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Effect of Replacement of Natural Sand by Manufactured Sand on the Properties of Concrete

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***Abstract*: There is a need to identify suitable alternative material from industrial waste in place of river sand. The utilization of quarry dust which is a waste material has been accepted as building material in many countries for the past three decades. The effect of w/c ratio on hardened properties of ordinary concrete with partial replacement of natural sand by manufactured sand is investigated. Designed Concrete mix with w/c ratio of 0.5 of grade M-25 is used in experimental study. Concrete cube specimens are tested for evaluation of compressive strength. The concrete exhibits excellent strength with 60% replacement of natural sand by manufactured sand. This project will help to find viable solution to the declining availability of natural sand to make eco-balance.**

***Keywords*: Cement, Fine aggregate, Course aggregate, M-sand and Compressive strength, split tensile strength.**

1. Introduction

It is generally known that the fundamental requirement for making concrete structures is to produce good quality concrete. Good quality concrete is produced by carefully mixing cement, water, fine and coarse aggregates and combining admixtures as needed to obtain the optimum product in quality and economy for any use. Good concrete, whether plain, reinforced or pre-stressed, should be strong enough to carry superimposed loads during its anticipated life. Other essential properties include impermeability, durability, minimum amount of shrinkage and cracking.

Although good concrete costs little more than poor concrete, its performance is vastly superior. The quality of good concrete is dependent mainly on the quality of its constituent materials. It is a known fact that concrete making aggregates constitute the large share of the total volume of concrete. In addition, unlike water and cement, which do not alter in any particular characteristic except in the quantity, in which they are used. The aggregate component is infinitely variable in terms of shape and grading. These shows the importance of the care that should be taken in processing and supplying aggregates for concrete production.

In addition to quality, one extremely important factor in concrete production is consistent supply of the coarse and fine aggregates. In this regard, coarse aggregate is produced by crushing basaltic stone, and river sand is the major natural resource of fine aggregate in our country. However, the intensive construction activity is resulting in a growing shortage and price increase of the natural sand in the country. In addition, the aggregate and concrete industries are presently facing a growing public awareness related to the environmental influence of their activities. The environmental impact is attributed to the non-renewable character of the natural resources, the environmental impact on neighborhood, land use conflicts, high energy consumption needed for aggregate production and the potential environmental or health impact of materials produced due to leaching of heavy metals, radioactivity and to special mineral suspects to have hazardous health effects. Therefore, due to the above-mentioned facts, looking for viable alternatives to natural sand is a must. One possible alternative material that can be used as a replacement for natural sand is the use of manufactured sand. Due to the forecast shortfall in the supply of natural sands and the increased activity in the construction sector, it is apparent that time will come, when manufactured sand may play a significant role as an ingredient in concrete production.

In the experimental study different concrete mixes with various percentages of natural and manufactured sands are prepared and the respective fresh and hardened properties of the resulting concrete mixes are determined and analyzed.

2. Objectives of the study

- To provide background information on use of manufactured sand in concrete.
- To check the suitability of manufactured sand in concrete.
- To study the influence of manufactured sand on the compression and tensile strength of concrete.
- To determine optimum percentage of replacement of manufactured sand.
- To compare strength of concrete with natural sand and concrete with manufactured sand.
- To make our structure in an economical cost without compromising the strength.

3. Study about M-sand

- The term-manufactured sand is used for aggregate materials having dimensions less than 5.0mm that are processed from crushed rock or gravel and intended for construction use. The term sand refers to relatively small particles and there are some variations of sand with regard to particle size.
- The use of manufactured sand in concrete has been known since the Roman time. In modern technology, natural sand has proved to be significantly economical in use, for which reason extensive use of manufactured sand has been concentrated to regions or projects where the availability of natural sand has been limited. The growing problem of surplus fines from hard rock quarries has, however, in recent times encouraged a development towards more use of manufactured sand in many populated areas, and for several concrete applications.

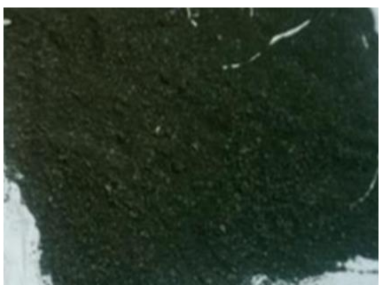

Fig. 1. Manufactured sand

- The advantage of manufactured sand is quarries can be kept in the near vicinity to its place of end use, therefore shortening transport distances, and increased employment opportunities for the locals.

Table 1
Comparison between natural sand & manufactured sand

River Sand	Manufactured Sand
Naturally available on river banks	Manufactured in factory
Smoother texture with better shape	Angular shape and has rougher texture
Demands less water	Angular aggregates demand more water. Water demand can be compensated with cement content
Moisture is trapped in between the particles which is good for concrete purposes	Moisture is available only in water washed M Sand
1 - 2% marine products like sea shells, tree barks etc.	0% marine products
Recommended for RCC, plastering and brick/ block work.	Highly recommended for RCC purposes and brick/ block works
No control over quality since it is naturally occurring. Same river bed sand can have differences in silt contents.	Better quality control since manufactured in a controlled environment

4. Materials

A. *Cement*

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. The commonly used cement is Portland cement. The specific gravity of Portland cement was 3.15. The ordinary Portland cement of 53grade manufactured by the Ultratech Cement Company was used in the study.

B. *Fine Aggregate*

Those particles passing the 4.75 mm sieve, and predominantly retained on the 75 µm sieve are called fine aggregate. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. The result of sieve analysis confirms to zone-II (according to IS: 383-1970). The specific gravity of sand was found to be 2.56.

C. *Coarse Aggregate*

Those particles that are predominantly retained on the 4.75 mm sieve and will pass through 3-inch screen are called coarse aggregate. The coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area. Size of coarse aggregate used in the investigation was 10mm. The specific gravity of the coarse aggregate was found to be 2.89.

D. *Water*

Water is a key ingredient in the manufacture of concrete. Water used in concrete mixes has two functions: the first is to react chemically with the cement, which will finally set and harden, and the second function is to lubricate all other materials and make the concrete workable. One of the most common causes of poor-quality concrete is the use of too much mixing water. Water for making concrete should have pH between 6 and 8. Locally available drinking water was used in this work.

E. *M-Sand*

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm.

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed

Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

5. Material testing

A. *Sieve analysis*

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

Table 2
Sieve analysis: comparison of river & manufactured sand

IS Sieve	% of passing (CA)	% of passing (Natural Sand)	% of passing (Manufactured Sand)	Zone II (As per IS:383)
20 mm	70.4	-	-	
10 mm	4	-	-	
4.75 mm	0	96	100	90-100
2.36 mm	0	89	85.9	75-100
1.18 mm	0	70.6	61.4	55-90
600 micron	0	23.1	35.6	35-59
300 micron	0	5.3	20.7	8-30
150 micron	0	0.9	4.9	0-20
Pan	0	0	0	Max 15
		Zone II	Zone II	

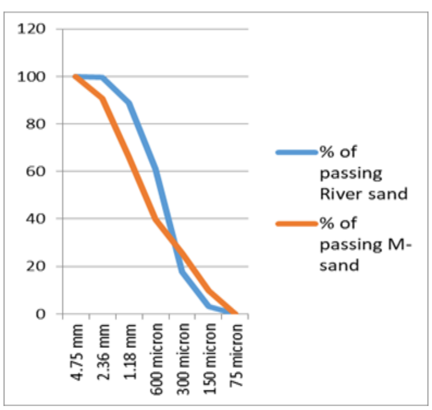

Fig. 2. Chart: Comparison of river & manufactured sand

Table 3
Specific gravity

S. No.	Description	CA	FA	M-Sand
1	Wt. of empty bottle	668	668	668
2	Wt. of bottle+ Dry sand	1173	1169	1171
3	Wt. of bottle+ Dry sand+ Water	1887	1862	1862
4	Wt. of bottle+ Water	1557	1557	1557
Specific Gravity		2.89	2.56	2.54

Table 4
Bulk density

S. No.	Description	CA	FA	M-Sand
1	Wt. of empty mould	14634	14634	14634
2	Wt. of mould + Dry sand	20255	20325	19564
Bulk Density		1665	1686	1461

6. Results and discussions

A. *Slump Test*

The slump cone apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:
Bottom diameter: 20 cm
Top diameter: 10 cm
Height: 30 cm

The bottom and top ends of the mould are open, parallel to each other and right angles to the axis of cone. The thickness of metallic sheet for the mould should not be less than 1.6 mm. The mould is provided with suitable guides for lifting vertically up. For tamping the concrete, a steel tamping rod of 16 mm diameter, 0.6 m length with bullet end is used.

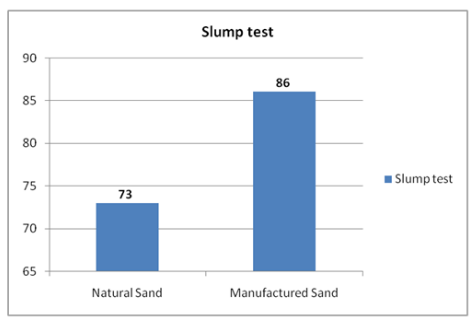

Fig. 3. Result of slump test

B. *Compressive strength*

Fig. 4. Compression test

Compression test is the most common test conducted on hardened concrete, partly because it is very easy and simple to perform and partly because many of the desirable properties of concrete are qualitatively related to its compressive strength. The size of standard cube specimen is 150 mm x 150 mm x 150 mm. Sometimes, the test is made on cylinder of size 150 mm diameter and 300 mm height.

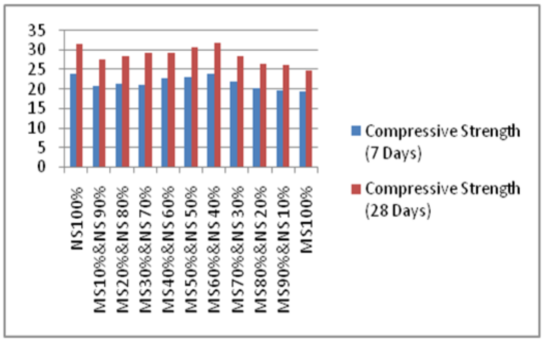

Fig. 5. Comparison of compressive strength

C. Split tensile strength

Split cylinder test is an indirect method of applying tension in the form of splitting. A concrete cylinder of size 150 mm diameter and 300 mm height is subjected to the action of compressive force along two opposite edges. The cylinder is placed with its axis horizontal between the platens of testing machine, and the load is increased until failure by splitting along the vertical diameter takes place. By applying force in this manner, the cylinder is subjected to compression near the loaded region and the larger portion corresponding to depth is subjected to a uniform tensile stress acting horizontally.

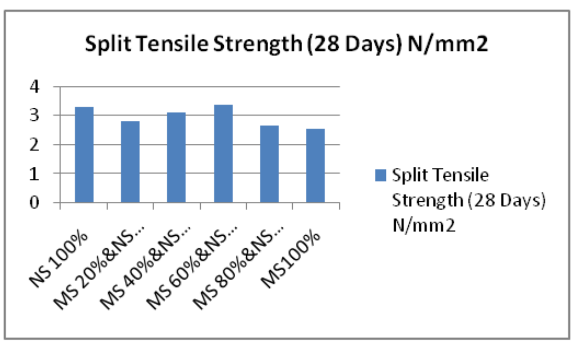

Fig. 6. Comparison of split tensile strength

D. Water absorption test

This test is used to determine the rate of absorption of water by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time. Water absorption can be linked to porosity and therefore to eventual deterioration. Water absorption is strongly affected by environmental temperature and concrete moisture content. These different conditions may cause incorrect evaluation of concrete performance.

Table 5
Compressive strength comparisons

Mix Type	Compressive Strength (7 Days) N/mm^2	Compressive Strength (28 Days) N/mm^2
NS100%	23.88	31.48
MS10%&NS 90%	20.69	27.58
MS20%&NS 80%	21.48	28.59
MS30%&NS 70%	21.02	29.44
MS40%&NS 60%	22.64	29.20
MS50%&NS 50%	23.04	30.73
MS60%&NS 40%	23.89	31.83
MS70%&NS 30%	22.03	28.33
MS80%&NS 20%	20.13	26.41
MS90%&NS 10%	19.56	26.04
MS100%	19.31	24.78

Table 6
Split tensile strength comparisons

Mix Type	Split Tensile Strength (28 Days) N/mm^2
NS 100%	3.29
MS 20%&NS 80%	2.79
MS 40%&NS 60%	3.09
MS 60%&NS 40%	3.36
MS 80%&NS 20%	2.65
MS100%	2.55

Table 7
Water absorption comparison

Mix Type	Water Absorption (gm)
NS100%	359
MS10%&NS 90%	392
MS20%&NS 80%	398
MS30%&NS 70%	410
MS40%&NS 60%	418
MS50%&NS 50%	438
MS60%&NS 40%	445
MS70%&NS 30%	464
MS80%&NS 20%	489
MS90%&NS 10%	508
MS100%	521

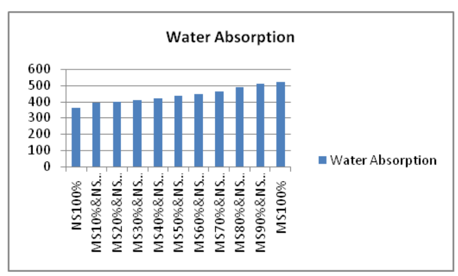

Fig. 7. Comparison of water absorption

7. Conclusion

- From experimental results it is observed that M-sand can be used as partial replacement for the natural sand and the compressive strength increases up to 60% of M-sand and afterwards compressive strength decreases.
- From experimental results it is observed that M-sand can be used as 60% replacement for the natural sand.

- The dwindling source of natural sand and its high cost could encourage the adoption of M-sand by partial replacement of natural sand.
- The compressive strength of concrete with natural sand 40% and M-sand 60% is 29.83 N/mm2, when the Split tensile strength is 3.36 N/mm2 for 28 days.
- Water absorption for optimum proportion (60%) is 445 gm.

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