A FEASIBILITY STUDY ON MECHANICAL PROPERTIES OF CONCRETE WITH GRAPHENE OXIDE

K.R.MOHAMMAD SHAREEF[1], SHAIK ABDUL RAWOOF[2], K.SOWJANYA[3]

[1]*M.Tech (Student), Civil Department, Bes Group of Institutions, Angallu, AP,India*
[2]*M.Tech (Student), Civil Department, Gitam University, Vishakapatanam, AP, India*
[3]*Assistant Professor, Civil Department, Bes Group of Institutions, Angallu, AP, India*

---***---

Abstract - *Cement-based concrete is a widely used material for a great variety of constructions. Although, cement has great properties and high performance, its intrinsic brittleness is a weakness that requires further investigation for improvement. Graphene demonstrates a number of excellent properties, such as high flexibility, 1TPaYoungsModulus, 130 GPa tensile strength, high electrical and thermal conductivity. This study investigated the feasibility of implementing graphene into the concrete matrix for improving its compressive and tensile or flexural strength.*

The aim of this research is to study the performance of graphene cement concrete, and also compare the compressive and split tensile strengths of M25 concrete by replacing cement with 1% and 2% graphene oxide. To study compressive strength cubes of 150mm x 150mm x 150mm size and for split tensile strength cylinders of 150mm dia x 300mm length were casted. These specimens were tested at 28days, 56days and 90 days of curing.

The specimens were tested for its compressive and split tensile strength and found that the use of graphene in Concrete is a good advantage than Normal Concrete.

***Key Words*: concrete, graphene oxide, cubes, cylinders, compressive test, tensile test**

1. INTRODUCTION

Cement based concrete is the most usually utilized material in civil infrastructure. Although cementitious materials have demonstrated awesome properties, they are likewise semi weak materials with low tensile strength and lessened strain limit.

The examination expects to address the shortcomings of cement in various ways. Logical research is led in various ways. The most common research technique gives accentuation on a base up approach of the issue with a multi scale assessment from nuclear level to nanoscale, at that point microscale lastly mesoscale level..

As per Sobolev and Gutierrez (2005) nanotechnology can change the world and particularly for cement based materials, concentrating on their structure at the nanoscale will conceivably give us more data on how we could enhance its attributes .therefore, cement could wind up plainly more grounded with expanded toughness, expanded strain limit and other imaginative properties. Later on, Sobolev and Shah (2008) recommended that with the advancement of nano-innovation new age of cementitious materials could be created later on:

- Cement-based materials with built nano and smaller scale structures could show incomparable strength.
- Self-recuperating materials and repair advances using fullerenes, nanoparticles, nanotubes, nanotubes and synthetic admixtures.
- Self-cleaning, non-contracting and low warm development materials or even Keen materials, for example, temperature-, dampness , stretch detecting materials.

Late research has demonstrated that utilizing nanomaterials (carbon nanotubes, graphene, titanium oxide, nano silica and nano alumina) can fundamentally enhance cementitious materials. Notwithstanding, the high cost and the tedious strategy of generation are imperative factors that need extraordinary thought. Such research for graphene has demonstrated that there is solid association between the structure and the execution of graphene-concrete nano composites (GCNCs). The functionalized graphene-nano platelets had enhanced interfacial quality, which thusly enhances their mechanical properties.

In this exploration the solid examples with 2%Graphene Oxide (GO) supplanted with concrete had expanded in its rigidity and furthermore that there was great holding between the GO surfaces and the cement framework. X-beam diffraction (XRD) information additionally demonstrated that the mortar with GO had expanded calcium silicate hydrates (C-S-H) gels in examination with ordinary cement concrete. To the extent it concerns this ace postulation, a possibility consider was led keeping in mind the end goal to explore the similarity of the functionalized graphene with the cement solid hydrates.

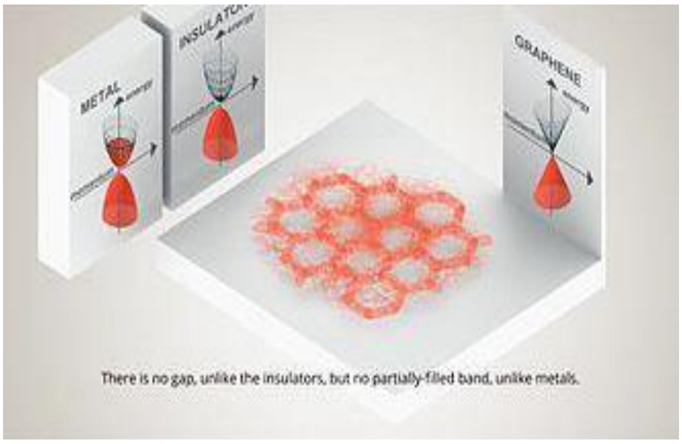
1.2 Purpose and goals :

The primary reason for this proposition is to examine the plausibility of functionalized

Graphene for similarity with concrete hydrates and support steel. The fundamental destinations of this proposition are: 1) Literature investigation of concrete solid cements with nano-materials, for example, graphene and their properties. 2) Investigation of the similarity by testing compressive and rigidity of solidified concrete examples blended with graphene oxide

1.3 Introduction to graphene oxide:

Graphene is an allotrope of carbon as a two-dimensional, nuclear scale, honeycomb cross section in which one particle shapes every vertex. It is the essential auxiliary component of different allotropes, including graphite, charcoal, carbon nanotubes and fullerenes. It can likewise be considered as an inconclusively vast fragrant particle, a definitive instance of the group of level polycyclic sweet-smelling hydrocarbons.



Element	% of Composition
Carbon	77.5
Oxygen	16
Sulphur	0.4
Hydrogen	1.2
Nitrogen	4.9

Table1.1 Chemical composition of Graphene oxide:

Graphene and its band structure and Dirac Cones, impact of a network on doping. Graphene has numerous remarkable properties. It is around 100 times more grounded than the most grounded steel. It conducts warmth and power proficiently and is about straightforward. Graphene additionally demonstrates an extensive and nonlinear diamagnetism, considerably more prominent than graphite, and can be suspended by Nd-Fe-B magnets. Scientists have distinguished the bipolar transistor impact, ballistic transport of charges and expansive quantum motions in the material.

Researchers have guessed about graphene for a considerable length of time. It has likely been accidentally created in little amounts for a considerable length of time, using pencils and other comparable uses of graphite. It was initially seen in electron magnifying lens in 1962, yet just considered while bolstered on metal surfaces. The material was later rediscovered, separated and described in 2004 by Andre Geim and Konstantin Novoselov at the University of Manchester. Research was educated by existing hypothetical portrayals of its piece, structure and properties. Superb graphene turned out to be shockingly simple to confine, making more research conceivable. This work brought about the two winning the Nobel Prize in Physics in 2010 "for weighty investigations in regards to the two-dimensional material graphene."

In this test think about, the strengthening impacts of graphene oxide (GO) on Portland concrete glue are researched. It is found that the presentation of 0.03% by weight GO sheets into the concrete glue can build the compressive quality and rigidity of the cement composite by over 40% because of the decrease of the pore structure of the concrete glue. In addition, the consideration of the GO sheets improves the level of hydration of the cement glue. Be that as it may, the workability of the GO-cement composite turns out to be to some degree decreased. The general outcomes demonstrate that GO could guarantee nanofillers for fortifying the building properties of Portland concrete glue.

Focal points

- Higher compressive and elasticity
- More solid
- Corrosion protection Technology
- High viewpoint proportion and porosity
- Very high electro-sorption limit
- Very thin peeled sheet
- Ultimately high virtue.

Parameters	Approximate values
Product Purity	99%
Number of layers	3-6
Surface area	>120m2/g
Thickness	0.8–2nm
Bulk density	0.121g/cc
Electrical Conductivity	Insulator
Lateral Dimension	5–10micrometer

Table 1.2 various parameters of Graphene Oxide:

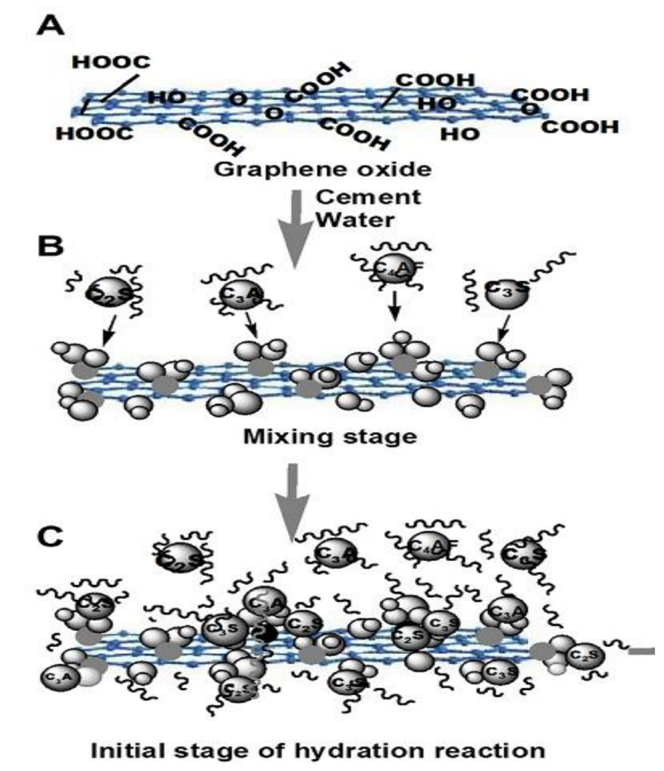


Fig 2: Cement improved by graphene

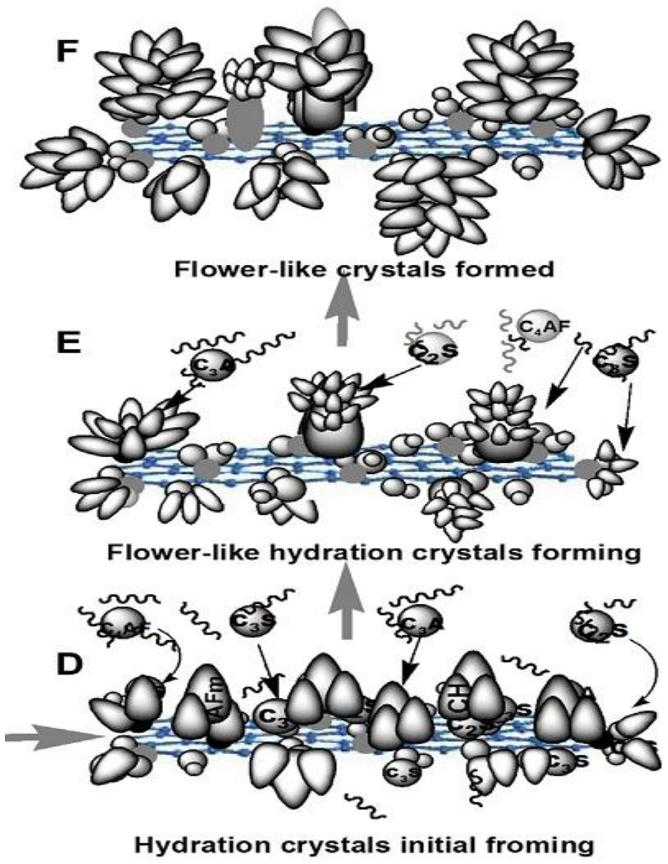


Fig 3: Schematic diagram of regulation mechanism of GO on cement hydration crystals

2. PRELIMINARY INVESTIGATION

The material properties are explored according to Indian codal determinations. The materials are tried and contrasted and the standard esteems. These subtle elements are exhibited in this part. The materials used as a piece of the present investigation are cement, sand, coarse aggregateand Graphene oxide. Each one of these materials is attempted in the examination focus to set up their physical and mechanical properties as per the assurance of Indian Standards. Blend Design was assessed utilizing the layout guidelines of IS 10262-2009 and Is 456 - 2000. Physical and mechanical attributes were conveyed for trial blend of M25 at first stage, throwing of regular totals solid shapes and barrels for the blend M25.

Ingredients Used and Their Properties

Diverse fixings utilized as a part of this work are:

1. Portland Cement
2. Fine aggregate
3. Coarse aggregate
4. Graphene oxide
5. Water

The tests which are typically directed as taken after:

- Specific Gravity of cement=3.15
- Fineness of cement=8%
- Soundness of cement=
- Consistency of Cement Paste= 33%
- Initial setting time of cement=40min
- Final Setting Time of cement=400min

3. MIX DESIGN PROCEDURE

The main object of concrete mix design is to select the optimum proportions of the various ingredients of concrete which will yield fresh concrete of desirable properties like workability and hardened concrete possessing specific characteristic compressive strength and durability.

MIX DESIGN CALCULATION

According to IS Code 10262-2009, the Design Mix Procedure is Carried Out:

Step1: **Target Mean Strength of the Mix Proportion is carried out as Fallows**,

For M25 grade of concrete:

$F^1_{ck} = F_{ck} + 1.65S$,

F^1_{ck}=Target Mean Compressive Strength of concrete@28days,

$F_{ck=}$ Compressive Strength of Concrete, S=Standard Deviation,

For M20-M25 Grade of Concrete Standard Deviation = 4Mpa.

Step 2: **Selection of Water Cement Ratio from table5 of IS456-2000**,

W/C =0.5,

Maximum water Content per m^3 of Concrete for Nominal Maximum size of aggregate:

For 20mm Nominal Maximum size of aggregate the Maximum water Content is 186kg.

Step 3: **Calculation of Cement Content**:

Water-Cement ratio is =0.5,

Cement Content = $\frac{186}{0.5}$ =372,

Step 4: **Proportioning of Volume of Coarse aggregate content table 3 of IS 10262-2009**:

Volume of Coarse aggregate content corresponding to 20mm size of aggregate of ZoneIII,

Volume of Coarse aggregate content = $0.64 m^3$,

Volume of Coarse aggregate content = 1 – 0.64,

= $0.36 m^3$,

Step 5: **Calculation regarding to Mix Design Volume of Concrete (a)** = $1 m^3$,

Volume of Cement (b) = $[\frac{\text{Mass of cement}}{\text{specific gravity of cement}}] * [\frac{1}{1000}]$,

= $[\frac{372}{3.15} * \frac{1}{1000}] = 0.118 m^3$.

Volume of Water (c) = $[\frac{\text{Mass of cement}}{\text{specific gravity of water}}] * [\frac{1}{1000}]$,

= $0.186 m^3$.

Volume of all in aggregate (d) = [a- (b + c)],

= [1- (0.118 + 0.186)]

= $0.696 m^3$.

Mass of Coarse aggregate = d * Volume of coarse aggregate * Specific gravity*1000,

= 0.696 * 2.64 * 0.64 * 1000,

= $1220.5 kg/m^3$.

Mass of Fine aggregate = d * Volume of fine aggregate * Specific gravity*1000,

= 0.696 *2.54 * 0.34 *1000,

= 648.39 kg/m3.

Then the total Quantity is:

Cement = $372 kg/m^3$,
Coarse aggregate = $1220.50 kg/m^3$,
Fine aggregate = $648.39 kg/m^3$,
W/C ratio = 0.50,
Water = 186 litres.
372: 648.39:1220.50 kg/m^3.

QUANTITIES OF MATERIALS

MIX DESIGNATION	CEMENT IN KG/M^3	GRAPHENE OXIDEIN KG/M^3	COARSE AGGREGATE IN KG/M^3	FINE AGGREGATE IN KG/M^3	W/C RATIO
M25	372	0	1220.50	648.34	0.50
MIX-I	40.34	0	132.35	70.3	0.50
MIX-II	39.937	0.403	132.35	70.3	0.50
MIX-III	39.534	0.806	132.35	70.3	0.50

Table 3 :Quantities off materials

PREPARATION OF TESTING SPECIMEN

Fig4&5:Mixing of cement with graphene oxide and Mixing of concrete

Fig6: Freshly casted cubes in the moulds

Fig7: Freshly casted cylinders in the mould

Fig8:Curing of specimens

Fig9: Compression Testing of cube specimens

Fig10: Split tensile testing of cylindrical specimen

MIX PROPORTIONS

Water: Cement: Fine Aggregate: Coarse Aggregate

MIX DESIGNATION	CEMENT IN KG/ M^3	GRAPHENE OXIDE IN KG/M^3	COARSE AGGREGATE IN KG/M^3	FINE AGGREGATE IN KG/M^3	W/C RATIO
M25	372	0	1220.50	648.34	0.50
MIX-1	40.34	0	132.35	70.3	0.50
MIX-2	39.937	0.403	132.35	70.3	0.50
MIX-3	39.534	0.806	132.5	70.3	0.50

Table 4:mix propotions

MIX-1: It refers to the mix design of concrete with 100%cement.
MIX-2:It refers to the mix design of concrete with 99%cement +1% graphene oxide.
MIX-3: It refers to the mix design of concrete with 98%cement +2% graphene oxide.

Total number of cubes and cylinders casted

S.NO	MIX DESIGNATION FOR M25	28 DAYS	56 DAYS	90 DAYS
1	MIX-1(100% CEMENT)	3	3	3
2	MIX-2 (100%CEMENT+1%GRAPHENE OXIDE)	3	3	3
3	MIX-3 (100%CEMENT+2%GRAPHENE OXIDE)	3	3	3

Table5:Number of cubes=27and cylinders casted=27

RESULTS

COMPRESSIVE STRENGTH TEST RESULTS

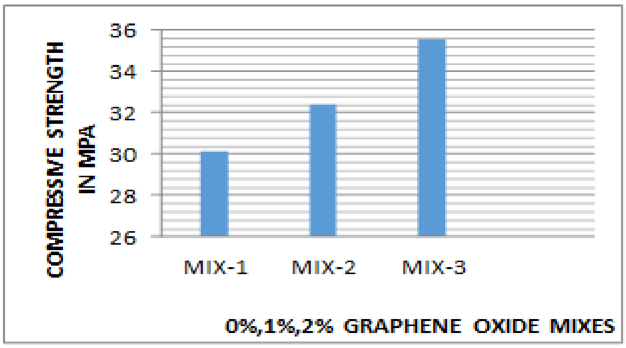


Chart -1: various mixes of GO versus compressive strength in Mpa of normal concrete and GO mixed concrete at 28days

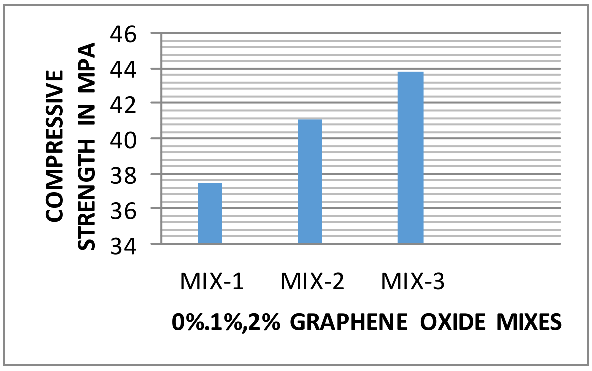


Chart -2: **various mixes of GO versus compressive strength in Mpa of normal concrete and GO mixed concrete at 56days**

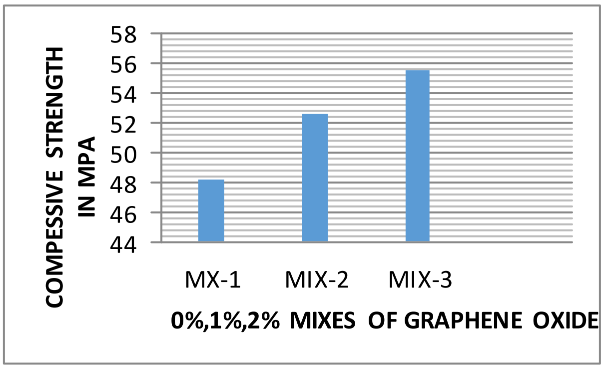


Chart -3: **various mixes of GO versus compressive strength in Mpa of normal concrete and GO mixed concrete at 90days**

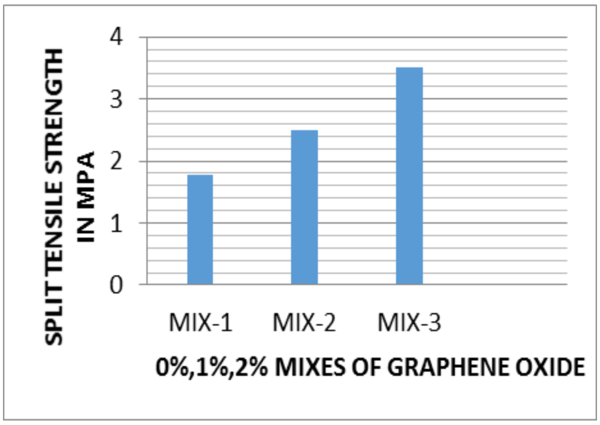


Chart -4: **various mixes of GO versus split tensile strength in Mpa of normal concrete and GO mixed concrete at 28 days**

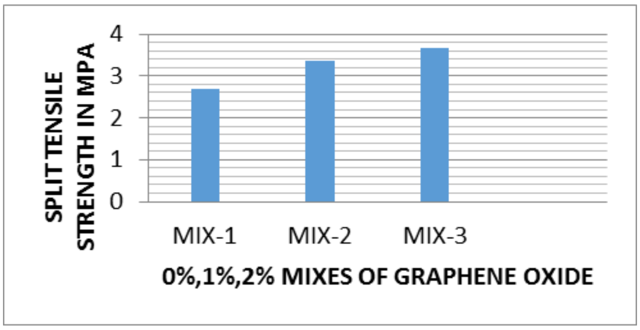


Chart -5:**various mixes of GO versus split tensile strength in Mpa of normal concrete and GO mixed concrete at 56days**

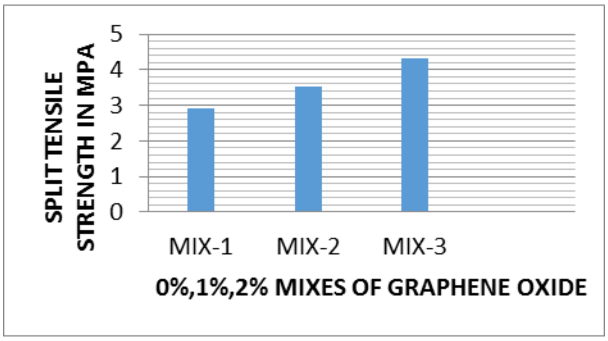


Chart -6: **various mixes of GO versus split tensile strength in Mpa of normal concrete and GO mixed concrete at 90days**

CONCLUSION

1. Incorporation of Graphene nano particles in concrete showed interested modifications in mechanical and micro structural properties.

2. Nano particles graphene oxide improves the mechanical properties of the concrete, both compression and flexural strength, concrete samples were tested with Graphene Oxide (GO) in percentage of 1% to 2% by weight to obtain high strength, it is carried out for M25 grade of concrete.

3. The compressive strength of concrete increased to 7% for 1%GO content and it increased up to 17% for 2%GO content when compared with control sample at 28days.

4. The compressive strength of concrete increased to 10.44% for 1%GO content and it increased up to 17.63% for 2%GO content when compared with control sample at 56days.

5. The compressive strength of concrete increased to 9.18% for 1%GO content and it increased up to 15.33% for 2%GO content when compared with control sample at 90days.

6. The split tensile strength of concrete increased to 17.41% for 1%GO content and it increased up to 28% for 2%GO content when compared with control sample at 28days.

7. The split tensile strength of concrete increased to 24.49% for 1%GO content and it increased up to 35.55% for 2%GO content when compared with control sample at 56days.

8. The split tensile strength of concrete increased to 21.30% for 1%GO content and it increased up to 48% for 2%GO content when compared with control sample at 90days.

REFERENCES

1. Shenghua Lv, Sun Ting, Jingjing Liu, and Qingfang Z. (2014), "Use of graphene oxide nanosheets to regulate the microstructure of hardened cement paste to increase its strength and toughness. CrystEngComm", 16(36):8508–8516.

2. Ye Qing, Zhang Zenan, Kong Deyu, and Chen Rongshen, (2007) "Influ- ence of nano-sio$_2$ addition on properties of hardened cement paste as compared with silica fume. Construction and Building Materials", 21(3):539–545.

3. Shiho Kawashima, Pengkun Hou, David J. Corr, and Surendra P. Shah. (2013), "Modification of cement-based materials with nanoparticles. Cement and Concrete Composites", 36:8–15, Special issue: Nanotechnology in Construction.

4. Samuel Chuah, Zhu Pan, Jay G Sanjayan, Chien Ming Wang, and Wen Hui Duan, (2014), "Nano reinforced cement and concrete composites and new perspective from graphene oxide", Construction and Building Materials, 73:113–124.

BIOGRAPHY

K.R.MOHAMMAD SHAREEF,
P.G Student, Department of Civil Engineering, BES Group of Institutions, Angallu, Andhra Pradesh, India.