North Asian International Research Journal of Sciences, Engineering & I.T.

IRJIF. I.F. : 3.821

ISSN: 2454-7514 Vol. 11, Issue-11, November-2025

Index Copernicus Value: 52.88 Indian Citation Index Thomson Reuters ID: S-8304-2016

A Peer Reviewed Refereed International Journal

EXPERIMENTAL INVESTIGATION ON CONCRETE WITH GRAPHENE OXIDE AND DUNITE POWDER

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ABSTRACT

Concrete is a widely used and versatile construction material made by mixing cement, water, and aggregates such as sand, gravel, or crushed stone. Initially, it is a fluid slurry that can be cast into nearly any shape using molds. As it cures, it undergoes hydration. A chemical reaction that transforms the mixture into a hard, rock-like mass.Graphene oxide is often added as a partial cement replacement because it greatly improves the mechanical strength and durability of concrete. oxide at proportions of 0%, 0.03%, 0.06%, 0.09%, 0.12%, and 0.15%, and with Dunite powder at replacement levels of 20%, 40%, and 60%.Compressive strength, split tensile strength, and Its functional groups act as nucleation sites, enhancing cement hydration and strengthening the interfacial bonding within the mix.Dunite powder is also used as a partial cement substitute in concrete. Rich in magnesium silicate and possessing pozzolanic activity, it contributes to improved mechanical properties and overall durability.In this study, cement is partially replaced with graphene ultrasonic pulse velocity tests were conducted to determine the mechanical and durability properties of the concrete.

KEYWORDS: ***Graphene Oxide, Dunite powder,magnesium silicate,Compressive Strength, Split Tensile Strength and Ultrasonic pulse velocity.***

1. INTRODUCTION

Concrete is an essential material in modern construction, composed mainly of cement, water, and fine and coarse aggregates. Its strength, versatility, and durability have made it the foundation of global infrastructure, used in structures ranging from buildings and bridges to roads and dams. However, the production of Ordinary Portland Cement (OPC).A key ingredient in concrete—is highly energy-intensive and contributes significantly to global

carbon dioxide emissions. In addition, the growing demand for natural aggregates places heavy pressure on natural resources, resulting in environmental issues such as riverbed erosion and the depletion of sand reserves.

Graphene oxide (GO) is gaining prominence in concrete technology because of its outstanding mechanical and chemical characteristics. Even at very low dosages, GO enhances cement hydration by acting as a nucleation site, leading to quicker and more efficient gel formation. It refines the concrete's microstructure by reducing porosity and limiting the development of microcracks. With its strong bonding capability, GO strengthens the interface between the cement paste and aggregates, resulting in improved compressive and tensile strength. Its high tensile nature also helps control crack propagation within the concrete matrix.

Additionally, GO increases durability by improving resistance to water penetration, chemical attacks, and environmental degradation. This results in a denser and more uniform concrete mix that performs better over time. GO-modified concrete maintains structural integrity under various loading conditions, and even small amounts produce noticeable enhancements. Overall, graphene oxide acts as an effective additive that significantly boosts the strength and longevity of concrete used in construction.

Dunite powder is emerging as a promising construction material used as a partial replacement for cement due to its rich magnesium silicate composition. Its pozzolanic activity contributes to improved binding properties within the concrete mix. When added to cement, dunite powder enhances the microstructure by reducing pore spaces and increasing density. This leads to higher strength and improved durability of the concrete. It also helps lower the overall heat of hydration, reducing the risk of thermal cracking.

Using dunite powder decreases cement consumption, which supports sustainable construction practices by reducing carbon emissions. Additionally, it provides improved resistance to chemical attack and long-term environmental degradation. Overall, dunite powder serves as an effective and eco-friendly alternative that enhances the performance of concrete.

2. OBJECTIVES

- **To evaluate the mechanical performance**of concrete by partially replacing cement with graphene oxide and dunite powder, focusing on improvements in compressive strength, split tensile strength, and durability.
- **To study the microstructural enhancements** achieved through the addition of graphene oxide and dunite powder, including reduced porosity, improved bonding, and refined internal structure.
- **To promote sustainable construction practices** by reducing cement consumption through the incorporation of dunite powder and graphene oxide, thereby lowering environmental impact and enhancing long-term concrete performance.

3. MATERIALS

3.1 Cement: Cement is a finely ground binding substance produced from processed limestone and clay materials. When water is added, it reacts chemically and transforms into a hardened, stone-like mass. It serves as the key ingredient in concrete, binding the fine and coarse aggregates into a solid structure.

3.2 Fine Aggregate: Fine aggregate refers to small mineral particles such as natural sand or finely crushed rock.

It fills the gaps between larger aggregates, helping to improve the mix's smoothness and workability. These particles generally fall within the size range of 0.075 mm to 4.75 mm.

3.3 Coarse Aggregate: Coarse aggregate includes larger particles such as gravel or crushed stone. It provides volume, strength, and stability to concrete mixes. Its particle size usually ranges from 4.75 mm to 20 mm or more.

3.4 Water: Water is a vital component in concrete that triggers the chemical reaction of cement hydration. It ensures proper mixing, placing, and finishing by providing necessary fluidity to the mixture. Both the purity and amount of water significantly influence the final quality and durability of concrete.

3.5Dunite Powder: Dunite powder is a naturally occurring mineral material rich in magnesium-based compounds. Used as a supplementary cementitious material, it reacts with calcium hydroxide to form additional binding compounds. Its inclusion improves the mechanical performance, durability, and eco-friendliness of concrete.

3.6Graphene Oxide: Graphene oxide is a nano-engineered material derived from graphite, containing various oxygen functional groups. It enhances the behavior of concrete by improving hydration efficiency and strengthening particlebonding.Even at very low doses, it boosts mechanical properties, durability, and resistance to cracking.

4. EXPERIMENTAL INVESTIGATIONS

4.1**Compressive Strength Results:**Compressive strength results indicate the maximum load a concrete specimen canwithstandbeforefailureundercompression. These results are obtained by applying increasing load to a cube or cylinder until it breaks. They reflect the concrete's ability to resist crushing forces and support structural loads. Higher compressive strength values represent stronger and more durable concrete.These results are essential for evaluating the quality, performance, and suitability of concrete in construction.

Table 1: Compressive Strength Results of Concrete with Partial Replacement of Cement with Dunite Powder.

S.No	% of Dunite powder	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.38	39.67
2	20%	28.44	40.85
3	40%	30.37	43.23
4	60%	27.89	41.38

Table 2: Compressive Strength Results of Concrete with Partial Replacement of cement with Graphene Oxide

S.No	% of Graphene Oxide	Compressive strength results, N/mm^2

		7 days	28 days
1	0%	27.38	39.67
2	0.03%	34.97	51.59
3	0.06%	38.01	55.18
4	0.09%	40.12	57.87
5	0.12%	41.66	59.52
6	0.15%	38.43	56.29

Table 3: Compressive strength of concrete for combined partial replacement of cement with 40% Dunite Powder+ 0.12% of Graphene Oxide.

S.No	Combined Replacements	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	27.38	39.67
2	40%DP+0.12% GO	43.21	61.29

4.2 Split Tensile Strength Test: The loading plates of the compression testing machine are adjusted horizontally using a standard concrete cylinder specimen measuring 300 mm in height and 150 mm in diameter. A uniform and gradually increasing compressive load is then applied along the vertical axis of the cylinder until it ultimately fails at its vertical diameter.

Table 4: Split tensile Strength Results of Concrete with Partial Replacement of Cement with Dunite Powder.

S.No	% of Dunite powder	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.61	3.88
2	20%	2.76	4.01
3	40%	2.99	4.27
4	60%	2.87	4.12

Table 5: Split tensileStrength Results of Concrete with Partial Replacement of cement with Graphene Oxide

S.No	% of Graphene Oxide	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.61	3.88
2	0.03%	3.42	5.05
3	0.06%	3.69	5.42
4	0.09%	4.01	5.76
5	0.12%	4.15	5.94
6	0.15%	4.09	5.59

Table 6: Split tensile strength of concrete for combined partial replacement of cement with 40% Dunite Powder+ 0.12% of Graphene Oxide.

S.No	Combined Replacements	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	2.61	3.88
2	40%DP+0.12% GO	4.34	6.25

4.3 Ultrasonic Pulse Velocity: Ultrasonic Pulse Velocity (UPV) is a non-destructive test used to evaluate the quality and uniformity of concrete. It works by measuring the speed of high-frequency sound waves passing through the material. Faster pulse velocity indicates denser, stronger, and more defect-free concrete. The test helps detect cracks, voids, and other internal imperfections. Overall, UPV is an effective method for assessing the integrity and durability of concrete structures
without causing damage.

Table 7: Ultrasonic Pulse Velocity Results of Concrete with Partial Replacement of Cement with DunitePowder.

S.No	% of Dunite powder	Ultrasonic Pulse Velocity results, m/s	
		28 days	Quality
1	0%	4391	Good
2	20%	4787	Excellent
3	40%	4884	Excellent
4	60%	4617	Excellent

Table 8: Ultrasonic Pulse VelocityResults of Concrete with Partial Replacement of cement with Graphene Oxide.

S.No	% of Graphene Oxide	Ultrasonic Pulse Velocity results, m/s	
		28 days	Quality
1	0%	4391	Good
2	0.03%	4784	Excellent
3	0.06%	4856	Excellent
4	0.09%	4972	Excellent
5	0.12%	5104	Excellent
6	0.15%	4778	Excellent

Table 9: Ultrasonic Pulse Velocityof concrete for combined partial replacement of cement with 40% Dunite Powder+ 0.12% of Graphene Oxide.

S.No	Combined Replacements	Ultrasonic Pulse Velocity results, m/s	
		28 days	Quality

1	0%	4391	Good
2	40%DP+0.12% GO	5435	Excellent

5. CONCLUSIONS

1. TheNormal concrete (0% replacement) had compressive strengths of 27.38 N/mm² at 7 days and 39.67 N/mm² at 28 days.
2. Replacing cement with Dunite Powder improved the strength up to 40%, where the concrete reached 30.37 N/mm² at 7 days and 43.23 N/mm² at 28 days.
3. Graphene Oxide greatly increased strength, and the best result was at 0.12% GO with 41.66 N/mm² at 7 days and 59.52 N/mm² at 28 days.
4. At 0.15% GO, the strength slightly dropped, showing that 0.12% GO is the ideal amount.
5. The combined mix of 40% Dunite Powder and 0.12% GO gave the highest compressive strength of all mixes, reaching 43.21 N/mm² at 7 days and 61.29 N/mm² at 28 days.
6. The Normal concrete showed split tensile strengths of 2.61 N/mm² at 7 days and 3.88 N/mm² at 28 days.
7. The highest split tensile strength for Dunite Powder was at 40% DP with 2.99 N/mm² at 7 days and 4.27 N/mm² at 28 days.
8. Graphene Oxide showed its best results at 0.12%, giving 4.15 N/mm² at 7 days and 5.94 N/mm² at 28 days.
9. The combined mix (40% DP + 0.12% GO) gave the highest split tensile strength overall, with 4.34 N/mm² at 7 days and 6.25 N/mm² at 28 days.
10. Normal concrete had a UPV value of 4391 m/s, indicating good quality, but all mixes with DP and GO showed higher UPV values.
11. Both 40% Dunite Powder and 0.12% GO gave excellent UPV values (4884 m/s and 5104 m/s), showing better internal quality compared to normal concrete.
12. The combined mix (40% DP + 0.12% GO) gave the highest UPV value of 5435 m/s, proving that this mix has the best overall quality and internal structure among all the tested concretes.

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