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An Innovative Idea to Enhance the Compressive and Tensile Strength of 53 Grade of Ordinary Portland Cement Using Graphene Oxide (GO) Contents

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Abstract: This paper concentrated on the impact of Graphene Oxide on the compressive strength and tensile strength of 53 grade of OPC. We prepared the GO contents in laboratory followed by sonication exfoliation. We have observed that the compressive strength of 53 grade of OPC are enhanced with the substitution of GO contents from 0.02% to 0.10% at different periods e.g. 7 days, 14days & 28 days. While the tensile strength is enhanced with optimum contents of GO but beyond that limit it is further declined and make a remarkable point in tensile strength. The overall results indicate that the GO contents can significantly enhance the compressive strength and tensile strength of 53 grade of Ordinary Portland Cement to control the specific area of cement particles that is most important factor for hydration of cement

Keywords*: Graphene Oxide (GO), Ordinary Portland Cement (OPC), Compressive Strength, Tensile Strength, Weighed by wight of cement (bwoc)*

INTRODUCTION:

Cement is a crucial element in concrete technology and it is a binding material which binds the fine and coarse aggregate. When cement comes in contact with water an exothermic reaction takes place which is called hydration. Cement is composed with several chemical components e.g., tricalcium silicate, dicalcium silicate, tricalcium aluminate (C_3A, $3CaO{\cdot}Al_2O_3$), tetra calcium aluminon ferrite (C_4AF, $4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$) and gypsum ($CaSO_4{\cdot}2H_2O$). during the hydration process, several products is formed such as ettringite (AFt), Mono sulfate (AFm), calcium hydroxide (CH) and calcium silicate hydrate (C–S–H).

Hydration process does not complete at defined period due to indecorous mixing of cement with fine and coarse aggregate and water. Hardened cement gain its strength but if it does not get desired hydration, it shows hair line crack on surface and it also becomes weak in strength. The hydration process of cement is mostly affected by the distribution of cement particles because every particle should be reacted with water to complete the hydration process that's why it is most important factor to achieve the strength of cement.

To enhance the strength of cement, there are lots of materials have been used such as steel bars, steel fibers, carbon fibers, polymer fibers or minerals and other fibers. Although, this material can increase the strength of cement while their effects on the micro structure of cement particles are negligible.

Therefore, the development of a material that can enhance the distribution of cement particles is key to improving the strength and durability of cement paste.

The Graphene Oxide is arising as a crucial material to resolve the problem. It is used in the nanosheets or nano particles to give specific surface area for the hydration of cement. In this paper we have carried out an investigation to know the impact of Graphene Oxide (GO) on the specific surface area of cement particles to enhance the strength, toughness, and durability of cement paste.

METHODLOGY:

The following ways were considered to perform the compressive strength and tensile strength test on hardened cement with replacement of Graphene Oxide (GO).

Material Required: Flaky Graphite, Superplasticizer, Polycarboxylate, Water, Standard Sand & Ordinary Portland Cement (OPC)

Chemical Required: Concentrated Sulfuric Acid (H_2SO_4, 98%), Potassium Permanganate ($KMnO_4$), Sodium Nitrate ($NaNO_3$) and Hydrogen Peroxide (H_2O_2, 30%)

Standard Sand: the standard sand confirming to IS: 650-1966

Water Requirement: ((P/4) +3.0) % combined mass of cement and sand, where P is the percentage of water

required to produce a paste of standard consistency determined as described in IS: 4031 (Part 4)-1988

Preparation of GO Contents (Shenghua Lv et.al.2014)**:**
A three-necked round-bottomed beaker was placed in an ice bath (<5 °C), and 5 g flaky graphite, 60 g concentrated H2SO4 and 2 g NaNO3 were added.

The mixture was heated to 35 °C and held at this temperature for 12 h. It was then diluted with 200 mL deionized water and heated to 90 °C, following which 30 g H2O2 (0.50 mol) was added dropwise into it over a period of 1 h.
The final product was a bright yellow suspension of graphite oxide, which was then purified by filtration and washed repeatedly with deionized water until the washing water contained no SO42− and had a pH of 7.0.
A 0.2% aqueous dispersion of the graphite oxide was treated with ultrasound for 30 min to produce a dispersion of GO contents.

Preparation Cement Paste blended with Graphene Oxide

The cement samples of 53 grade of OPC are prepared by mixing the chemical components with five different proportions of GO in weight ratio of 100:0.02:0.04:0.06:0.08:0.10

Table.1 showing the chemical composition of 53 grade of Ordinary Portland Cement.

Chemical Compositions of 53 grade of Ordinary Portland Cement	
Chemical Components	**Content (wt./wt. %)**
Calcium oxide (Cao)	66.67
Silicon dioxide (SiO_2)	18.91
Aluminum oxide (Al_2O_3)	4.51
Ferric oxide (Fe_2O_3)	4.94
Alkalis (Na_2O equivalent)	0.55
Magnesium oxide (MgO)	0.87
Sulfur trioxide (SO_3)	2.5
Loss on ignition (LOI)	1.05

Vibration Machine: Vibration Machine conforming to IS: 10080-1982.

Cube Mould or Sample Size for Compressive strength: Cube Mould of 70.6 mm size conforming to IS: 10080-1982.

Briquette Sample for Tensile Strength Test:
76.20mmx25.4mm12.70mm with proportion of 1:3 add GO contents.

Compression Testing Machine: Compression Testing Machines conform to IS: 14858 (2000) and calibrated with an accuracy of ± 1% as per the requirement of 1828 (Class1).

RESULTS & DISCUSSION:

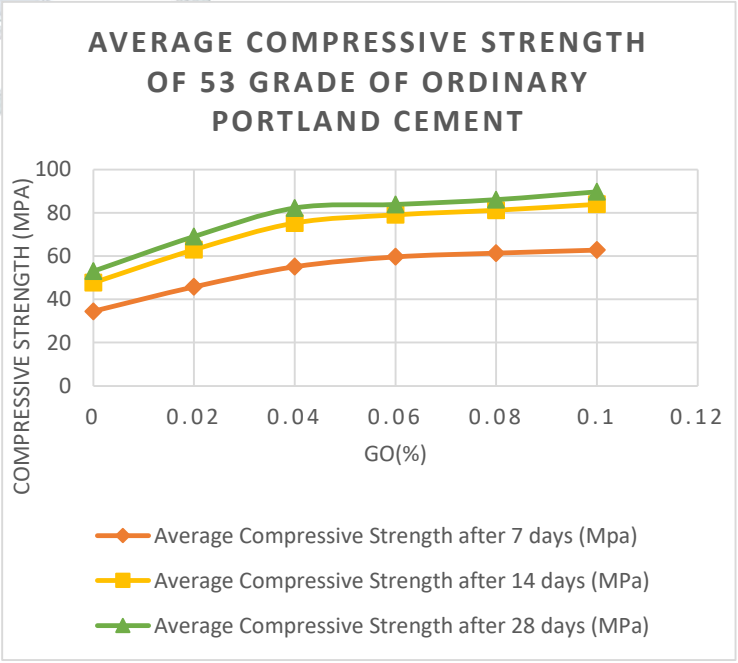
We have determined the compressive strength and tensile strength of hardened cement of 53 grade with replacement of GO at different ages.

Then, 6 g KMnO4 was slowly added to the flask over 15 min. After the solution had
turned green, the reaction mixture was maintained at 5 °C for 1 h. The mixture was heated to 35 °C and held at this temperature for 12 h. It was then diluted with 200 mL deionized water and heated to 90 °C, following which 30 g H2O2 (0.50 mol) was added dropwise into it over a period of 1 h.

The compressive strength of 53 grade of OPC at 7 days without the replacement of Graphene Oxide is 34.45 MPa and adding 0.02% GO contents, it increased with rate of 32.8% as shown in given below table.1
The compressive strength enhances with replacement of 0.06% GO contents, it is achieved 83.85 MPa at 28 days. This shows that the specific surface area of cement particles is increased with replacement of Graphene Oxide (GO), it means that high Go contents have severe effect on the compressive strength of cement.

Table.2 showing the results of compressive strength Test on 53 grade of OPC with replacement of GO contents.

GO Content (%)	Compressive Strength in MPa					
	7 days	Rate of Increase (%)	14 days	Rate of Increase (%)	28 days	Rate of Increase (%)
0.0	34.45	0.00	47.7	0.00	53	0.00
0.02	45.75	32.80	62.92	31.90	69.01	30.20
0.04	55.09	59.90	75.27	57.80	82.20	55.10
0.06	59.63	73.10	79.04	65.70	83.85	58.20
0.08	61.39	78.20	81.19	70.20	86.07	62.40
0.10	62.80	82.30	83.90	75.90	89.68	69.20

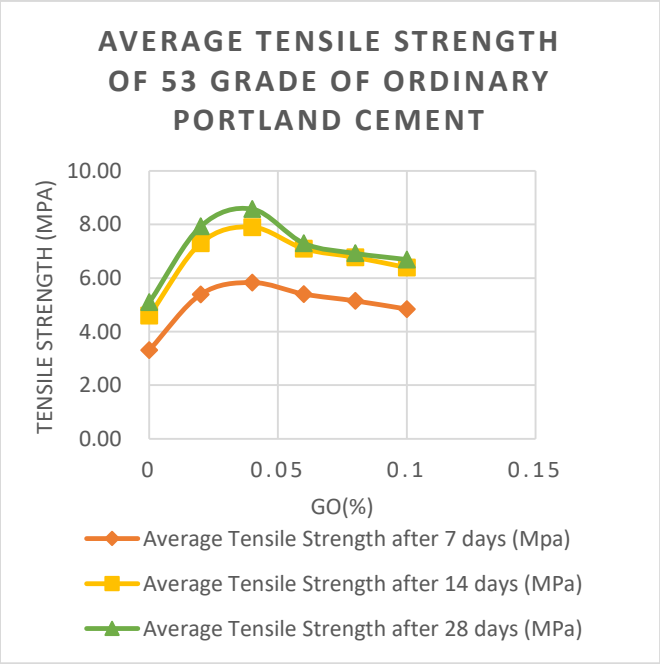


The tensile strength enhances with replacement of GO contents but it is maximum at optimum contents of GO which is 0.04% bwoc and tensile strength is 8.58MPa. Beyond the

optimum content of GO contents (0.04%), the tensile strength decreases with further replacement of GO contents. The maximum rate of increase in tensile strength is 68.2% at 28 days. This result shows that the flower -like crystals or particles are responsible for the enhance the toughness of cement.

Table.3 showing the results of Tensile strength Test on 53 grade of OPC with replacement of GO contents.

GO Content (%)	Tensile Strength in MPa					
	7 days	Rate of Increase (%)	14 days	Rate of Increase (%)	28 days	Rate of Increase (%)
0.0	3.31	0.00	4.6	0.00	5.10	0.00
0.02	5.39	62.80	7.30	58.80	7.94	55.60
0.04	5.83	76.10	7.90	71.80	8.58	68.20
0.06	5.40	63.10	7.10	54.30	7.30	43.20
0.08	5.15	55.40	6.77	47.20	6.93	35.80
0.10	4.84	46.20	6.39	38.90	6.70	31.30



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CONCLUSION:

The compressive strength of 53 grade of Ordinary Portland Cement is enhanced with replacement of GO contents.

The compressive strength of 53 grade of OPC with replacement of 0.02% GO contents indicates that the strength has been achieved 69.01MPa with rate of increase of 30.2% at 28 days

The compressive strength of 53 grade of OPC with replacement of 0.04% GO contents indicates that the strength has been achieved 82.20MPa with rate of increase of 55.10% at 28 days

The compressive strength of 53 grade of OPC with replacement of 0.06% GO contents indicates that the strength has been achieved 83.85MPa with rate of increase of 58.20% at 28 days

The compressive strength of 53 grade of OPC with replacement of 0.08% GO contents indicates that the strength has been achieved 86.07MPa with rate of increase of 62.40% at 28 days

The compressive strength of 53 grade of OPC with replacement of 0.10% GO contents indicates that the strength has been achieved 89.68MPa with rate of increase of 69.20% at 28 days

This result shows that the specific surface area of cement particles is increased with replacement of Graphene Oxide (GO), it means that high Go contents have severe effect on the compressive strength of cement.

While the tensile strength of 53 grade of OPC is enhanced with optimum GO contents. It is maximum at optimum GO contents which is 8.58 MPa at the rate of increase of 68.20% with the replacement of 0.04% GO contents. The tensile strength decreases with further replacement of GO contents. This result shows that the flower -like crystals or particles are responsible for the enhance the toughness of 53 grade of OPC.

The overall of results indicate that the GO contents can significantly enhance the compressive strength and tensile strength of 53 grade of Ordinary Portland Cement to control the specific area of cement particles that is most important factor for hydration of cement

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