STUDY ON THE MODIFICATION OF MICRO STRUCTURE OF CONCRETE USING GRAPHENE AS ADMIXTURE

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Abstract: Cement is the only reliable construction material which imparts strength and durability to the structures constructed out of it. But it emits CO_2 greatly which is dangerous to environment. So, the replacement of cement in concrete or reducing the need of cement is important. In this research, the chemical admixture Graphene is added to the concrete , investigated and the strength increased due to Graphene as a results of modification in microstructure of the concrete is found. In this study, Concrete specimens are to be casted with and without adding graphene as admixture to investigate the mechanical properties of concrete. The increase in strength may be recommended to reduce the size of the concrete members for the same loading condition or the load can be increased for the same concrete section. Since the size of the concrete is reduced, amount of cement to be used will also be reduced. To study the effect of Graphene in this research, M25 grade concrete is proposed. The optimum percentage of Graphene is obtained from trial mixes of Graphene added in 0.01%, 0.03% & 0.05%. At last, the test results of the specimens cast for finding the optimum percentage of Graphene was compared with the ordinary conventional concrete to predict the benefits of the admixture and strength of the concrete under the influence of Graphene as admixture and finally results will be concluded.

Key words: *Graphene, microstructure, optimum percentage of graphene, admixtures, mechanical properties.*

I. INTRODUCTION:

Concrete is composed principally of aggregates, Portland cement, and water, and may contain other cementitious materials and/or chemical admixtures. It will contain some amount of entrapped air and may also contain purposely entrained air obtained by use of admixture or air- entraining cement. Chemical admixtures are frequently used to accelerate, retard, improve workability, reduce mixing water requirements, increase strength, or alter other properties of the concrete. The selection of concrete proportions involves a balance between economy and requirements of strength, durability, density, and appearance. Concrete proportions must be selected to provide workability, consistency, density, strength, and durability, for the particular application.

Concrete has low tensile strength and hence cracks easily. Therefore, concrete is to be reinforced with steel bars and meshes. Fresh concrete shrinks on drying and harden concrete expands on wetting. Provision for contraction joints has to be made to avoid the development of cracks due to drying shrinkage and moisture movement. Concrete expands and contracts with the changes in Temperature. Hence expansion joints have to be provided to avoid the formation of cracks due to thermal movement. Concrete under sustained loading undergoes creep resulting in the reduction of prestress in the prestressed concrete construction. Concrete is not entirely impervious to moisture and contains soluble salts which may cause efflorescence. Concrete is liable to disintegrate by alkali and sulphate attack. The lack of ductility inherent in concrete as a material is disadvantageous with respect to earthquake resistant design.

II. MATERIALS AND METHODS

Admixture is an optional ingredient of concrete which is added to modify the properties of fresh, hard concrete and grout materials as per some requirements. As per IS: 9103- 1999 Page No.1, Concrete Admixture is defined as a material other than water, aggregates and hydraulic cement and additives like Pozzolana or slag and fiber reinforcement, used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state.

III. GRAPHENE

It is an allotrope of carbon consisting of a single layer of Graphite (pure crystalline carbon) arranged in a hexagonal lattice. A modern material with unique physical properties that could reshape our future.

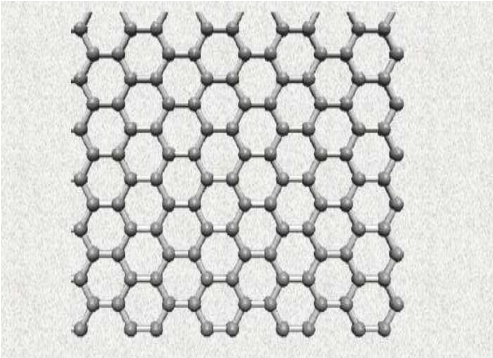

Figure.1- Single layer of carbon atoms

Graphene has been impractical to use in construction since its discovery. In theory, it is an excellent material, as it is incredibly lightweight while being stronger and stiffer than both steel and carbon fiber. potentially, it could be combined with more traditional materials to create stronger beams and cables, allowing for more impressive structures. They are seperated from graphite flakes either by mechanical exfoliation or by chemical exfoliation or by liquid exfoliation.

IV. SPECIFICATIONS OF GRAPHENE USED

- Purity : 99 % (approx.)
- Thickness : 2 – 5nm
- Surface area : 380 m^2/g
- Number of layers : 2 – 4
- Concentration : 0.5 %
- Diameter : 5 to 10 micron
- İngridents : distilled water

V. METHODS:

Cement with specific gravity of 3.12 and conforming to IS code was used to produce concrete of grade M25. M Sand and coarse aggregate confirming to relevant IS code was obtained from a reliable sorce near Tirunelveli . Potable water as per IS 456- 2000 was drawn from a nearby well to cast the specimens. As per IS 10262: 2009, the proportion of concrete grade M25 was arrived as 1: 1.87 :3.58. The materials so proportioned as per the mix ratio, has been used to cast specimens with and without graphene. The dosage of graphene was varied like 0.01%, 0.03% and 0.05% by the weight of cement. Since the cost of graphene is high , a tiny amount of dosage by weight of cement increased the strength like compressive strength , flexural strength and tensile strength of concrete to a greater extent.

VI. RESULT AND DISCUSSION

The materials are tested as per IS codal provision. The mechanical properties of hardened concrete like compressive strength, splıt tensıle strength and flexure strength of concrete at the age of 7, 14 and 28 days were determined. The compressive strength of concrete was carried out as per IS516-1959. Concrete specimens of 150 x 150 x150 mm cubes were cast with different types of admixture percentages. After 24 hours the specimens were demoulded and subjected to curing for 28 days in ordinary tap water. After the curing period was over, the cubes were tested in the Compression Testing

Machine (CTM) of capacity 2000kN, at the rate of loading of 140 kN/minute. Fig.12 shows the compression test setup on concrete cube specimen. The ultimate load at which the cube failed was taken. Tests were carried out on three specimens and average compressive strength values were recorded.

Table 1 Compressive strength test at 7 days.

Cube No	Compressive strength at 7 days (N/mm^2)			
	0 % graphene	0.01 % graphene	0.03 % graphene	0.05 % graphene
1	21.364	25.724	27.468	26.16
2	22.672	26.596	28.34	26.59
3	21.79	25.528	27.904	25.98
Average	21.94	25.95	27.90	26.24

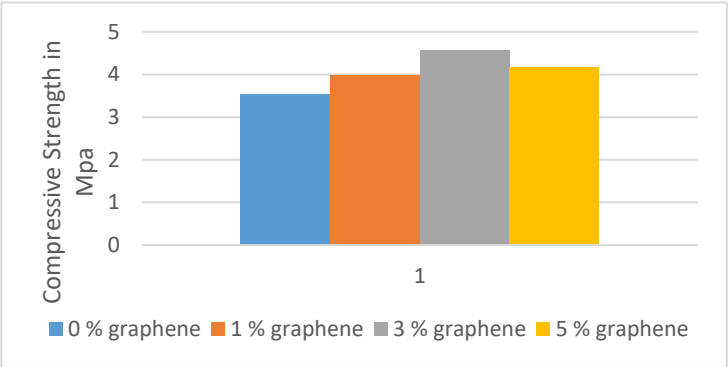

Figure. 2. Comparison of Compressive Strength results at 7 days

Table 2 Compressive strength test at 28 days

Cube No	Compressive strength at 28 days (N/mm^2)			
	0 % graphene	0.01 % graphene	0.03 % graphene	0.05 % graphene
1	31.393	37.5	44.91	39.93
2	34.22	39.24	42.06	41.26
3	32.16	37.06	42.73	39.53
Average	32.59	37.93	43.23	40.24

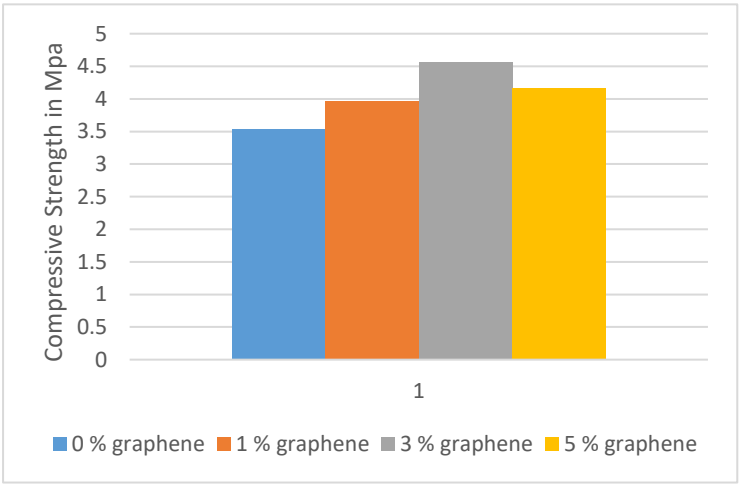

Figure. 3. Comparison of Compressive Strength results at 28 days

Split tensile test was carried out as per ASTM C496-90. Concrete cylinders of size 150 mm

diameters and 300 mm height were cast. During casting, the cylinders were mechanically vibrated using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After the specified curing period was over, the concrete cylinders were subjected to split tensile test by using universal testing machine. Tests were carried out on three specimens and the average split tensile strength values were recorded..The method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter.it is an indirect method of testing tensile strength of concrete.

Table 3 Split tensile strength test at 7 days.

Cube No	Split tensile strength at 7 days (N/mm^2)			
	0 % graphene	0.01 % graphene	0.03 % graphene	0.05 % graphene
1	1.54	2.05	2.96	2.01
2	2.18	2.35	2.73	2.38
3	1.87	2.24	2.82	2.29
Average	1.86	2.21	2.84	2.23

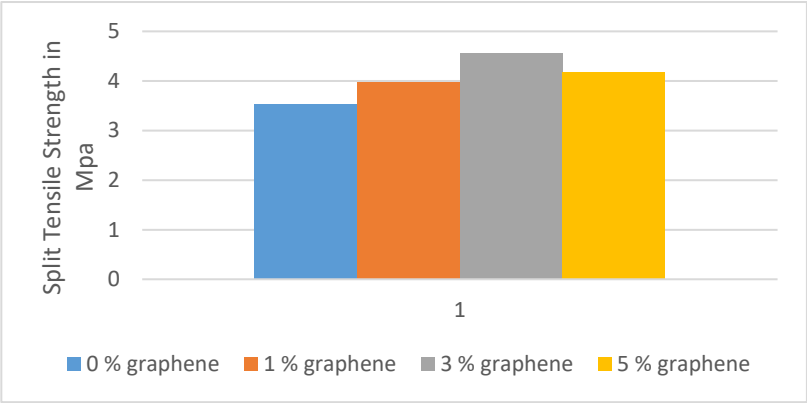

Figure. 4. Comparison of Split Tensile Strength results at 7 days

Table 4 Split tensile strength test at 28 days

Cube No	Split tensile strength at 28 days (N/mm^2)			
	0 % graphene	0.01 % graphene	0.03 % graphene	0.05 % graphene
1	3.74	3.38	3.88	3.69
2	3.12	3.57	4.16	3.91
3	2.81	3.48	4.23	3.64
Average	3.22	3.48	4.09	3.75

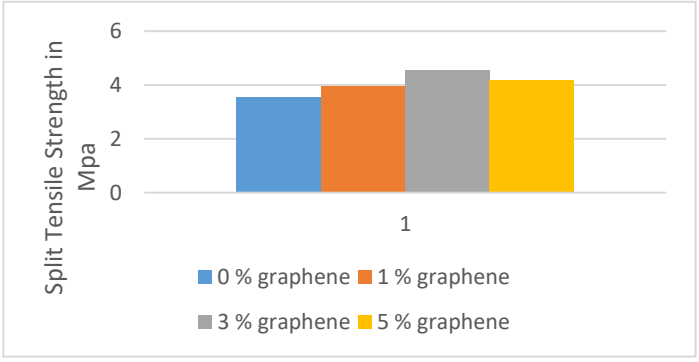

Figure. 5. Comparison of Split Tensile Strength results at 28 days

Flexural strength test was carried out as per IS516-1959 by casting concrete beams of size 500 x 100 x 100 mm size. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After the specified curing period was over, the 12 concrete specimens were subjected to flexural test by applying two-point loading using UTM. It is also known as modulus of rupture bend strength or fracture strength mechanical parameter for brittle material is defined as a material ability to resist deformation under load.

Table 5 Flexure strength test at 28 days

Cube No	Flexure strength at 28 days (N/mm^2)			
	0 % graphene	0.01 % graphene	0.03 % graphene	0.05 % graphene
1	3.37	3.93	4.552	4.12
2	3.584	3.92	4.624	4.34
3	3.656	4.05	4.512	4.05
Average	3.54	3.97	4.56	4.17

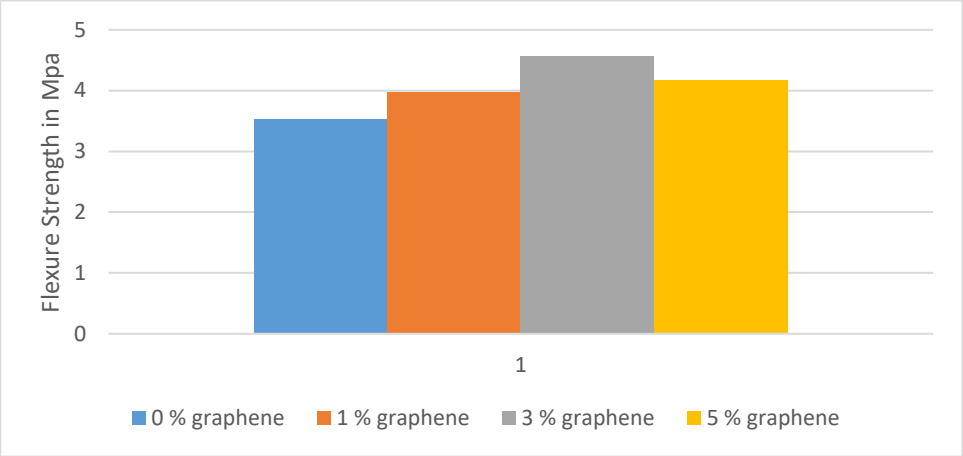

Figure. 6. Comparison of Flexure Strength results at 28 days

While comparing compression, split tensile and flexural strength of the concrete specimens with variation of graphene fibers with 0% to 5%, specimens with 3% graphene gives better results in all the strengths. So the optimum percentage of graphene was found as 3%. RC Concrete beams with no graphene and 3% graphene was casted and the flexure test was carried out and the results were compared.

Table 6 Deflection of beam for conventional concrete & 3 % mix

S.NO	LOAD (KN)	DEFLECTION (mm)	
		0 % graphene	0.03 % graphene
1.	0	0	0
2.	4.5	0.82	8.5
3.	9.0	2.03	1.97
4.	13.5	3.39	3.10
5.	18.0	5.11	4.48
6.	22.5	11.26	11.20
7.	24.3	18.11	12.41
8	27.0	-	13.35

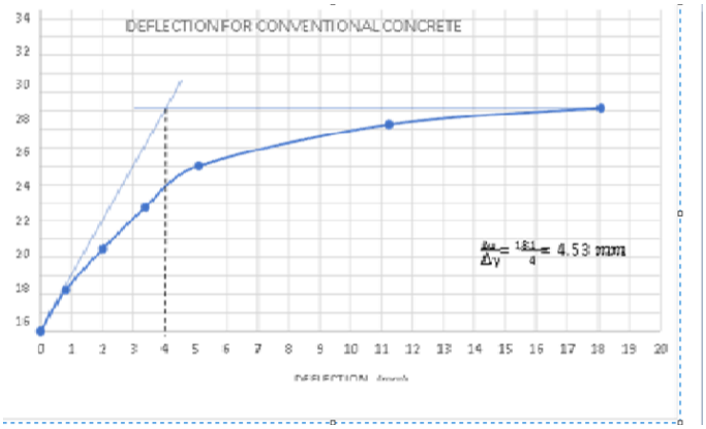

Figure 7 Deflection of beam for conventional concrete

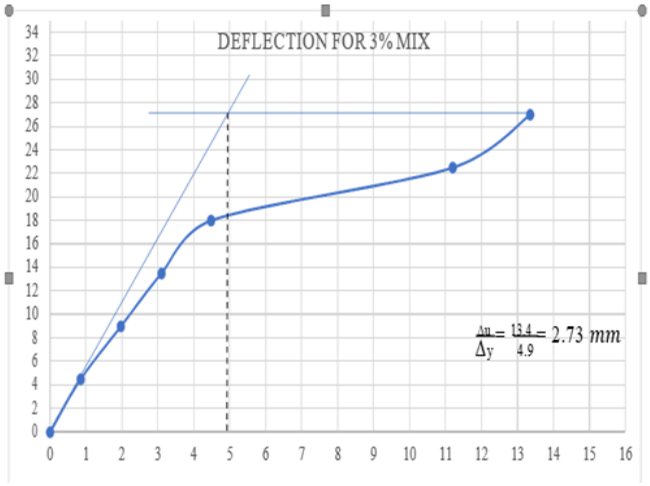

Figure 8 Deflection for 3% mix

VII. CONCLUSION

From this project it is observed that the usage of Graphene as an admixture in the concrete greatly increases the strength of the concrete. It is important to know the specifications of the graphene to be used since it defines the percentage of the graphene going to be used. Based on the percentage of Graphene, strength of the concrete differs. For us, for these specifications of graphene, optimum percentage of graphene is 3%. To find this optimum percentage, three trial mixes 0.01%, 0.03% and 0.05% of graphene to the weight of the cement is taken. The strength of the concrete increases to the maximum at 0.03% and when taking nearer to 0.03% such as 0.025%, 0.0275%,0.03%, the strength of the concrete increases at 2.75%. So, the graphene percentage in this project is finalized as 0.025% and 0.03%. These two percentages are added to the concrete and casted as cube, cylinder and prism to find compression, split tension and flexure respectively. These results are compared with the conventional concrete and found that the compressive strength of the concrete is increased by 29% for 0.025% and 46% for 0.03%. Whereas the strength of the tension is increased by 40.5% for 0.03% during the indirect tension test (Split tensile test) and 74.8% for 0.03% during the direct tension test (Flexure test). In addition to this it is also observed that deflection of the reinforced concrete while using 0.03% of graphene to the weight of the cement also decreases and ductility ratio decreased from 4 to 2.73 which consequently increases the strength of the concrete. From the results it is observed that the compressive strength, tensile strength and ductility of the concrete has been increased greatly. So, the usage of graphene in construction industry will greatly help to decrease the size of the concrete section which reduces the amount of materials, including cement. As a result of this, the amount CO_2 emission will also be reduced. Since this concrete reduces the CO_2 emission.This is ecofriendly.

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