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STRENGTH STUDIES ON CONCRETE WITH GRAPHENE OXIDE AND SILICA FUME

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ABSTRACT

This study investigates the effects of incorporating graphene oxide (GO) and silica fume (SF) into concrete on its mechanical properties. Graphene oxide, known for its exceptional mechanical and chemical properties, and silica fume, a byproduct of silicon metal or ferrosilicon alloy production, are utilized to enhance the strength and durability of concrete. The research involves preparing concrete mixtures with varying percentages of GO (0.06%, 0.12%, 0.18%) and SF (5%,7.5%, 12.5%) and testing them for compressive strength and Split tensile strength at different curing periods. *To calculate compressive ,split tensile strengths for 7 and 28 days and Ultrasonic pulse Velocityfor 28 days.*

KEYWORDS: Graphene Oxide, Silica Fume, CompressiveStrength, Split Tensile Strength and Ultrasonic pulse Velocity.

1. INTRODUCTION:

The demand for concrete is second only to water. As innovation has advanced and the sector in which cement and mortars are used has grown, various characteristics of ordinary cement have to be modified in order to make it more sensible, environmentally friendly, and suitable for a wider range of situations. This is what has led to the use of cementitious materials.

silica fume, is a by-product of the manufacturing of silicon and ferrosilicon alloys. It is an ultrafine powder made up of spherical particles with an average diameter of 150mm. Use as pozzolanic material for high performance concrete is the primary application.The average diameter of spherical particles in silica fume is around 0.15 µm, making it an ultrafine substance. As a result, it is around 100 times smaller than a typical cement particle. Depending on the level of densification in the silo, silica fume's bulk density can range from 130 (undensified) to

600 kg/m3. The BET or nitrogen adsorption methods can be used to determine the specific surface area of silica fume.

Graphene oxide (GO) is an oxidized form of graphene, characterized by the presence of oxygen-containing functional groups on its basal plane and edges. This nanomaterial has garnered significant attention due to its exceptional mechanical, electrical, and thermal properties. Unlike pristine graphene, graphene oxide is hydrophilic and can be dispersed in water and other solvents, making it easier to handle and integrate into various matrices. The introduction of oxygen groups imparts GO with unique chemical reactivity and the potential for further functionalization. These properties make graphene oxide a versatile additive for enhancing the performance of composite materials, particularly in fields like electronics, energy storage, and biomedicine. In the context of construction, graphene oxide has shown promise in improving the mechanical properties and durability of cementitious materials, offering potential for creating more resilient and sustainable infrastructure.

2. OBJECTIVES

1. This objective aims to determine the optimal proportions of these additives to achieve maximum strength enhancement.

2. This includes evaluating the long-term performance and structural integrity of the concrete under various conditions.

3. Investigate the potential of graphene oxide and silica fume to improve the compressive, tensile, and flexural strengths of concrete.

3. MATERIALS

3.1 Cement: One substance with cohesive and adhesive qualities is cement. When combined with water and mineral pieces, cement binds the particles together to form a solid whole. A significant number of cementing materials are mentioned in this description. Cement is used in construction projects to bind materials like bricks, sand, and stones. Our research is restricted to cement utilized in building, specifically in concrete projects.

3.2 Fine Aggregate: The foundation of concrete mixes,mortar, and asphalt is fine aggregate, which is often made out of sand, crushed stone, orgravel with particles smaller than 4.75 mm. It is important forconstruction projects notonlyforstrengthand volumestability,butalso forimprovingworkabilityandeconomics.

3.3 Coarse Aggregate: In this investigation, coarse aggregate with a maximum size of 20 mm that was readily available locally was used. After being cleaned to get rid of dirt and dust, the aggregates were dried until they were surface dry.

3.4 Silica Fume: Silica fume, also known as microsilica, is a byproduct of the production of silicon and ferrosilicon alloys in electric arc furnaces. It consists of very fine, spherical particles of silicon dioxide (SiO_2), typically less than 1 micron in diameter. Silica fume is known for its high pozzolanic activity, meaning it reacts with calcium hydroxide in cement to form additional calcium silicate hydrate (C-S-H), which contributes to the strength and durability of concrete.

3.5 Graphene Oxide: Graphene oxide (GO) is a derivative of graphene, a single layer of carbon atoms arranged in a hexagonal lattice. Unlike pristine graphene, graphene oxide contains various oxygen-containing functional groups, such as hydroxyl, epoxy, and carboxyl groups, on its basal plane and edges. These groups make graphene oxide hydrophilic and dispersible in water and other solvents. GO is produced through the oxidation of graphite, followed by exfoliation. This material has garnered significant attention due to its unique properties, including mechanical strength, electrical conductivity, and chemical reactivity, making it suitable for a wide range of applications.

3.6 Water: The potable waterish generally considered satis factory for mixing and curing of concrete. Water composition is H_2O and pH range of water is 6 to 8.

4. EXPERIMENTAL INVESTIGATIONS:

4.1**Compressive Strength Results:** Test specimens are either 15-cm cubes or 15-cm diameter, and the concrete to be tested shall not have nominal maximum aggregate sizes greater than 20 mm. Usually, the concrete specimens are tested when they are 7 and 28 days.

Table 1: - Compressive Strength Results of Concrete with Partial Replacement of Cement by Silica Fume.

S.No	% of Silicafume	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	34.36	49.13
2	5%	36.78	53.07
3	7.5%	40.42	56.95
4	12.5%	35.89	52.59

Table 2: - Compressive Strength Results of Concrete with Partial Replacement of Cement by Graphene Oxide.

S.No	% of Graphene Oxide	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	34.36	49.13
2	0.06%	47.77	68.35
3	0.12%	51.58	73.39
4	0.18%	48.31	69.21

Table3: - Combined Replacement of Compressive Strength Results of Concrete with Partial Replacement of Cement by 7.5% of Silica fume + 0.12% of Graphene Oxide.

S.No	7.5% of Silica fume +0.12% of Graphene Oxide	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	34.36	49.13
2	7.5% of Silica fume +0.12% of Graphene Oxide	54.02	77.29

4.2 Split Tensile Strength Test: The compression testing machine's loading surfaces are separated horizontally by a conventional test cylinder of concrete specimen (300 mm x 150 mm in diameter). The compression force is delivered consistently and symmetrically over the cylinder's length until the cylinder fails at its vertical diameter.

Table 4: - Split tensile Strength Results of Concrete with Partial Replacement of Cement by Silica Fume.

S.No	% of Silicafume	Split tensile Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.34	4.82
2	5%	3.71	5.25
3	7.5%	4.18	5.97
4	12.5%	3.26	4.73

Table 5: - Split tensile Strength Results of Concrete with Partial Replacement of Cement by Graphene Oxide.

S.No	% of Graphene Oxide	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.34	4.82
2	0.06%	4.78	6.82
3	0.12%	5.21	7.41
4	0.18%	4.94	7.07

Table6: - Combined Replacement of Split tensileStrength Results of Concrete with Partial Replacement of Cement by 7.5% of Silica fume + 0.12% of Graphene Oxide.

S.No	7.5% of Silica fume +0.12% of Graphene Oxide	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.34	4.82
2	7.5% of Silica fume +0.12% of Graphene Oxide	5.38	7.64

4.3 Ultrasonic pulse Velocity Test: Pulse of Ultrasonic Wave Concrete's density and elastic modulus are the primary determinants of its velocity.

Table 7: - Ultra Pulse Velocity Results of Concrete with Partial Replacement of Cement by Silica Fume.

S.No	% of Silicafume	Ultrasonic pulse Velocity,(m/s)	
		28 days	Quality of Concrete
1	0%	4212	Good
2	5%	4454	Good
3	7.5%	4582	Excellent
4	12.5%	4618	Excellent

Table 8: - Ultrasonic pulse Velocity Results of Concrete with Partial Replacement of Cement by Graphene Oxide.

S.No	% of Graphene Oxide	Ultrasonic pulse Velocity,(m/s)	
		28 days	Quality of Concrete
1	0%	4212	Good
2	0.06%	4571	Excellent
3	0.12%	4957	Excellent
4	0.18%	4718	Excellent

Table 9: - Combined Replacement of Ultrasonic pulse Velocity Results of Concrete with Partial Replacement of Cement by 7.5% of Silica fume + 0.12% of Graphene Oxide.

S.No	7.5% of Silica fume +0.12% of Graphene Oxide	Ultrasonic pulse Velocity, (m/s)	
		28 days	Quality of Concrete
1	0%	4212	Good
2	7.5% of Silica fume +0.12% of Graphene Oxide	5136	Excellent

5. CONCLUSIONS:

1. The Normal Concrete Compressive Strength Results for 7 and 28 days is 34.36 and 49.13N/mm^2.

2. The optimum compressive strength results of concrete with partial replacement of cement by 7.5% silica fume at 7 and 28 days is and 40.42 and 56.95 N/mm^2.

3. The optimum compressive strength results of concrete with partial replacement of cement by 0.12% Graphene Oxide at 7 and 28 days is and 51.58 and 73.39 N/mm^2.

4. By combining a replacement of 7.5% silica fume and 0.12% graphene oxide with cement, the compressive strength results for 7 and 28 days are 54.02 and 77.29 N/mm^2.

5. The Normal Concrete Split tensile Strength Results for 7 and 28 days is 3.34 and 4.82N/mm^2.

6. The optimum split tensile strength results of concrete with partial replacement of cement by 7.5% silica fume at 7 and 28 days is and 4.18 and 5.97 N/mm^2.

7. The optimum split tensile strength results of concrete with partial replacement of cement by 0.12% Graphene Oxide at 7 and 28 days is and 5.21 and 7.41 N/mm^2.

8. By combining a replacement of 7.5% silica fume and 0.12% graphene oxide with cement, the split tensile strength results for 7 and 28 days are 5.38 and 7.64 N/mm^2.

9. The Ultrasonic Pulse Velocity Results of Normal Concrete at 28 days is 4212 m/s.

10. The optimum Ultrasonic Pulse Velocity results of concrete with 7.5% silica fume as a partial replacement of cement at 28 days is 4582 m/s .

11. The optimum Ultrasonic Pulse Velocity results of concrete with 0.12% Graphene Oxide as a partial replacement of cement at 28 days is 4957 m/s.

12. By combining a replacement of 7.5% silica fume and 0.12% graphene oxide with cement, the Ultrasonic Pulse Velocity results at 28 days is 5136 m/s.

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