ISSN: 0974-5823 Vol. 7 No. 6 June, 2022

International Journal of Mechanical Engineering

INNOVATIVE IDEA TO ENHANCE THE STRENGTH OF CONCRETE USING NANOMATERIAL GRAPHENE OXIDE (GO)

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Abstract

Graphene with excellent properties proved itself as a brilliant reinforcement material in cement composites. Due to graphene oxide materials become stronger, durable and smarter.The purpose of the present investigation is to unravel the influence of graphene oxide on the mechanical and durability properties of concrete. Mixes M15, M20, M25, M30, M35, M40 were prepared with inclusion of GO (0.10%, 0.12%, 0.14%, 0.16%, 0.20%). The mix with 0.16% of GO at 28 days has shown better results of compressive and tensile strength test compared to rest of mixes.

Keywords: Graphene, Graphene oxide, Compressive strength, Tensile strength, Water cement ratio.

Introduction

Concrete is a binding material which is made up of cement, water, fine and coarse aggregates. The binding material are cement and water when water comes in contact with cement, there takes place a chemical process called Hydration. In hydration Process, heat generates due to exothermic reaction of Tricalcium silicate (C3S), Dicalcium Silicate (C2S) with water.The aluminate (C3A) reacts with water (Calcium and sulphate ions) to form ettringite (aluminate hydrate). The hydration process of cement depends on several factors such as grinding of cement, distribution of particles size, water to cement ratio and curing period.

Heat develops rapidly during setting and initial hardening and gradually declines and finally stabilises as hydration slows. Hence, 50% of the heat is generated in the first 3 days and 80% in the first 7 (Soria, 1980). Moreover, the substantial temperature variations recorded in the first few hours may cause shrinkage, generating the cracks observed in some construction works involving large masses of concrete or structures with cement-rich mortar or concrete (Springe Schmid, 1991). All the cement constituents participate in the generation of this heat: most prominently tricalcium aluminate with 207 cal/g and free lime with 279 cal/g, while dicalcium silicate contributes the least, with 62 cal/g (M.I. Sánchez de Rojas Gómez, 2013). Due to incomplete hydration process, hair cracksappear on the massive concrete structures.

Literature review

Virginie Wiktor conducted laboratory tests to show that only 0.05% of GO is needed to improve flexural strength of an OPC matrix from between 41% to 59% and compressive strength between 15% to 33%. Laboratory tests also show that the addition of 0.05% GO improves pore structure and decreases total porosity from 32.6% to 28.2%, providing higher compressive strength and a more durable product. The addition of GO improves the degree of hydration of the cement paste andincreases the density of the cement matrix, creating a more durable product.

AhmadrezaSedaghat, A. Zayed studied the incorporation of graphene nanoparticles in cement paste showed interesting modifications in microstructural, morphological, electrical and thermal properties of the paste. Thermal diffusivityand electrical conductivity were found to increase with increasing the graphenecontent in the composite. The increase in thermal diffusivity of the hydrated graphene cement composite is a clear indication of the heat sink capacity of graphene. This effect is of significant importance especially during the exothermic reactions taking place during the initial stages of hydration of portland cement. The hydratedgraphene-cement samples indicate the presence of graphitic plane in the composite structure. The rod or needle-shaped morphology of ettringite, which is typically observed in hydrated cement paste, was less prevalent in the graphene composites and appeared to be affected by graphene content. The metal oxides in cement act as acatalyst for the oxidation of graphene at higher temperatures (600˚C to 750˚C), regardless of the quantity of graphene present in cement-based composite. The impact of the incremental increase of graphene on the electrical conductivity of thecomposites indicates the potential of using graphene in application where electrostatic dissipation (ESD) of charge is desirable.

Fakhim Babak, HassaniAbolfazl synthesized GO via exfoliation of graphite oxideprepared by a colloidal suspension route and was used to prepare GO-cement nanocomposites (GCNC) using an ultrasonic method. A polycarboxylate super plasticizer (0.5 wt% of cement) was used to improve the adhesion properties of the GO and uniformly disperse it in the cement matrix. Use of an optimal percentage (1.5wt %) of GO nanoplatelets caused a 48% increase in the tensile strength of the cement mortar specimens. Moreover, using FE-SEM observation of the fracture surface of the samples containing 1.5wt% GO revealed that the GO nanoplatelets were well dispersed and no GO agglomerates were seen in the matrix. In addition, XRD data shows growth of the calcium silicate hydrates (C-S-H) gels in GO cement mortar compared with the normal cement mortar. It can be because of the nucleation of C-S-H by the GO flakes which was shown in FESEM images. The hydrated cement products deposited on the GO flakes due to their higher surface energy and the presence of hydrophilic groups on the GO surfaces acted as a nucleation site. The results indicated that the main reason for the observed high bond strength was the nucleation of C-S-H by the GO flakes and its formation along them. FE-SEM observation also revealed microcracks in the GO flakes, implying that the GO flakes stretched across microcracks in the mortar. The breakage observed indicated that very high stresses were applied to the GO flakes. Because the theoretical tensile strength of GO flake is very high, more GO flakes are needed to carry stresses. The tensile strength of specimens containing 2 wt% GO flakes was much less than that of the control samples. This behaviour was justified by taking into account that GO was hydrophilic enough to absorb most of the water contained in the cement mortar, hampering the proper hydration of the cement mortar and making dispersion of the GO within the matrix difficult. This hypothesis was confirmed by the 24.7% increase obtained in the tensile strength of specimens containing 2wt% GO at a water/cement ratio of 0.5 compared with that of the sample containing 2.0wt% GO at a water/cement ratio of 0.4.

Objective:

1. To analyze the compressive strength and Split Tensile Strength of M15 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%
2. To analyze the compressive strength and Split Tensile Strength of M20 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%
3. To analyze the compressive strength and Split Tensile Strength of M25 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%
4. To analyze the compressive strength and Split Tensile Strength of M30 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%
5. To analyze the compressive strength and Split Tensile Strength of M35 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%
6. To analyze the compressive strength and Split Tensile Strength of M40 Grade of concrete replacing Graphene Oxide from 0.1%, 0.12%, 0.14%, 0.16% & 0.2%.

Methodology:

Selection of sample was done as per IS code:516-1959. All the materials was taken at room temperature (27+3) and atmospheric pressure. Before the proportioning all ingredients was well prepared, cement was thoroughly mixed in dry state to ensure the greatest blending and uniformity in the material and fine and coarse aggregates were separated through IS 480 Sieve.

S**ample Size for Compressive Strength Test** :150mmx150mmx150mm, Cube shape

Sample Size for Tensile Strength Test : 150mm Dia and 300mm in Depth, cylindrical shape

Cement: Ordinary Portland Cement (OPC) of 53 Grade was used to prepare the sampling as per IS Code: 383-1970

Fine Aggregates: Grading zone-II of IS Code**:**383-1970, Specific Gravity is 2.6

Coarse Aggregates: Granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383 – 1970. Its specific gravity is 2.75.

Chemical Admixture: Graphene Oxide (GO) & Gypsum to enhance the strength of concrete

Water : Potable water as per IS:456-2000 was used to prepare the sampling

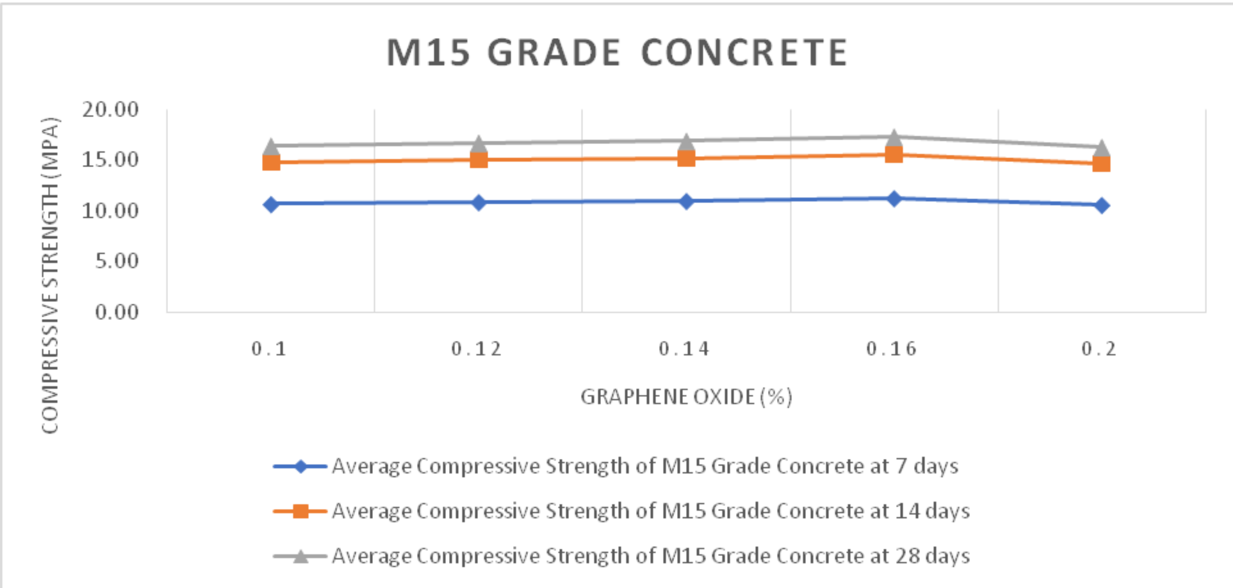
The different grade of concrete such as M15, M20, M25, M30, M35 & M40 were based on IS: 10262-2009 and water cement ratio as follows.

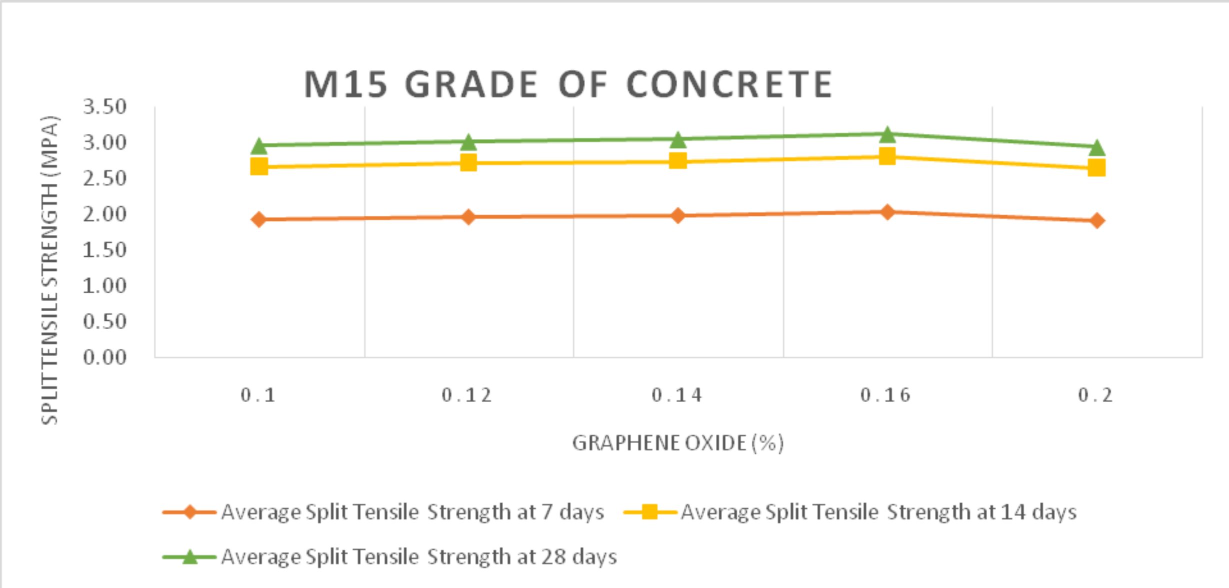
Grade of Concrete	Proportioning (Cement: FineAggregate: Coarse Aggregate)	Water Cement Ratio	Reference
M15	1:2:4	0.55	IS:456-2000 (Clause» 6.1.2, 8.2.4.1 and 9.1.2)
M20	1:1.5:3	0.55	
M25	1:1:2	0.50	
M30	1:0.75:1.5	0.45	
M35	1:0.5:1	0.45	
M40	1:0.25:0.5	0.40	

Analysis and discussion:

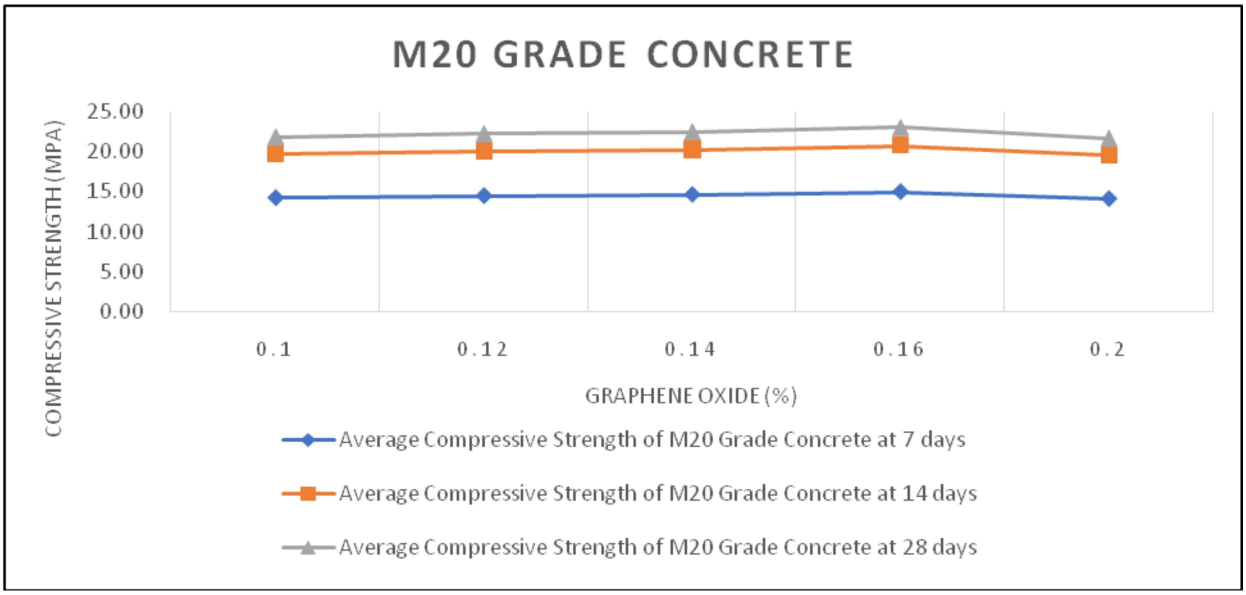
The results of compressive strength test and tensile strength test are shown in given below tables

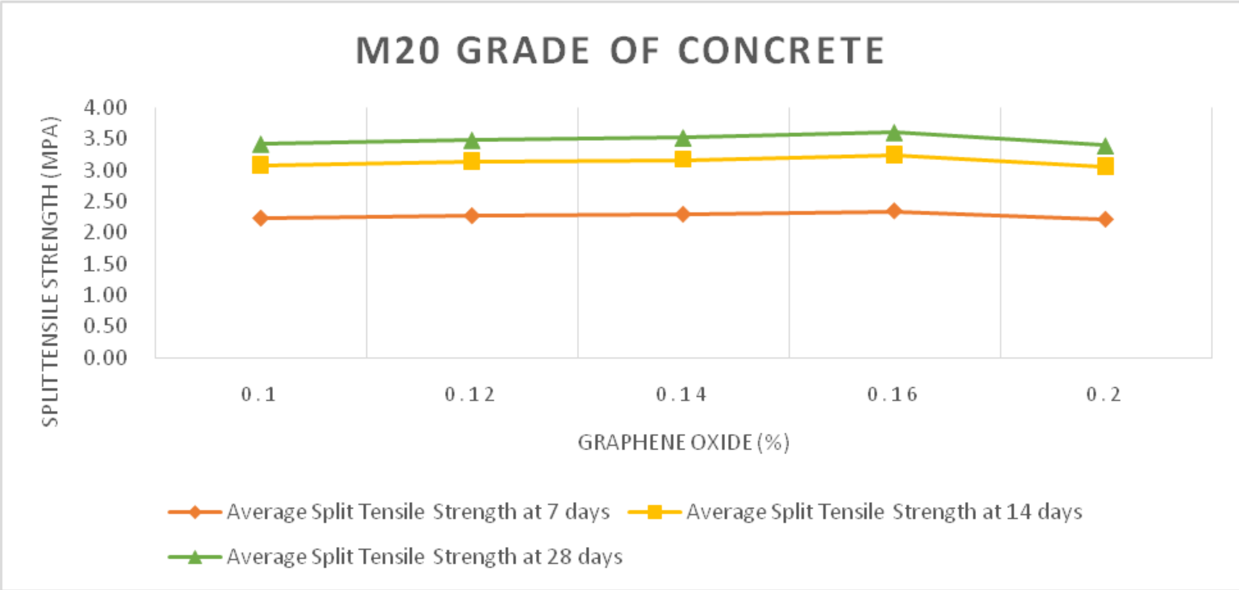
S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M15	0.10	10.66	1.93	14.75	2.67	16.39	2.96
2	M15	0.12	10.84	1.96	15.02	2.71	16.68	3.02
3	M15	0.14	10.96	1.98	15.18	2.74	16.86	3.05
4	M15	0.16	11.22	2.03	15.54	2.81	17.27	3.12
5	M15	0.20	10.57	1.91	14.64	2.65	16.26	2.94



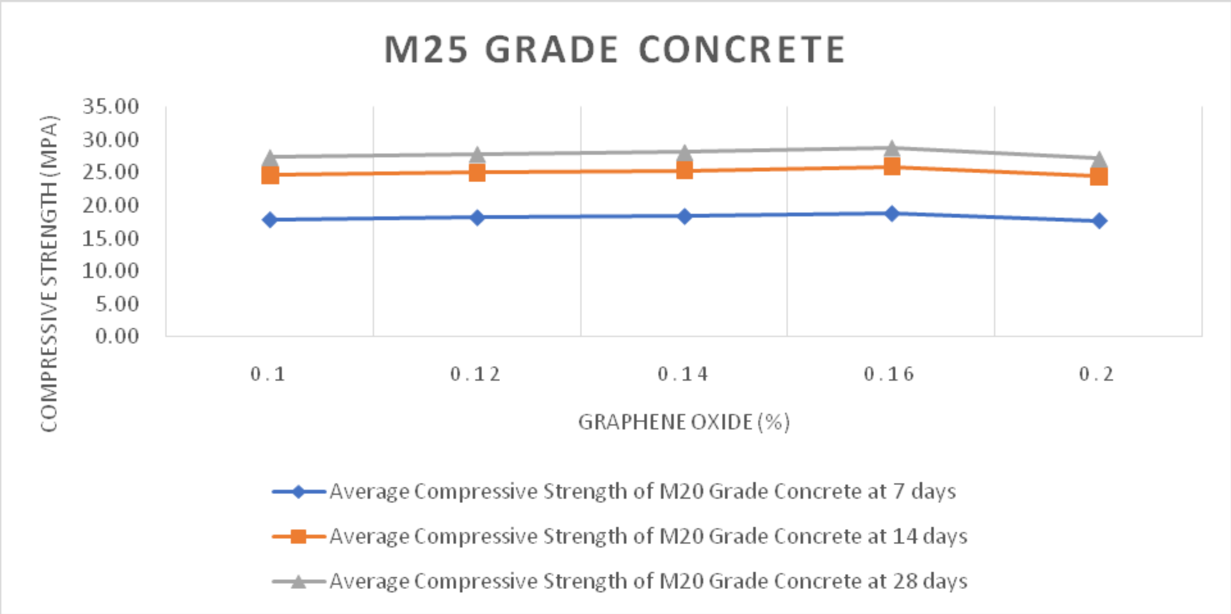


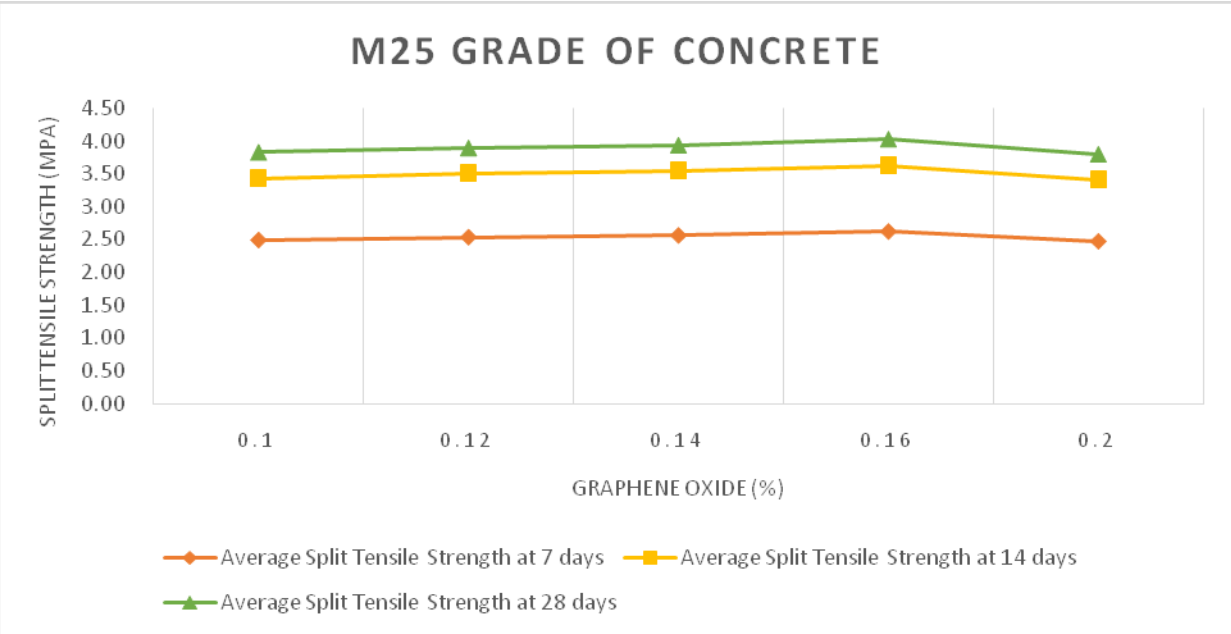
S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M20	0.10	14.21	2.22	19.67	3.08	21.86	3.42
2	M20	0.12	14.46	2.26	20.02	3.13	22.25	3.48
3	M20	0.14	14.61	2.29	20.23	3.17	22.48	3.52
4	M20	0.16	14.96	2.34	20.72	3.24	23.02	3.60
5	M20	0.20	14.09	2.21	19.52	3.05	21.68	3.39



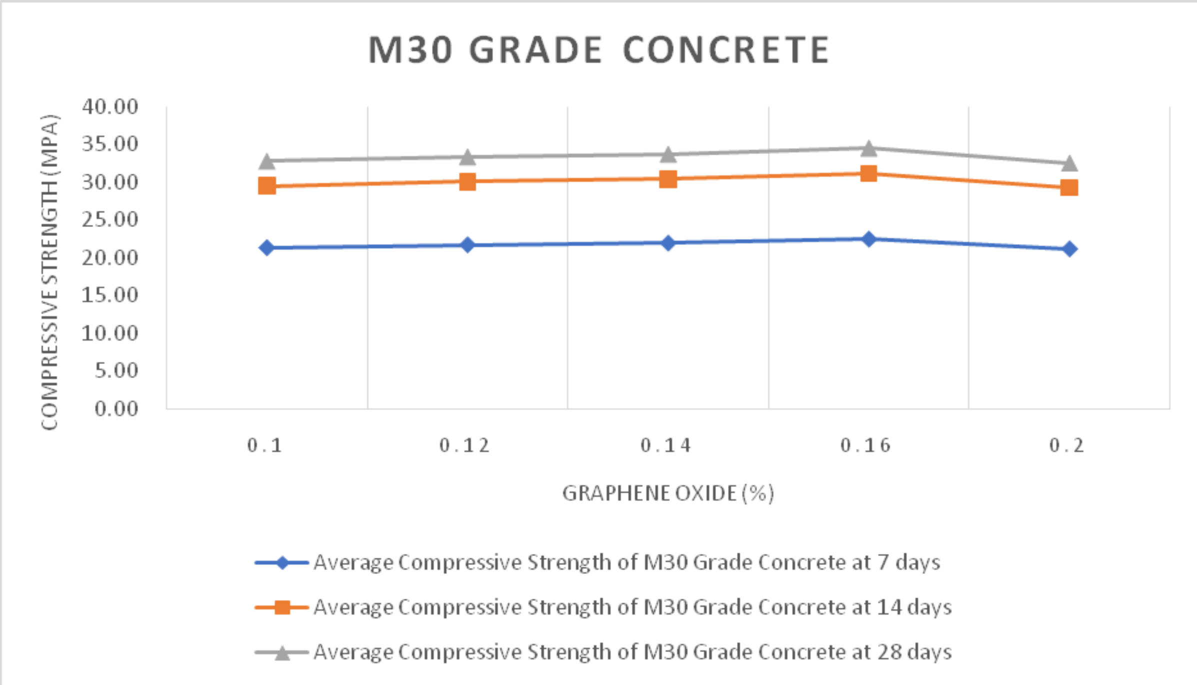


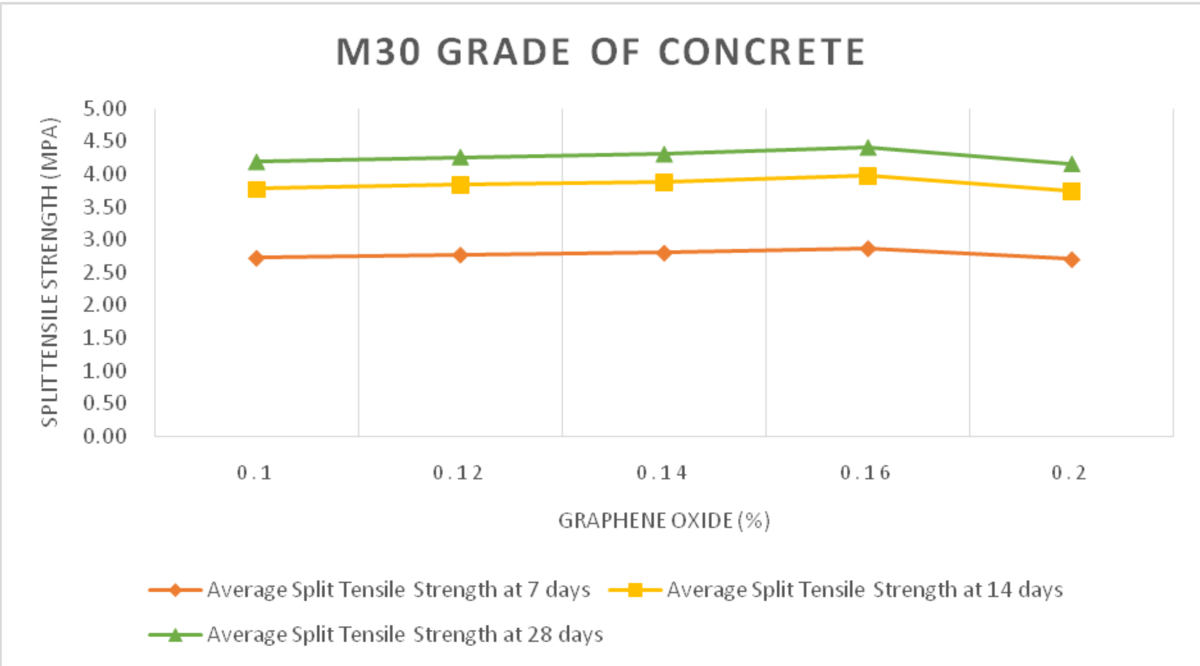
S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M25	0.10	17.76	2.49	24.59	3.44	27.32	3.83
2	M25	0.12	18.07	2.53	25.03	3.50	27.81	3.89
3	M25	0.14	18.27	2.56	25.29	3.54	28.10	3.93
4	M25	0.16	18.71	2.62	25.90	3.63	28.78	4.03
5	M25	0.20	17.62	2.47	24.39	3.42	27.11	3.79



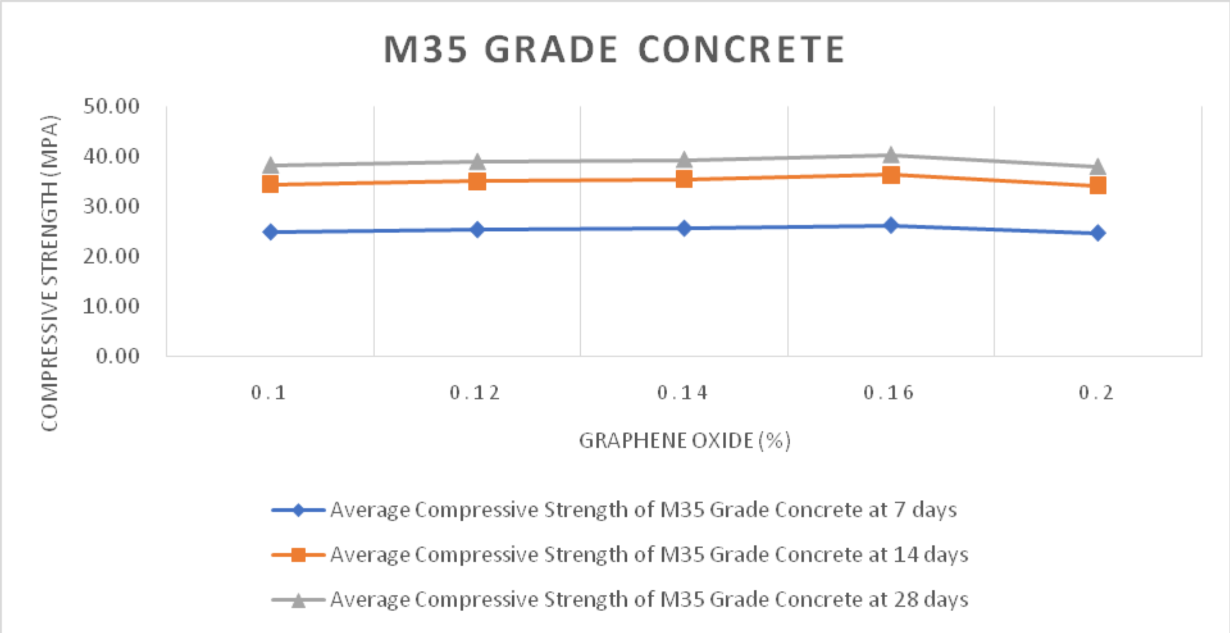


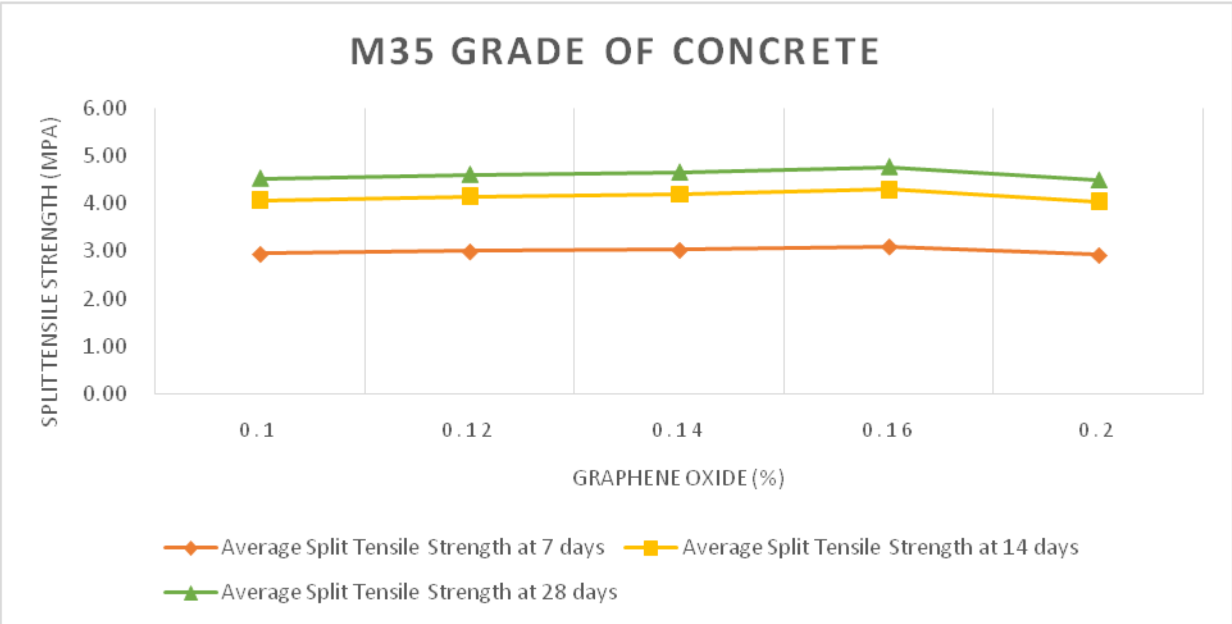
S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M30	0.10	21.31	2.72	29.51	3.77	32.79	4.19
2	M30	0.12	21.69	2.77	30.03	3.84	33.37	4.26
3	M30	0.14	21.92	2.80	30.35	3.88	33.72	4.31
4	M30	0.16	22.45	2.87	31.08	3.97	34.53	4.41
5	M30	0.20	21.14	2.70	29.27	3.74	32.53	4.16



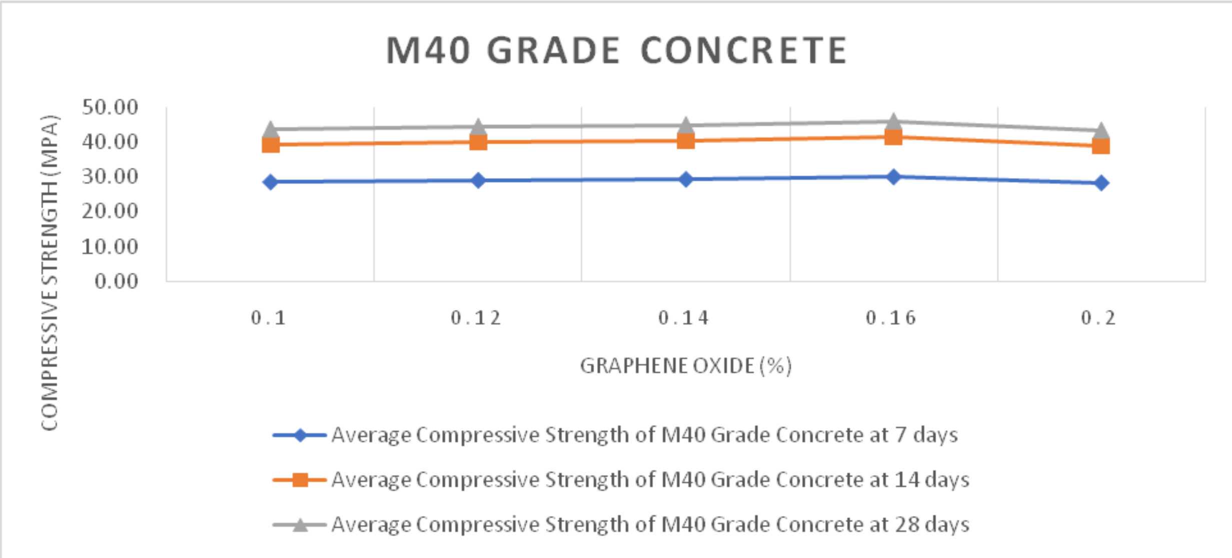


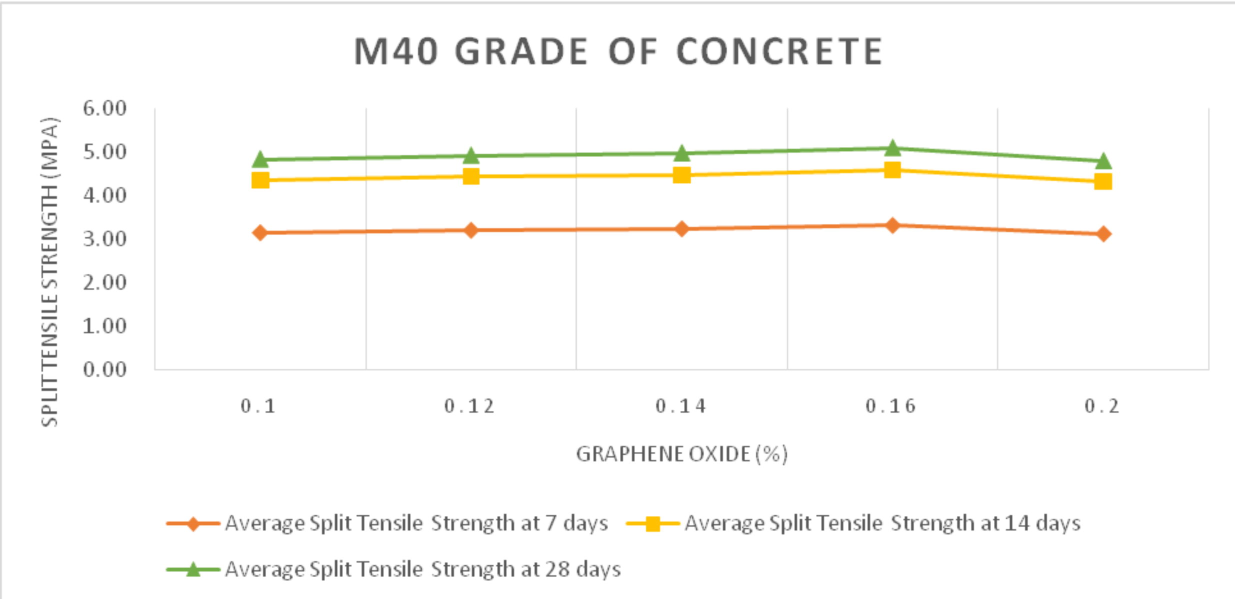
S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M35	0.10	24.86	2.94	34.43	4.07	38.25	4.53
2	M35	0.12	25.30	2.99	35.04	4.15	38.93	4.61
3	M35	0.14	25.57	3.03	35.41	4.19	39.34	4.66
4	M35	0.16	26.19	3.10	36.26	4.29	40.29	4.77
5	M35	0.20	24.67	2.92	34.15	4.04	37.95	4.49





S.No.	Grade of Concrete	GO % of Cement	Compressive Strength and Tensile Strength of Concrete in MPa					
			After 7 Days		After 14 days		After 28 days	
			F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)	F_c (MPa)	F_{st} (MPa)
1	M40	0.10	28.42	3.15	39.34	4.35	43.72	4.84
2	M40	0.12	28.92	3.20	40.04	4.43	44.49	4.92
3	M40	0.14	29.23	3.23	40.47	4.48	44.96	4.98
4	M40	0.16	29.93	3.31	41.44	4.59	46.04	5.10
5	M40	0.20	28.19	3.12	39.03	4.32	43.37	4.80





Conclusion

The compressive strength and tensile strength of several grades of concrete are increased with replacement of GrapheneOxide.

The compressive strength of several grades of concrete such as M15, M20, M25, M30, M35 & M40 with replacement of 0.10%, 0.12%, 0.14%, 0.16% & 0.2% Graphene Oxide (GO)indicatee that the strength increased up to 9.29%, 11.23% 12.41%, 15.11% & 8.42% respectively while the tensile strength increased up to 9.0%, 11%, 12%, 15% & 8% respectively.

Graphene Oxide (GO) in %	Enhance Compressive Strength (%)		
	After 7 days	After 14 days	After 28 days
0.10	4.5	5.2	9.29
0.12	5.4	6.7	11.23
0.14	6.2	7.3	12.41
0.16	7.4	8.8	15.11
0.20	4.4	5.1	8.42

Graphene Oxide (GO) in %	Enhance Split Tensile Strength (%)		
	After 7 days	After 14 days	After 28 days
0.10	4.4	5.1	9.00
0.12	5.2	6.2	11.00
0.14	6.3	7.1	12.00
0.16	7.4	8.2	15.00
0.20	4.2	5.0	8.00

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