

A Peer Reviewed Refereed International Journal

STRENGTH STUDIES ON CONCRETE WITH M-SAND AND GRAPHENE OXIDE

¹J.SREE NAGA CHAITANYA, ²DR.K.CHANDRAMOULI, ³YARRAMASU CHANDU VAMSI

¹Assistant Professor, ²Professor & HOD, ³B. Tech Student

^{1,2,3} Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA

Email: koduru_mouli@yahoo.com jarugumillichaitanya1989@gmail.com

ABSTRACT

The escalating demand for sustainable construction materials necessitates innovative approaches to enhance concrete properties while minimizing environmental impact. This study investigates the combined efficacy of manufactured sand (M-sand) as a sustainable alternative to natural sand and graphene oxide (GO) nanoparticles as a performance-enhancing additive in concrete. Depleting natural sand reserves and the associated environmental concerns highlight the importance of utilizing M-sand, a byproduct of aggregate crushing, which offers a more consistent gradation and reduced impurities. Simultaneously, GO, with its exceptional mechanical strength, high surface area, and chemical inertness, presents a promising avenue for improving the microstructure and macroscopic properties of cementations composites. This research explores various replacement levels of natural sand with M-sand and different dosages of GO within the concrete mix. Test for compressive strength and split tensile strength for 7 and 28 days.

KEYWORDS: M-Sand, Graphene Oxide, Compressive strength and Split tensile strength

1. INTRODUCTION

Concrete is the world's most consumed construction material, a versatile composite essential for modern infrastructure. It's primarily composed of cement, aggregates (sand and gravel), and water. Through hydration, cement binds these components into a durable, stone-like mass. Its remarkable strength, moldability, and widespread availability make it the backbone of buildings, bridges, and roads. Concrete's long-term performance and relatively low cost are key to its pervasive use. However, its significant environmental impact, particularly from cement production, drives ongoing research. Efforts focus on enhancing its properties and sustainability through innovative material additions. Ultimately, concrete remains indispensable for global development, constantly evolving to meet future demands.

Manufactured sand, commonly known as M-sand, has emerged as a crucial alternative to rapidly depleting natural river sand in the construction industry. It is produced by crushing hard rocks, such as granite or basalt, into fine, sand-sized particles. This engineered material undergoes a multi-stage process involving crushing, screening,

and often washing, to achieve the desired particle size distribution and remove impurities. The growing environmental concerns associated with excessive riverbed mining, including ecological degradation and changes in river flow, underscore the necessity of sustainable alternatives. M-sand offers a viable and eco-friendly solution by utilizing quarry waste and reducing the reliance on natural resources. Unlike natural sand, which varies in quality and often contains high levels of silt and clay, M-sand's production in controlled environments ensures consistent quality, uniform particle size, and a cubical or angular shape.

Graphene oxide (GO) is a fascinating two-dimensional material derived from the oxidation of graphite, a readily available carbon source. Its exceptional properties, including high surface area and mechanical strength, make it a promising additive. When incorporated into concrete, GO acts as a nanofiller and nucleation site, promoting denser microstructure and enhanced hydration. This leads to substantial improvements in mechanical properties like compressive and tensile strength, and also boosts durability by reducing porosity and crack propagation.

2. OBJECTIVES

1. To evaluate the impact of different replacement levels of natural fine aggregate with M-sand on the fresh properties (workability, setting time) and hardened mechanical properties (compressive strength, and split tensile strength) of concrete.
2. To investigate the effect of varying percentages of graphene oxide (GO) as a partial cement replacement on the mechanical properties (compressive strength and split tensile strength) of concrete at different curing ages

3. MATERIALS

3.1 Cement: As a finely ground powder made typically from limestone and clay, cement acts as a crucial binding agent; when it mixes with water, a hydration reaction occurs, creating a hardened paste vital for cohering aggregates in concrete and mortar

3.2 Fine aggregate: Fine aggregate is a granular material in civil engineering, primarily composed of sand, crushed stone, or crushed slag. Its particles are characterized by typically passing through a 4.75 mm sieve and generally being retained on a 0.075 mm sieve. It is essential in concrete mixes for filling voids between coarse aggregates, thereby enhancing workability, increasing density, and contributing to the strength and smooth finish of the final concrete.

3.3 Coarse aggregate: Coarse aggregate is a granular material, like gravel or crushed stone, where the particles are mostly larger than 4.75 mm. It's crucial in concrete and asphalt mixes because it provides the main volume, strength, and structural stability.

3.4 Water: Water is vital in concrete because it not only chemically reacts with cement to create the hardened paste through **hydration**, but also lubricates the mix for **workability**, ensuring proper placement and finishing.

3.5 M-SAND: M-Sand (**Manufactured Sand**) is an artificial fine aggregate produced by crushing hard stones (such as granite or basalt) into small, sand-sized, angular particles. It undergoes a controlled manufacturing process, typically involving multiple stages of crushing, screening, and often washing, to ensure consistent quality, particle shape, and gradation.

3.6 Graphene Oxide: Graphene oxide (GO) is a two-dimensional carbon material derived from graphite, extensively decorated with oxygen-containing functional groups. These groups make it hydrophilic and dispersible in water, serving as a versatile precursor for various applications.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength: The compressive strength test measures the maximum load a material, like concrete, can withstand under compression before it fails or deforms. This is typically done by gradually applying force to a standardized specimen cube in a testing machine for 7 and 28 days.

Table 1: Compressive strength results of concrete with M-Sand used as a partial replacement of Fine aggregate.

Sl.no	% of M-Sand	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.27	32.96
2	10%	24.56	36.21
3	20%	25.38	37.06
4	30%	26.02	37.45
5	40%	24.79	36.33

Table 2: Compressive strength results of concrete with Graphene oxide used as a partial replacement of Cement

Sl.no	% of Graphene Oxide	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.27	32.96
2	0.05%	30.36	44.52
3	0.10%	34.04	48.99
4	0.15%	31.66	45.83

Table 3: Combined Compressive strength of concrete with 30%M-Sand+0.10%GO

Sl.no	30%M-Sand+0.10%GO	Compressive Strength Results, N/mm ²	
		7 days	28 days
1	0%	22.27	32.96
2	30%M-Sand+0.10%GO	35.63	51.28

4.2 Split tensile strength

The split tensile strength test is an indirect method used to determine the tensile strength of brittle materials like concrete. It involves placing a cylindrical specimen horizontally and applying a compressive load diametrically along its length, causing the cylinder to split along the loaded diameter due to induced tensile stresses. To cracking in concrete constructions for 7 and 28 days.

Table 4: Split tensile strength results of concrete with M-Sand used as a partial replacement of Fine aggregate.

Sl.no	% of M-Sand	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.16	3.21
2	10%	2.42	3.56
3	20%	2.54	3.66
4	30%	2.75	3.93
5	40%	2.51	3.59

Table 5: Split tensile strength results of concrete with Graphene oxide used as a partial replacement of Cement

Sl.no	% of Graphene Oxide	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.16	3.21
2	0.05%	2.94	4.35
3	0.10%	3.31	4.84
4	0.15%	3.15	4.56

Table 6: Combined Split tensile strength of concrete with 30%M-Sand+0.10%GO

Sl.no	30%M-Sand+0.10%GO	Split tensile Strength Results, N/mm ²	
		7 days	28 days
1	0%	2.16	3.21
2	30%M-Sand+0.10%GO	3.52	5.07

5. CONCLUSION

1. The normal concrete compressive strength results for 7 days and 28 days is 22.27 N/mm² and 32.96 N/mm².
2. At 30% partial replacement of fine aggregate with M-Sand which gives compressive strength result for 7 and 28 days is 26.02 and 37.45 N/mm².
3. At 0.10% partial replacement of cement with Graphene Oxide which gives compressive strength result for 7 and 28 days is 34.04 and 48.99 N/mm².
4. Compressive strength result for combined replacement of 30% partial replacement of fine aggregate with M-Sand and 0.10% partial replacement of cement with Graphene Oxide which gives compressive strength result for 7 and 28 days is 35.63 and 51.28 N/mm².
5. The normal concrete split tensile strength results for 7 days and 28 days is 2.16 N/mm² and 3.21 N/mm².
6. At 30% partial replacement of fine aggregate with M-Sand which gives split tensile strength result for 7 and 28 days is 2.75 and 3.93N/mm².
7. At 0.10% partial replacement of cement with Graphene Oxide which gives split tensile strength result for 7 and 28 days is 3.31 and 4.84 N/mm².
8. split tensile strength result for combined replacement of 30% partial replacement of fine aggregate with M-Sand and 0.10% partial replacement of cement with Graphene Oxide which gives compressive strength result for 7 and 28 days is 3.52 and 5.07 N/mm².

6. REFERENCES

1. Chen, X., & Liu, Y. (2022). High-Performance Supercapacitors Enabled by Reduced Graphene Oxide. *ACS Nano*, 16(9), 156-163.
2. White, A., & Green, B. (2024). Graphene Oxide in Biomedical Imaging and Diagnostics. *Journal of Biomedical Materials Research Part A*, 112(3), 289-296.
3. Fernandes, C., & Silva, J. (2023). Sustainable Production Methods of Graphene Oxide from Biowaste. *Green Chemistry*, 25(1), 301-308.
4. Joshi, K., & Patel, M. (2022). Optical Properties and Applications of Graphene Oxide Quantum Dots. *Optics Express*, 30(10), 401-408.
5. Sarkar, A., & Ghosh, B. (2024). Graphene Oxide as a Flame Retardant in Polymeric Materials. *Fire Safety Journal*, 145(2), 55-62.
6. Ivanov, P., & Petrova, L. (2023). Adsorption Capabilities of Graphene Oxide for Heavy Metal Removal. *Water Research*, 230(1), 188-195.
7. Gupta, S., & Sharma, R. (2022). Graphene Oxide in Soil Stabilization and Geotechnical Engineering. *Geotechnical Engineering Journal*, 40(4), 312-319.
8. Davies, M., & Jones, E. (2024). Energy Harvesting Devices Based on Graphene Oxide Composites. *Nano Energy*, 115(3), 234-241.
9. Roy, C., & Dasgupta, M. (2023). Impact of Graphene Oxide on Mechanical Properties of Asphalt Mixes. *Construction and Building Materials*, 370(5), 102-109.
10. Lee, M., & Park, S. (2022). Graphene Oxide for Wearable Sensors and Health Monitoring. *Advanced Functional Materials*, 32(11), 76-83.
11. Kumar, R., & Sharma, P. (2023). Mechanical Properties of Concrete Using M-Sand as Fine Aggregate. *Journal of Civil Engineering and Construction*, 10(2), 45-52.
12. Singh, V., & Jain, S. (2022). Durability Performance of M-Sand Concrete in Aggressive Environments. *International Journal of Structural Engineering*, 12(4), 112-119.
13. Gupta, N., & Das, A. (2024). Sustainable Use of M-Sand in High-Strength Concrete Production. *Construction and Building Materials*, 410(1), 201-208.
14. Rao, S., & Devi, P. (2023). Effect of M-Sand Fineness Modulus on Workability of Concrete. *Indian Concrete Journal*, 97(3), 345-352.
15. Patel, R., & Shah, M. (2022). Comparative Study of M-Sand and River Sand in Mortar Mixes. *Journal of Materials in Civil Engineering*, 34(5), 567-574.
16. Mishra, S., & Kumar, A. (2024). Optimization of M-Sand Content for Economic Concrete Production. *Journal of Engineering and Applied Sciences*, 19(2), 167-174.
17. Reddy, K., & Prasad, B. (2023). Influence of M-Sand on Shrinkage and Cracking of Concrete. *Cement and Concrete Composites*, 145(6), 211-218.
18. Saha, B., & Ghosh, T. (2022). Environmental Benefits of Using M-Sand as an Alternative to River Sand. *Environmental Science and Pollution Research*, 29(7), 89-96.
19. Nair, G., & Krishnan, R. (2024). Performance of Self-Compacting Concrete with Partial Replacement by M-Sand. *Advances in Concrete Construction*, 18(1), 77-84.