Experimental Investigation on the Influence of Manufactured Sand on the Fresh and Hardened Properties of Self-Compacting Concrete

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Abstract — Self-Compacting Concrete (SCC) is an advanced type of concrete that can flow under its own weight, fill complex formwork, and pass through congested reinforcement without the need for mechanical vibration. However, the increasing demand for natural river sand in concrete production has resulted in environmental concerns, depletion of natural resources, and increased construction costs. Manufactured Sand (M-Sand), produced by crushing hard rocks, offers a potential alternative to natural river sand in SCC. The present study investigates the influence of M-Sand as a partial and complete replacement for natural river sand on the fresh and hardened properties of self-compacting concrete. The experimental programme considers different replacement levels of M-Sand, including 0%, 25%, 50%, 75%, and 100%. The fresh properties of SCC are evaluated through slump flow, T500, L-box, and V-funnel tests to assess filling ability, passing ability, and resistance to segregation. The hardened properties are examined through compressive strength, split tensile strength, flexural strength, and bond strength tests at specified curing ages. The study aims to identify the optimum replacement level of M-Sand that provides satisfactory fresh concrete performance and improved mechanical properties. The findings are expected to contribute to the development of sustainable SCC by reducing dependence on natural river sand and promoting the effective utilization of manufactured aggregates in construction. The study also provides useful information for the practical application of M-Sand in producing durable and environmentally responsible concrete.

Keywords: Self-Compacting Concrete, Manufactured Sand, River Sand, Fresh Properties, Compressive Strength, Split Tensile Strength, Flexural Strength, Sustainable Construction

I. INTRODUCTION

Concrete is one of the most widely used construction materials in the world because of its strength, durability, versatility, and economic feasibility. Fine aggregate plays an essential role in concrete by filling voids between coarse aggregate particles and contributing to the workability, strength, and overall performance of the concrete mixture. Natural river sand has traditionally been used as fine aggregate in conventional concrete and self-compacting concrete. However, excessive extraction of river sand has led to environmental degradation, riverbed erosion, groundwater-related concerns, and a reduction in the availability of suitable natural resources. These challenges have encouraged researchers and construction professionals to explore alternative materials for fine aggregate replacement.

Self-Compacting Concrete (SCC) is a special type of concrete that can flow, compact, and achieve sufficient consolidation under its own weight without requiring external vibration. It was developed to improve construction efficiency, ensure uniform concrete placement, and reduce problems associated with inadequate compaction, particularly in heavily reinforced structural members. SCC generally requires a carefully proportioned mixture containing cementitious materials, fine aggregate, coarse aggregate, water, and suitable chemical admixtures. Its performance depends on the balance between flowability, viscosity, passing ability, and resistance to segregation.

Manufactured Sand (M-Sand) is produced by mechanically crushing hard rocks into particles of suitable sizes for use as fine aggregate. Compared with natural river sand, M-Sand can offer more consistent availability and controlled grading when it is properly manufactured and processed. Its use can also reduce pressure on natural river resources and support more sustainable construction practices. However, the particle shape, surface texture, grading, and fines content of M-Sand may differ considerably from those of natural river sand. These characteristics can influence water demand, paste requirements, workability, and the mechanical properties of concrete.

In SCC, the selection of fine aggregate is particularly important because the concrete must achieve sufficient flowability and passing ability while maintaining stability against segregation and bleeding. The angular and relatively rough surface of manufactured sand particles may improve particle interlocking and the bond between aggregate and cement paste. At the same time, these characteristics can increase internal friction and affect the flow behaviour of fresh concrete. Therefore, the performance of SCC containing M-Sand depends on its physical properties, replacement percentage, mix proportions, and the type and dosage of chemical admixture used.

The fresh properties of SCC are commonly evaluated using slump flow, T500, L-box, and V-funnel tests. The slump flow test determines the unrestricted flowability of the concrete, while the T500 time indicates the rate at which the concrete spreads to a diameter of 500 mm. The L-box test assesses passing ability through reinforcement-like obstructions, and the V-funnel test evaluates flow time and provides information about the mixture's viscosity and stability. These tests are important for determining whether the concrete satisfies the requirements for self-compaction.

The hardened properties are equally important in evaluating the suitability of M-Sand for SCC. Compressive strength indicates the concrete's ability to resist compressive loads, while split tensile strength evaluates its resistance to tensile cracking. Flexural strength measures resistance to bending, and bond strength provides information about the interaction between concrete and reinforcing steel. Evaluating these properties at different curing ages helps establish the influence of M-Sand replacement on strength development and structural performance.

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The present experimental investigation examines the effect of replacing natural river sand with M-Sand at different proportions of 0%, 25%, 50%, 75%, and 100%. The study evaluates both fresh and hardened properties to understand how increasing M-Sand content affects the performance of SCC. The results are intended to identify a suitable replacement level that maintains the required fresh properties while providing satisfactory mechanical performance. The investigation may help establish practical guidelines for using M-Sand in SCC and contribute to reducing the environmental impacts associated with excessive river sand extraction.

A. Literature Review

Lee (2025) conducted an advanced experimental investigation on the long-term performance of Self-Compacting Concrete (SCC) incorporating Manufactured Sand (M-Sand) as a complete replacement for natural river sand. The study focused on evaluating durability characteristics under aggressive environmental conditions such as chloride exposure and cyclic wetting–drying. The research utilized high-performance SCC mixes with optimized particle grading and advanced superplasticizers.

Sharma (2024) investigated the durability performance of SCC containing varying percentages of M-Sand. The study focused on key durability indicators such as water absorption, permeability, and resistance to sulphate and chloride attacks. The research involved experimental testing on SCC specimens cured under controlled conditions.

Sharma also observed that while durability improved, there was a slight reduction in workability due to increased internal friction. However, this issue was mitigated by optimizing the dosage of superplasticizers and maintaining an appropriate water-to-cement ratio.

The study concluded that M-Sand-based SCC is highly suitable for infrastructure projects exposed to harsh environmental conditions, making it a sustainable and durable alternative to conventional concrete.

Kumar (2023) conducted a microstructural analysis of SCC incorporating M-Sand using advanced techniques such as Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD). The primary objective was to understand the internal structure and bonding characteristics of M-Sand concrete.

Ali (2022) focused on the rheological behavior of SCC containing M-Sand. The study examined parameters such as viscosity, yield stress, and flowability using advanced rheological models. The research aimed to understand how M-Sand influences the fresh properties of SCC.

II. Objective of Research Work

The main objectives of the present investigation are:

1) To investigate the influence of manufactured sand as a partial and complete replacement for natural river sand in self-compacting concrete.
2) To evaluate the fresh properties of SCC containing different percentages of M-Sand using slump flow, T500, L-box, and V-funnel tests.
3) To determine the effect of M-Sand replacement on the compressive strength of SCC at different curing ages.
4) To identify a suitable replacement percentage of M-Sand that provides a balance between fresh concrete performance and hardened mechanical properties.
5) To assess the potential of M-Sand as a sustainable alternative to natural river sand and promote its application in environmentally responsible construction.

III. Result

A. Workability Of SCC

1) Slump flow and T500 test

The slump flow and T500 slump flow tests were employed to analyse the flow capacity of SCC. The inclusion of alccofine, micro silica, and M-sand enhanced the deformation and flow capacity of self-compacting concrete. The test results are displayed in Figure 4.1

Mixes	Slump flow
NC	655
MS-25	680
MS-50	695
MS-75	730
MS-100	780

Table 1: Slump flow test

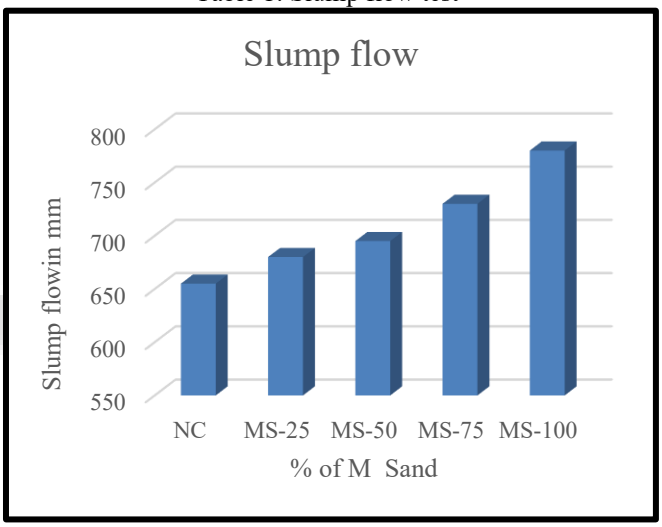

Fig. 1: Slump flow test

The slump flow test was conducted to evaluate the workability and flowability of concrete mixes containing different percentages of manufactured sand (MS). The control mix (NC) recorded a slump flow of 655 mm. With increasing manufactured sand content, the slump flow gradually increased to 680 mm, 695 mm, 730 mm, and 780 mm for MS-25, MS-50, MS-75, and MS-100, respectively.

The increase in slump flow indicates improved flowability and workability with higher manufactured sand replacement. The MS-100 mix showed the highest slump flow of 780 mm, indicating the greatest flowability among the tested mixes. Overall, the results suggest that manufactured sand replacement had a positive effect on the fresh-state flow characteristics of the concrete.

Mixes	T500 test
NC	4.1
MS-25	4.2
MS-50	4.4
MS-75	4.5

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MS-100	5.8

Table 2: T500 test

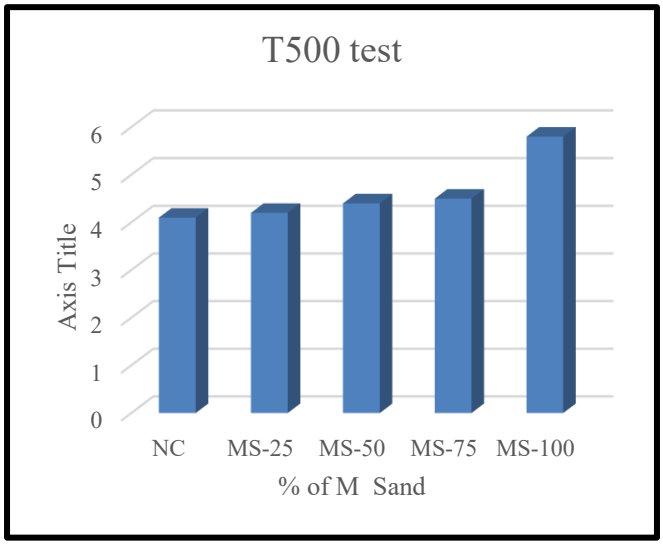

Fig. 2: T500 test

The increase in T500 time indicates a gradual increase in the viscosity of the concrete mix with higher manufactured sand content. The MS-100 mix showed the highest T500 value of 5.8 seconds, indicating comparatively slower flow. Overall, the results show that increasing manufactured sand content affected the flow characteristics and viscosity

2) Compressive strength of SCC

Mixes	Compressive strength		
	7 days	21days	28days
NC	31.7	43.2	52.1
MS-25	32	45.2	52.8
MS-50	33	45.8	53.1
MS-75	34.1	46.5	55.2
MS-100	35.6	48.3	56.34

Table 3: Compressive strength of all mixes

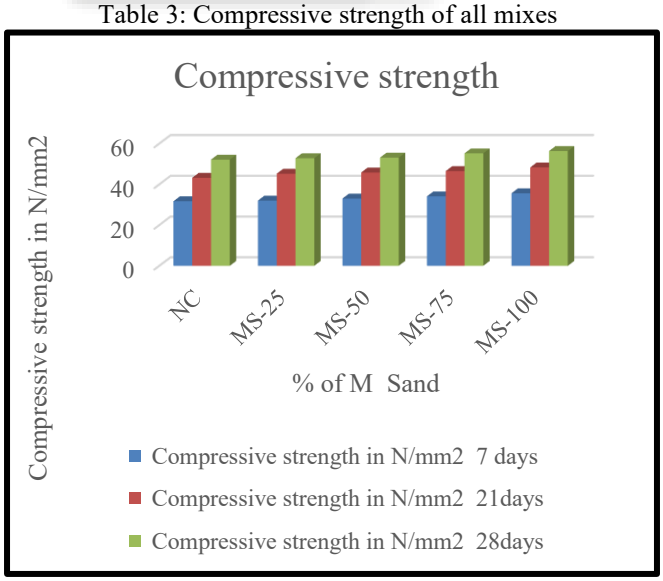

Fig. 3: Compressive strength of all mixes

The compressive strength test was conducted at 7, 21, and 28 days to evaluate the strength development of concrete containing different percentages of manufactured sand. The control mix (NC) achieved 31.7, 43.2, and 52.1 MPa at 7, 21, and 28 days, respectively.

With increasing manufactured sand content, compressive strength gradually increased. The MS-100 mix recorded the highest strength of 35.6 MPa, 48.3 MPa, and 56.34 MPa at 7, 21, and 28 days, respectively. At 28 days, the strength increased from 52.1 MPa for NC to 56.34 MPa for MS-100.

Overall, the results indicate that the incorporation of manufactured sand improved the compressive strength of concrete, with MS-100 showing the highest strength among the tested mixes.

IV. Conclusion

1) Slump Flow: The slump flow increased from 655 mm for NC to 780 mm for MS-100, indicating improved flowability of concrete with increasing manufactured sand content.
2) T500 Test: The T500 time increased from 4.1 s for NC to 5.8 s for MS-100, indicating a change in the viscosity and flow characteristics of the fresh concrete.
3) L-Box Test: The L-box ratio increased from 0.81 for NC to 0.93 for MS-100, showing improved passing ability of the concrete.
4) Compressive Strength: The 28-day compressive strength increased from 52.1 MPa for NC to 56.34 MPa for MS-100. The MS-100 mix therefore showed the highest compressive strength among the investigated mixes.

Reference

[1] M. S. Shetty, *Concrete Technology: Theory and Practice*, 8th ed. New Delhi, India: S. Chand, 2019.
[2] A. M. Neville, *Properties of Concrete*, 5th ed. Harlow, U.K.: Pearson Education, 2011.
[3] P. K. Mehta and P. J. M. Monteiro, *Concrete: Microstructure, Properties, and Materials*, 4th ed. New York, NY, USA: McGraw-Hill Education, 2014.
[4] J. Newman and B. S. Choo, *Advanced Concrete Technology: Constituent Materials*. Oxford, U.K.: Butterworth-Heinemann, 2003.
[5] M. Collepardi, *Modern Concrete*. Bologna, Italy: Grafiche C. T., 1993.
[6] K. H. Khayat, "Workability, testing, and performance of self-consolidating concrete," *ACI Materials Journal*, vol. 96, no. 3, pp. 346–353, 1999.
[7] P. Bartos, M. Sonebi, and A. Tamimi, *Workability and Rheology of Fresh Concrete: Compendium of Tests*. Crowthorne, U.K.: British Cement Association, 2002.
[8] P. K. Mehta, "Sustainable cements and concrete for the climate change era—A review," *ACI Concrete International*, vol. 25, no. 4, pp. 23–28, 2003.
[9] M. Sonebi, "Medium strength self-compacting concrete containing fly ash: Modelling using factorial experimental plans," *Cement and Concrete Research*, vol. 34, no. 7, pp. 1199–1208, 2004.
[10] P. Domone, "A review of the hardened mechanical properties of self-compacting concrete," *Cement and Concrete Composites*, vol. 29, no. 1, pp. 1–12, 2007.
[11] P. Domone, "Self-compacting concrete: An analysis of 11 years of case studies," *Cement and Concrete Composites*, vol. 28, no. 2, pp. 197–208, 2006.

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