Influence of Manufactured Sand on Mechanical Properties of Self Compacting Concrete

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Abstract - This experimental work aims to investigate the effect of manufactured sand on mechanical behavior of self-compacting concrete. In the present study, natural river sand has been replaced by manufactured sand for fine aggregates, in the percentages of 0, 25, 50, 75, and 100. A total of 54 cubical specimen measuring 0.15 x 0.15 x 0.15 meters, 45 cylindrical specimen measuring 0.15 x 0.15 x 0.3 meters and 20 prism specimen measuring 0.5 x 0.1 x 0.1 meters were cast respectively to study the compressive, tensile and flexural strength of the self – compacting concrete after a curing period of 7, 14 and 28 days. It was observed that the addition of manufactured sand enhanced the mechanical properties of self-compacting concrete.

Index Terms – Self-compacting concrete, Self-consolidating concrete, Artificial sand, Manufactured Sand, M-sand.

I. INTRODUCTION

Self-compacting also known as self-consolidating concrete, is a concept that was proposed by Prof. Okamura at Ouchi University – Japan, in 1986. During that time skilled labor was in a limited supply, and this caused major setbacks in the construction industry. Self-compacting concrete was designed to flow under its own weight, thus eliminating the need for external compaction using vibrators, especially in structures where heavy reinforcements were provided to handle the loads coming on them. Heavy structures require provision of heavy reinforcement and concrete with medium to high strength. The self-compacting concrete met these requirements at the time when the construction industry was suffering with shortage in skilled labor.

The construction industry is continuously facing challenges of depleting resources and increasing carbon emissions. Sustainable development and use of alternative building materials to replace the conventional materials used in concrete, is the need of the hour, to meet these challenges. Manufactured-sand, is one such material, which has been allowed as a replacement to natural river sand by Bureau of Indian Standards (IS 383:1970), to be utilized in concrete as fine aggregates. Manufactured-sand is much more angular and has cubical shaped particles when compared to that in the natural river sand. Angular shape of these fine aggregate particles, leads to improved strength, when used in concrete, due to better internal interlocking of particles.

Fig. 1 Manufactured Sand

II. RESEARCH OBJECTIVES

The main object of this experimental process is to study the rheological and mechanical behavior of self – compacting concrete using manufactured-sand.

1. To design self-compacting concrete with manufactured – sand, for a target strength of M40, using Nan-Su et al. method.
2. To study, investigate and understand the mechanical behavior of the designed concrete viz. compressive, tensile and flexural strength.

III. METHODOLOGY OF THE STUDY

A. Materials used

Cement – Ordinary Portland cement(OPC), of 53 grade was used in the manufacture of concrete. Cement is an integral part of the concrete composite that imparts the binding property to the concrete. Cement is a highly reactive material and is known for the hydration process when added with water. The addition of cement imparts strength to the concrete. The water to cement ration in the concrete greatly effects the strength of the concrete.

Aggregates –
Fine Aggregate – Natural river sand was replaced in percentages by manufactured-sand obtained from quarries, with particles passing through an IS sieve of 4.75 mm were used as fine aggregates in the present investigation.
Course Aggregate – Angular granite stone particles passing through 20mm IS sieve but retained on 4.75mm IS sieve were used as coarse aggregate in the present study.

Water – Water helps in the process of hydration and is an inevitable ingredient in the concrete. Water also has an important role during curing and helps concrete in the strength gain. In this present study, potable water of drinking quality has been used, both for mixing as well as curing.

Mineral Admixture – Ground Granulated Blast Furnace Slag (GGBS)
Chemical Admixture – Super Plasticizer Glenium B233.

B. Material properties and results.

Table 1. Ordinary Portland cement

PROPERTY	RESULTS
Specific gravity of cement	3.15
Normal consistency of cement	33%

Table 2. Natural River sand

PROPERTY	RESULTS
Specific gravity of river sand	2.784
Water absorption of river sand	1.13%
Fineness modulus of river sand	3.42

Table 3. Manufactured sand

PROPERTY	RESULTS
Specific gravity of M sand	2.41
Water absorption of M sand	2%
Fineness modulus of M sand	3.013

Table 4. Properties of coarse aggregate

PROPERTY	RESULTS
Specific gravity of CA	2.54
Water absorption of CA	1.02%

Table 5. Properties of GGBS

PROPERTY	RESULTS
Specific gravity	2.4

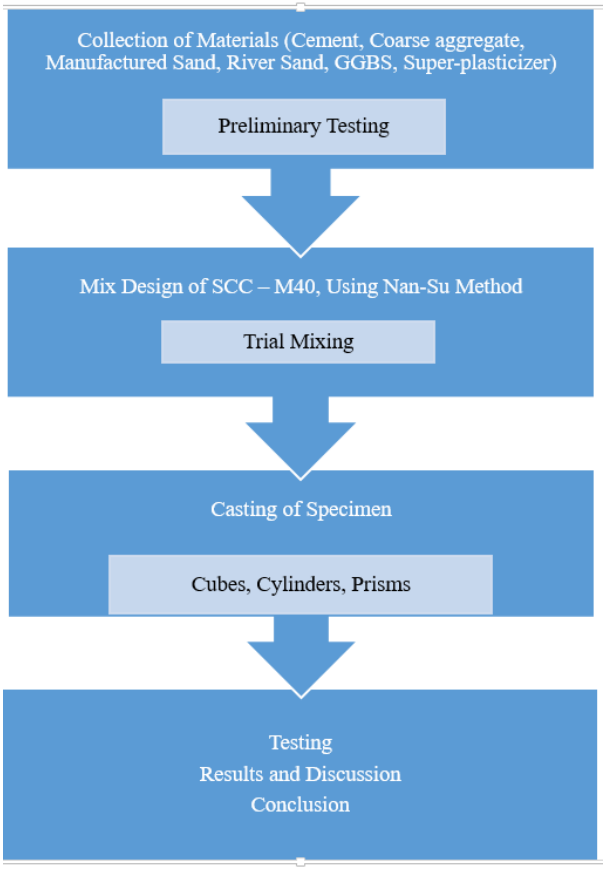

Fig. 2 Experimental set up

IV. MIX DESIGN OF SELF-COMPACTING CONCRETE

- Design of self-compacting concrete for target strength of M40.
- Casting of concrete beams and cubes and cylinders and finding the mechanical properties of SCC.
- In the trial mixes, natural river sand was partially replaced in percentages of 0,25,50,75 and 100, by manufactured-sand.
- A total of 54 numbers of cubical specimen measuring 0.15 x 0.15 x 0.15 mt were casted for each percentage of replacement of M-sand.
- 45 numbers of cylinders of size 0.30 x 0.15 mt were casted for each percentage of replacement of M-sand.
- 20 numbers of prisms of size 0.50 x 0.10 x 0.10 mt were casted for each percentage of replacement of M-sand.
- All the cubes, cylinders and prisms are tested on 7^{th}, 14^{th} and 28^{th} day for compression, tension and flexure.

Fig. 3 Casting of Specimen

V. RESULTS AND DISCUSSIONS

A. Tests on Fresh Concrete:

After conducting the tests on fresh concrete as per EFNARC-2005, it was found that the designed concrete met the requirements, as specified in the guidelines.

Table 6. Fresh Properties of Self-Compacting concrete

Sl. No.	Test	Obtained value
1.	Slump Test	620 mm
2.	L-Box Test	0.7
3.	V-Funnel	9 Sec

B. Compressive strength:

Addition of manufactured sand brings down the flowing ability of the self-compacting concrete but has been observed to increase its compressive strength.

Compressive tests were carried out in the laboratory, using compression testing machine on cubical specimens that measured 0.15 x 0.15 x 0.15 mt, on 7th, 14th and 28th day. The data obtained from the test conducted, showed a steady increase in the compressive strength of cubical specimen, as the percentage replacement of manufactured sand was increased.

Fig 4. Testing of cubical specimen in the laboratory under the compression machine

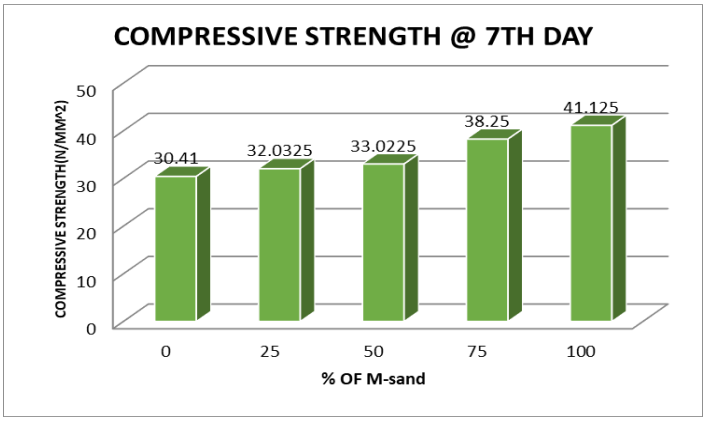

Fig 5. Compressive strength result on 7th day

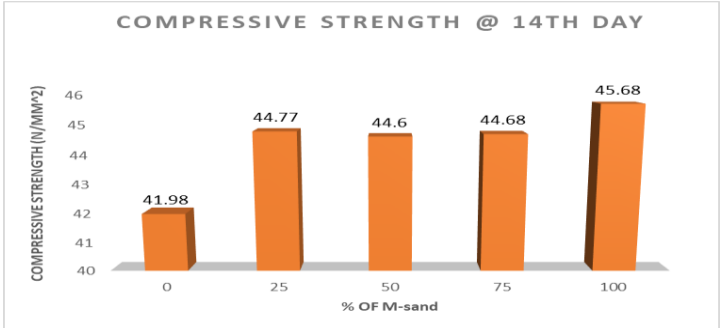

Fig 6. Compressive strength result on 14th day

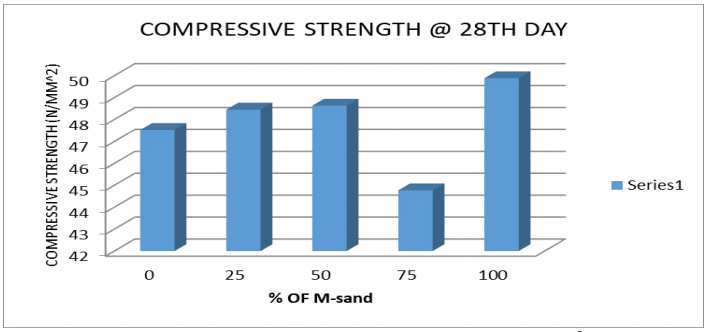

Fig 7. Compressive strength result on 28th day

C. Tensile strength:

Split Tensile strength test was conducted in the laboratory on cylindrical specimens measuring 0.15 x 0.15 x 0.30 mt, using compression testing machine. It is known that, concrete is strong in compression but shows weak behavior in tension. The present study showed that the tensile strength of concrete increased steadily with increase in percentages of manufactured-sand.

Fig 8. Testing of cylindrical specimen in the laboratory under compression testing machine

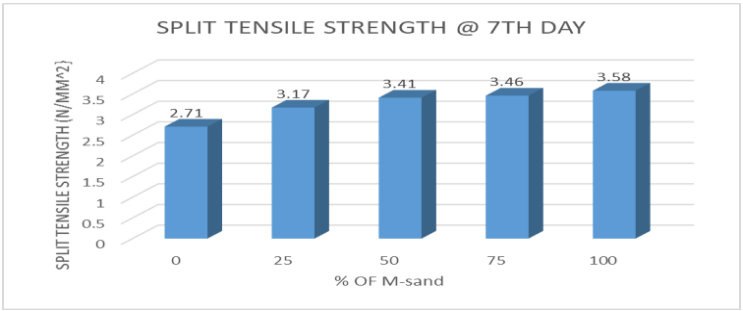

Fig 9. Split tensile strength test result on 7th day

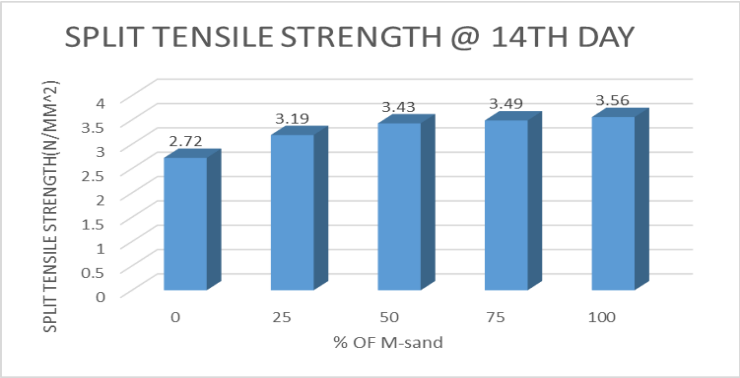

Fig 10. Split tensile strength test result on 14th day

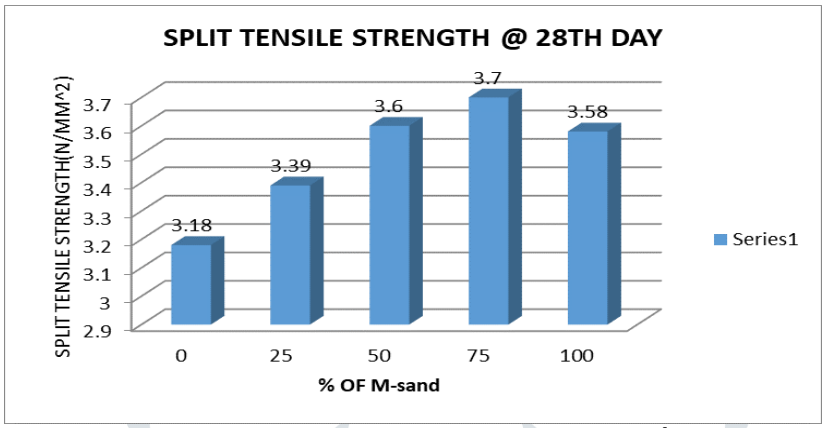

Fig 11. Split tensile strength test result on 28th day

D. Flexural strength:

For flexural strength, prism specimen of size 500x100x100 mm, were tested for flexure under two-point loading on 7th and 28th day.

Fig 12. Testing of prism specimen in the laboratory under two-point loading

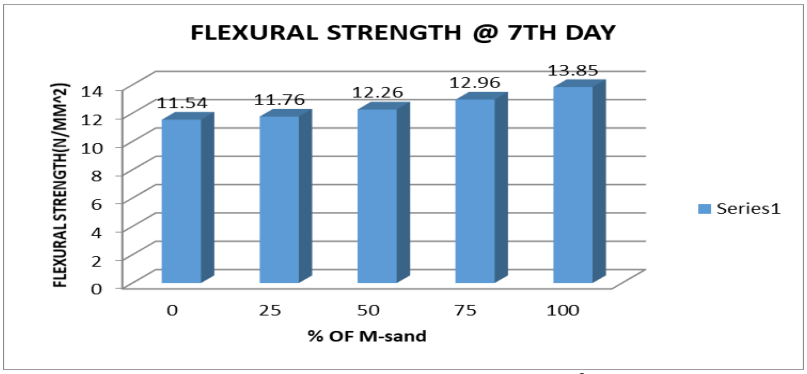

Fig 13. Flexural strength result on 7th day

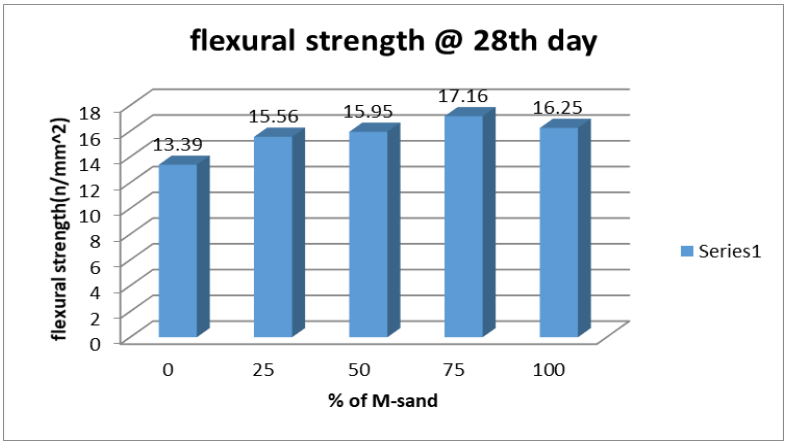

Fig 14. Flexural strength result on 28th day

V. CONCLUSIONS

Replacing of river sand by manufactured sand in self-compacting concrete has proved to improve the mechanical properties of concrete.

In the current investigation, the self-compacting concrete was studied for fresh and mechanical properties and the conclusion is as follows:

1. It is noticed that the results of strength under compression test increases with the increase in M-sand. The maximum strength 0%-46.2 N/mm^2 and 25% 48.99 N/mm^2.
2. It is noticed that the results of strength under split tensile test increases with the increase in M-sand. The maximum strength 0%-3.58 N/mm^2 and 25% 3.6 N/mm^2.
3. It is noticed that the results of strength under flexural test increases with the increase in M-sand. The maximum strength 0%-16.25 N/mm^2 and 25% - 17.17 N/mm^2.
4. Manufactured Sand was observed to reduce the flow-ability of concrete.

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