A FEASIBILITY STUDY ON GRAPHENE WITH CEMENT CONCRETE

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ABSTRACT

Concrete is one of the most widely recognized material. Superiority of concrete over other construction material is due to high compressive strength along with other advantages such as water resistant, low maintenance cost, ease in mould ability to required size and shape, less energy input in manufacture and so on. Thus, concrete requires some form of tensile reinforcement. In this study graphene is added to the M30 grade of concrete to improve the compressive strength, flexural strength, split tensile strength and to prevent the cracking of concrete subjected to tensile stress. The process of mixing water with graphene is known as "High Shear Exfoliation". The contrast between concrete and graphene is quite stark. Graphene reinforced concrete also minimizes the "Alkali-Silica Reaction". In this project, to investigate the graphene and its derivatives with cement composites. The graphene is used in this study contained functional groups with silicon oxides, which were polymerized and inactive for chemical interaction with the cement hydrates. Graphene also works as anti-corrosion coating We are conducting experiments on concrete specimens of cubes size (150x150x150)mm and beams (500x100x100) mm with addition of various percentages of graphene i.e. 0.5 %, 1.0%, 1.5% and 2.0% by weight of cement and results were compared with those of normal cement concrete. For each percentage of graphene added in concrete specimens were tested for their respective mechanical properties at curing periods of 7, 14 & 28 days. The results were obtained the "Optimum Strength of Concrete".

Keyword : - *Graphene, Cement, Hydrates, graphene powder, Flexural strength of concrete etc.….*

1.INTRODUCTION

Graphene invented by Konstantin Novoselor and Andre Geim. It is relatively new in the market, which are recently used in several studies as micro reinforcements for the concrete. According to Sobolev and Guttierez (2005) Nanotechnology can change the world and specifically for cement-based materials, focusing on their structure at the nanoscale will possibly give us more information on how we could become stronger with increased durability, increased strain capacity and other innovative properties. It is noted that the graphene easily dispersed within the concrete mix without causing segregation and thegraphene lose their shape due to the flexible structure. Graphene is a high strength material with high elastic modulus, high thermal stability, chemical stability and electrical characteristics.

Graphene could possibly integrate into the cement paste or mortar and strengthen the bonds of the cement hydrates. As a result, the fundamental properties of cement and especially its tensile, flexural and compressive could be improved. Graphene can self repair holes, when exposed to molecules containing carbon such as hydrocarbons. Bombarded with pure carbonatoms, the atoms are perfectly align into hexagons completely filling the holes. It is an allotrope of carbon in the form of a plane od sp2 bonded atoms with a molecular bond lengthof 0.142 nanometers.

1.1 BENEFITS OF USING GRAPHENE

The three main benefits provided by graphene in concrete are in terms of volume, strength, and water resistance of concrete.

• Graphene in concrete alters the chemistry of concrete, making it stronger and durable.
• The volume of concrete is decreased by 15%, reducing the heat emitted during hardening.
• Graphene in concrete increases flexural strength by 70%, which reduces the amount of steel reinforcement.
• The water resistance of concrete is increased by 300%, extending the service life and saving cost from maintenance.

1.2 **LITERATURE REVIEW**

Chandrasekaretal (2019): This paper involves a study on the mechanical properties of graphene. It was observed that graphene can definitely a potential building material having higher thermal stability and higher mechanical properties. In this paper increase in compressive, splitting tensile, flexural strength and elastic modulus of concrete at 28 days having 0.05% by weight of graphene increase the 53% compressive strength and 79% tensile strength, 1.5% weight of graphene increase the 8-9% young's modulus and 2.0% weight reduces the 31% porosity.

Sam Ghazizadeha et al. (2018): Investigated the effect of graphene powder on concrete mechanical and durabilites properties. By increasing graphene percentage (0%, 0.5%, 1.0%,1.5%, 2.0%) with respect to cement weight in a certain dosages we can observe there is a certain amount of change in Mechanical (Tensile, Compressive & Bending Strength) Properties & Durability Properties. We can compare above properties with respect to other design mixes without graphene content.

2. MATERIALS AND PROPERTIES

MATERIALS USED

In this investigation, the following materials were used:

- Ordinary Portland Cement of 53 Grade cement conforming to IS:10262-2019 Fine aggregate and coarse aggregate conforming to IS: 10262-2019.
- Water.
- Graphene powder

2.1 Properties Of Materials

CEMENT (IS: 10262-2019):
Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non specialty grout. It developed from other types of hydraulic lime in England in mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker, we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn't be less than 53MPa or 530 kg/cm2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also..Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being affected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 10262-2019 and for chemical requirement in accordance IS: 4032-1988.The physical properties of the cement are listed in Table – 1

Fig 1: Cement sample Table-1 Properties of cement

SL.NO	Properties	Test results	IS: 10262-2019
1.	Normal consistency	0.45	
2.	Initial setting time	30min	Minimum of 30min
3.	Final setting time	598min	Maximum of 600min
4.	Specific gravity	3.14	

FINE AGGREGATES (IS: 10262-2019):

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral.Hence, it is used as fine aggregate in concrete.River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.The sand was surface dried before use.

Fig 2: Fine aggregate sample

Table 2: Properties of Fine Aggregate

S.No	Description Test	Result
1	Sand zone	Zone- III
2	Specific gravity	2.63
3	Free Moisture	0.01
4	Fineness modulus	3.19

COARSE AGGREGATES (IS: 10262-2019):

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386- 1963. The individual aggregates were mixed to induce the required combined grading. The particular specific gravity and water absorption of the mixture are given in table.

Fig 3: Coarse aggregate sample

Table 3: Properties of Coarse Aggregate

S.No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.837
3	Fineness modulus	7.22
4	Water absorption	0.15%

WATER:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding take place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9 .

GRAPHENE POWDER

Graphene is a wonder material, it is the world's strongest man made material. Graphene is composed of carbon atoms arranged in a honey comb lattice pattern. The structure is nearly transparent to one atom thickness. Graphene can self repair holes, when exposed to molecules containing carbon such as hydrocarbons. Bombarded with pure carbon atoms, the atoms are perfectly align into hexagons completely filling the holes. It is an allotrope of carbon in the form of a plane od sp2 bonded atoms with a molecular bond length of 0.142 nanometers.

Fig 4: GRAPHENE POWDER

2.2 FINAL MIX PROPORTIONS:
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C	**:**	**FA**	**:**	**CA**	**:**	**W**
547.66	**:**	608.36	**:**	1095.72	**:**	197.16
1	**:**	1.1108	**:**	2.00	**:**	0.36

MIX PROPORTIONS

For 0.5%, 1.0%, 1.5%, 2.0% of graphene

C	**:**	**FA**	**:**	**CA**	**:**	**W**
547.66	:	608.36	:	1095.72	:	197.16
1	:	1.1108	:	2.00	:	0.36

3 TEST RESULTS

WORKABILITY:

A total of 30 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days after conducting the workability tests. The results are tabulated below:

SLUMP CONE TEST:
The test was conducted for fresh concrete prepared before the moulding process. A total of 4 concrete mixes are prepared at different times. Workability Results obtained from slump cone test for M30 grade of concrete is shown in below table.Table-4: Test results from slump cone test for workability in mm

S. No	**Graphene %**	**Workability(mm)**
		Slump value

1	0	98
2	0.5	90
3	1.0	84
4	1.5	70
5	2.0	60

The workability from the slump cone test is in increasing manner as the mix proportion increasing. The workability range of concrete increasing as mentioned while being in medium range overall.

COMPRESSIVE STRENGTH TEST:

A total of 30 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days after conducting the workability tests. The results are tabulated below:

Table-5: Compressive strength results of M_{30} grade of concrete for 7, 24 and 28 days

S. No	Graphene %	Compressive strength of M_{30} grade in N/mm^2		
		7 days	14 days	28 days
1	0	24.33	28.33	32.00
2	0.5	29.42	32.70	38.25
3	1.0	30.42	34.33	38.95
4	1.5	29.52	34.33	40.65
5	2.0	27.35	29.88	36.50

TENSILE STRENGTH :

A total of 15 Cylinders of size 300 mm height and 150 mm dia were casted and tested for 7 days, 14 days and 28 days after conducting the workability tests. The results are tabulated below:

Tensile strength Table 6: Tensile strength results for M_{30} grade of concrete

S. No	Graphene %	Tensile strength of M_{30} grade in N/mm^2		
		7 days	14 days	28 days
1	0	2.54	3.19	4.2
2	0.5	2.72	3.34	4.31
3	1.0	2.94	3.91	4.45
4	1.5	3.05	4.02	4.71
5	2.0	3.01	3.92	4.68

FLEXURAL STRENGTH TEST:

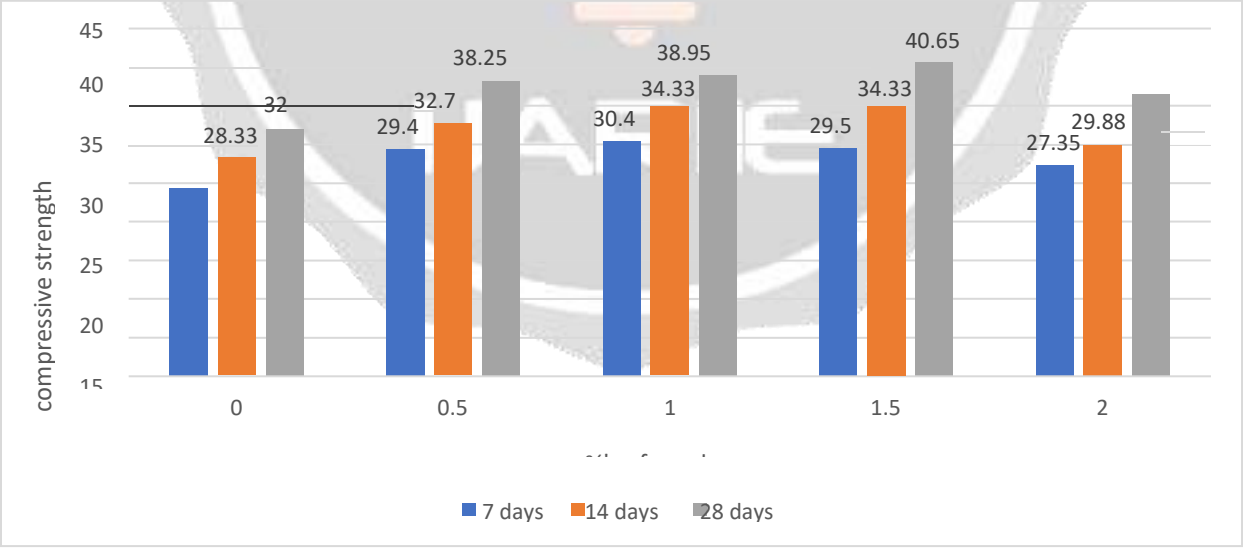
A total of 30 beams of size 500 x 100 mm were casted and tested for 7 days, 14 daysand 28 days after conducting the workability tests. The results are tabulated below:

Flexural strength Table 6: flexural strength results for M_{30} grade of concrete

S. No	Graphene %	Flexural strength of M_{30} grade in N/mm^2		
		7 days	14 days	28 days
1	0	2.33	4.75	5.65
2	0.5	3.75	5.25	6.385
3	1.0	4.23	5.72	6.825
4	1.5	4.88	6.23	7.25
5	2.0	4.32	5.92	6.925

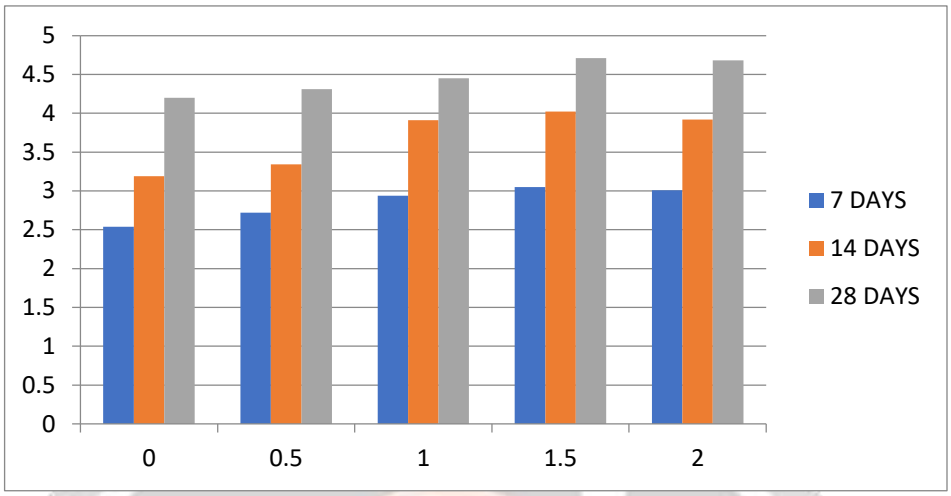
3.1 Discussion

Compressive strength:



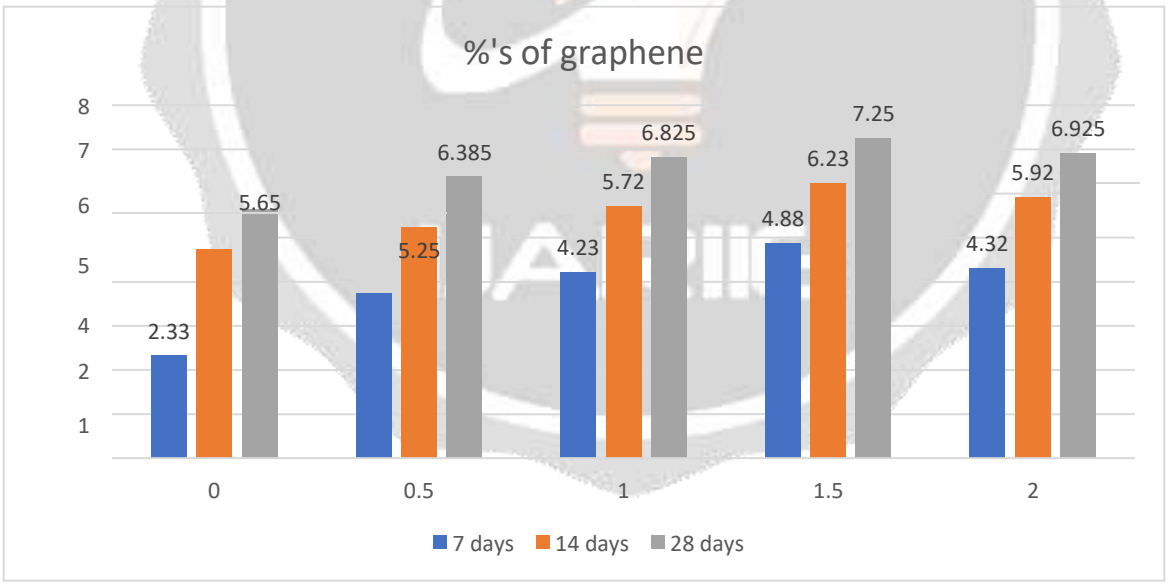
- The Compressive strength of concrete varies as 4.8%, 9.6%, 11.5%,11.1%for M1, M2,M3 and M4 compared with the conventional concrete after 7days of curing.
- The Compressive strength of concrete varies as 3.8%, 5.5%, 6.1%, 5.4% for M1, M2,M3 and M4 compared with the conventional concrete after 14days of curing.
- The Compressive strength of concrete varies as 5.6%, 7.6% ,9.1%,7.2% For M1, M2,M3 and M4 compared with the conventional concrete after 28days of curing.

TENSILE STRENGTH :



The strength i.e., the tensile strength, from the results is clearly in an increment way compared to the conventional concrete at all the curing ages of 7days, 14 days and 28 days. The addition of graphene by various proportions has positive effect on the strength of the concrete.

Flexural strength



- The flexural strength of concrete varies as 8.5%, 15.9%, 22.6%, 20.6% for M1, M2,M3 and M4 compared with the conventional concrete after 7days of curing.
- The flexural strength of concrete varies as 4.9%, 13.7%, 17%, 16% for M1, M2, M3and M4 compared with the conventional concrete after 14days of curing.
- The flexural strength of concrete varies as 11.7%, 23.5%, 36.6%, 31% for M1, M2,M3 and M4 compared with the conventional concrete after 28days of curing.

4. CONCLUSIONS

Graphene concrete increases the compressive strength, flexural strength and tensilestrength as compared with the conventional concrete.As the percentage of the graphene in concrete increases workability of concrete decreases.From strength point of view, conventional concrete by using graphene shows thepositive results.It was found from the failure pattern of the specimens, which the formation of cracks ismore in the case of concrete without adding of graphene powder to the concrete.Graphene increases the mechanical properties of concrete.It is possible to use graphene powder in the field of reinforced cement and concrete.The addition of graphene had a greater compressive and flexural strength at earlystages.

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