constructions. Artificial sand or manufactured sand has found excellent substitute of natural sand. Manufactured sand shows greater durability, high strength, greater workability, economic and Eco friendly. In this paper review has been done on “Effect on compressive strength with replacement of manufactured sand with natural sand in concrete”.

**Keywords:** Natural Sand, River Sand, Manufactured Sand, Compressive Strength, Workability

## I. INTRODUCTION

Concrete is the most widely material of construction all over the world. A huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced by using natural sand obtained from the riverbeds as fine aggregate. One of the important ingredients of conventional concrete is natural sand or river sand, which is scarce and expensive. However, due to the increased use of concrete in almost all types of construction works, the demand of natural or river sand has increased tremendously over the years. To meet this demand of construction industry, excessive quarrying of sand from river beds is taking place causing the depletion of sand resources. The scarcity of natural sand due to such heavy demands in growing construction activities have forced to find the suitable alternative. One of the cheapest and the easiest ways of getting substitute for natural sand is by crushing natural stone to get artificial or manufactured sand of desired size and grade. The promotional use of manufactured sand will conserve the natural resources for the sustainable development of the concrete in construction industry. Manufactured sand is a process controlled crushed fine aggregate produced from quarried stone by crushing and classification to obtain a controlled graded product that completely passes the 4.75 mm sieve. Manufactured sand generally contain more angular particles with rough surface textures and flatter face than natural sand that are more rounded as a result of weathering. Over the time some investigations have shown that angular particles, rough surface of artificial sand influences the workability and finish ability in fresh concrete. The manufactured sand has to satisfy the technical requisites such as workability, strength and durability of concrete and hence it has become necessary to study these properties in order to check the suitability and appropriate replacement level of artificial

sand in comparison with the natural sand for producing concretes in an economical way.

## II. EFFECT OF REPLACEMENT OF MANUFACTURED SAND WITH NATURAL SAND ON COMPRESSIVE STRENGTH (LITERATURE REVIEW)

Sahu, A. K. (2003) showed that there is an increase in compressive strength, modulus of rupture and split tensile strength by replacing natural sand with stone waste with 20 and 40 percent as fine aggregate.

Villanovan et al. (2006) studied the strength and behaviour of concrete by using crushed rock dust as fine aggregate. They investigated the possibility of using crushed rock as 100% replacement for sand with varying compacting factors.

Suitability of Crushed sand to replace river sand in concrete production was also investigated Manaseeh Joel (2010). Slump, compressive and indirect tensile strength tests were performed on fresh and hardened concrete. Twenty eight days peak compressive and indirect tensile strength values of 40.70 N/mm<sup>2</sup> and 2.30 N/mm<sup>2</sup> respectively were obtained with the partial replacement of river sand with 20% crush sand, as against values of 35.00 N/mm<sup>2</sup> and 1.75 N/mm<sup>2</sup> obtained with the use of river sand as fine aggregate.

M. R. Chitlange (2010) showed that mixes with manufactured 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 manufactured sand.

Vinayak R. Supekar & Popat D. Kumbhar (2012) experimentally studied the strength of concrete cubes and workability of concrete by replacing the natural sand with manufactured sand by 20%, 40%, 60% and 100%. The results have shown that the natural sand can be replaced with the manufactured sand upto a maximum replacement level of 60% in order to produce concrete of satisfactory strength. The results have also indicated that concrete slab panels showed minimum area of cracks on its surfaces thus improving the durability property.

% replacement of natural sand by manufactured sand	0	20	40	60	80	100
Area of crack						
Compressive strength (N/mm <sup>2</sup> )	23.48	27.12	31.38	35.16	33.28	33.27

Table 1: Comp. St. for different % replacement of natural sand by manufactured sand

% replacement of natural sand by artificial sand	Workability Tests		
	Slump (mm)	Compaction factor	Flow (%)
0	40	0.91	27.16
20	48	0.92	25.70
40	50	0.90	9.32
60	56	0.90	11.33
80	54	0.90	7.68
100	45	0.87	9.12

Table 2: Workability values of Concrete for different % replacement of natural sand

Rajendra P. Mogre & Dhananjay K. Parbat (2013) have made a comparable test results of compression, flexural and split tensile strength of concrete by replacing natural sand by 0%, 20%, 40%, 60%, 65%, 70%, 75%, 80% and 100% by manufactured sand for M20, M25, M30, M35 and M40 grades of concrete. It has been observed that optimum replacement of natural sand by manufactured sand is 65%. There has been consistent increase in strength of concrete by replacing natural sand with manufactured sand up to 65%. It has been observed that the percentage increase in strength is maximum for M20 grade and gradually reducing for M40 grade. It has been seen that the sharp edges of particle in manufactured sand provide better bond is cement than natural sand. The cost of manufactured sand is less than that of natural sand. Hence manufactured sand can be recommended to competitive alternative to natural sand.

P Daisy Angelin and P Ravi Kishore (2015) discussed the properties of concrete such as workability and compressive strength of concrete which is prepared by replacing natural sand with manufactured sand at different replacement levels (0%, 20%, 40%, 60%, 80% and 100%). The results have predicted that replacement of natural sand with manufactured sand in order of 60% will produce concrete of satisfactory workability and compressive strength. Durability of the concrete is also tested by immersing the cubes in 5% hydrochloric acid solution. The specimens are studied for M20 & M30 grades of concrete for replacement of natural sand with manufactured sand when immersed in hydrochloric acid, the strength results of the specimens that are immersed in hydrochloric acid solution is found out.

Pradip S. Ingale & Neelam S. Kawade (2016) have found that replacement of manufactured sand proves economical in the construction and it is the best substitute for natural sand. But it has been found that maximum replacement of artificial sand causes some structural problems such as cracks, workability and permeability. Manufactured sand has not fulfilled the few properties of natural sand so that they have decided to replace optimum percent of manufactured sand with natural sand. As per the experimental study, the replacement of 65-70% of manufactured sand has given excellent results such as compressive, flexural and split tensile strengths. Mix design has been done for M25 grade concrete as per Indian Standard for the conventional concrete. Test has been conducted and compared with natural sand. It has been found that compressive and flexural strengths of manufactured sand is more than natural sand. So,

replacement of natural sand gives a proper solution over scarcity of natural sand and also helps in making eco-balance.

K. Srinivas Reddy (2016) has also studied the effect of partial replacement of natural sand by manufactured sand on the compressive strength of cement concrete of grade M25 (1:1.4:2.88 –Design mix) with water cement ratio as 0.44. Results have been compared with reference mix of 0% replacement of natural sand by manufactured sand. The compressive strength of cement concrete with 20%, 40% and 60% replacement of natural sand by manufactured sand has revealed higher strength as compared to reference mix. The overall strength of concrete increased linearly for 0%, 20%, 40% and 60% replacement of natural sand by linearly sand as compared with reference mix. Manufactured sand has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance. Non-availability of natural sand at reasonable cost, forces to search for alternative fine aggregate. Artificial sand has qualified itself as suitable substitute for river sand at reasonable cost. The manufactured sand has been found to have good gradation and better bonding compared to natural sand.

Prasanna K and Anandh K S (2017) conducted experiments on M60 grade concrete with fine aggregate replacement in proportion of 0%, 25%, 50%, 75% and 100%. The properties such as compressive & split tensile strengths and ultrasonic pulse velocity are determined from cubes and cylinders cast with manufactured sand procured from kundrathur and river sand taken from Araniar basin. The replacement of 75% natural sand by manufactured sand recommended as this proportion gave comparatively better results in special concrete such as high performance concrete. Hence the manufactured can be used in high performance concrete without any doubt which will also improve the environment as well as sustainability of construction industry.

Rameshwar S. Ingalkar and Shrikant M. Harle (2017) have performed a experimental studies on various operational parameters like workability, compressive and tensile strengths of concrete with manufactured sand as replacement to the natural sand. The concrete with manufactured sand performed better than concrete with natural sand as the property of manufactured crush sand is better than that of natural sand. It has been concluded that different manufactured sand gives different results for compressive strength depending on different quarries and at 40% to 50% replacement of manufactured sand, maximum compressive strength is obtained. The maximum tensile strength of concrete has been obtained at 60% and 70% replacement of natural sand with manufactured sand.

Kiran. M. Mane, Dr. Dilip. K. Kulkarni and Abhishek. A. Joshi (2017) systematically studied the effect of percentage replacement of manufactured sand by natural sand as 0%, 20%, 40%, 60%, 80% and 100% on workability and strength characteristics such as compressive & shear strengths of M30 grade of concrete with 0.45 water cement ratio. It has been observed that replacement of natural sand by 60% manufactured sand, resulted in producing the concrete of higher shear and compressive strengths as

compared to reference mix. The replacement of natural sand with manufactured sand would help in conserving the natural resources of sand and maintain the ecological balance of the nature.

K Shyam Prakash<sup>1</sup> and Dr Ch Hanumantha Rao (2017) has observed that strength characteristics of quarry dust was same as sand. The chemical composition of quarry dust and sand possess that the strength property remained constant for both the materials. The silica percentage was above 80% which gave the high strength as same as sand. The specific gravity and sieve analysis result shows that the quarry dust can be used as alternative to sand. The specific gravity of all the crusher samples lies between 2 to 2.7. From the experimental studies, it has been concluded that the quarry dust can be used as a substitute for sand. It has been shown that 40% replacement of sand by quarry dust gave good result in strength than normal concrete for M20 and M30 grades. The results showed that 40% replacement of sand by the quarry dust induced higher compressive strength and the workability of concrete decreases as replacement increases.

M. N. Bajad & Sarang Sakhare (2018) experimentally studied the properties of concrete and mortar by replacing the 100% natural sand with manufactured sand. The results have shown that the natural sand can be replaced with the manufactured sand to produce concrete and mortar of satisfactory strength and durability. Compressive strength of concretes with manufactured sand is 6.5 – 9% higher when compared to the results using natural sand. Use of manufactured sand exhibits 12 – 15% higher flexural strength in comparison to the results of concrete with natural sand. The bond strength is found to be slightly more in case of concrete with manufactured sand. Water retentivity of mortar by using manufactured sand was found to be improved by 11.9%. Resistance to penetration of water as proved by rapid chloride penetration test is increased with manufactured sand in concrete. Concrete with natural sand gave higher slump value. Usage of manufactured sand reduced the cost of concrete.

### III. CONCLUSIONS

Literature surveys of journal articles published between 2010 and 2018 yields that studies vary in scope and level of analysis, yet with consistently good results have been observed. A review of different experimental studies performed by various researchers has been carried out to examine workability and compressive strength of concrete with manufactured sand as replacement to the natural sand. The data assembled during the course of investigation leads to the following conclusions;

- The concrete with manufactured sand performed better than concrete with natural sand as the grade of concrete mix increases.
- The flexural strength of concrete with manufactured sand increased marginally of the strength of concrete with natural sand.
- The percentage increase in strength with replacement of natural sand by manufactured sand was more for lower grade of concrete and gradually reducing for higher grades of concrete.

- Most of the test results from above research papers show that replacement of natural sand by manufactured sand by 60-75% gives optimum result for compressive strength.
- The workability of concrete cast with manufactured sand was lesser than that with natural sand. The round shape and smooth surface texture of natural sand reduces the inter particle friction in the fine aggregate component so that the workability is higher in natural sand. Manufactured sand particles are angular in shape and their rough surface texture improves the internal friction in the mix. Because of that the workability is reduced.
- Manufactured sand is free from chemical impurities such as sulphates and chlorides which improves the properties of concrete like strength and durability. Manufactured sand contains no organic impurities; hence it gives increased strength of concrete with same cement content and does not harm the environment in any way. No wastage since sand is already sieved in the required size (below 4.75 mm).
- Manufactured sand is economical as compared to natural river sand.

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