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EXPERIMENTALINVESTIGATIONON HIGHSTRENGTHSELFCOMPACTING CONCRETE USING GRAPHENE COMPOUND

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ABSTRACT

A great deal of recent study has focused on the use of nanomaterials in cement composites. This study aims to discover a means to include graphene oxide, one of these materials, into self-compacting concrete so that it can reach its maximum strength potential. Researchers in this research found that varying the weight % of graphene oxide added to self-compacting concrete produced a wide range of strengths. In lieu of cement, 30% GGBS was used to the concrete mixture to achieve an M60 grade. The specimens underwent new property testing, including Slumpflow, V-funnel, and L-box, before to casting. Hardened concrete, compression, split tensile strength, and flexural strength tests were performed on the specimens after 7 and 28 days of curing. According to the findings, adding 0.05% graphene oxide to the concrete brought out its greatest strengths.

INTRODUCTION

One metric ton of Portland cement requires about 3.0 metric tons of raw materials, which include fuel, silica, alumina, calcium, and iron. Reason being, aggregates in mortar and concrete are most often bound by cement. The construction industry's growing demand for cement has led to an oversupply of cement makers. All kinds of living and inanimate items are affected by the resultant rise in global temperatures.

The four main ingredients of concrete—water, coarse aggregate, fine aggregate, and cement—are mixed together to create the material. The concrete mixture consists of coarse materials, such as gravel, and fine aggregates, such as sand and rock dust. At some point in time after mixing, the strength of concrete stops rising and becomes constant. Regular (M10–M20 grade), standard (M25–M55 grade), and high strength (M60–M80 grade) are the three primary categories into which this concrete is categorized according to Indian regulations.

There were a number of issues with the building industry's reliance on mechanical vibrators

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for traditional concrete's filling gaps and covering the whole shuttering area. A solution to these problems was the creation of self-compacting concrete. Strengthening Concrete

In concrete, the word "self-compacting concrete" refers to a specific kind of material that may harden by drawing itself closer together. In addition to not vibrating, which means less money spent on labor and equipment, and being able to flow to all corners of the formwork—where the heavy reinforcement is placed—these concrete features are highly sought after.

All three of the common concrete mixes are made using the mix design procedure to create self-compacting concrete, as specified in IS 10262: 2019. Following the completion of the mix design, the fresh and hardened concrete properties are tested to see whether they meet the design requirements. Shelf-friendly concrete features

Graphene oxide, a well-known nanomaterial, is now a component of cement composites. The extraordinary range of qualities shown by graphene oxide will most likely result in concrete that is both stronger and more durable. We examined the workability, strength, and durability of graphene oxide (GO) in both new and old cement concrete to determine its performance. A controlled way was used to incorporate graphene oxide into the cement at various weight percentages, ranging from 0% to 0.05%. The newly created GO-based concrete was subjected to fluidity tests in order to ascertain its workability. The GO-based concrete was tested for compressive, split tensile, and flexural strengths after7,14, and 28 days of cure. Evaluations of reliability, with an emphasis on the following: rapid chlorine flow

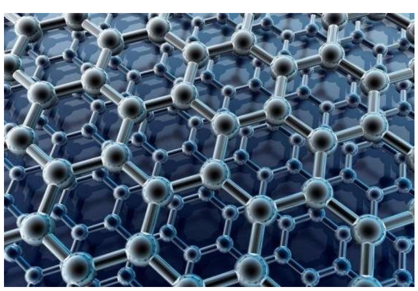

Fig: Structureof graphene compound

Fig:Graphenepowder

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NANOMATERIALS

Nanostructured materials are known to have improved material effectiveness due to their extraordinary physical and chemical characteristics. Nanomaterials' small size, large specific surface area, and robust interface interactions with the cement matrix allow them to enhance mechanical performance and service life in nanocomposites based on cement. Furthermore, nanoinundations might be helpful in reducing the cement dosage. Carbon nanotubes (CNTs), nano titanium oxide (NiO2), and graphene oxide (GO) are only a few examples of the nanomaterials that may be used to strengthen cement matrix. A paradigm shift is occurring towards the construction of nano cement composites based on GO as a result of its high-performance properties in cement concrete. Concrete is made more durable by modifying the cement's microlevel hydration structure with one of the nanomaterials, graphene oxide. Graphene oxide is produced from graphite powder by use of Hummer's Method. The most of the time, nanoparticles

Despite its oxidative properties, which allow it to dissolve rapidly in water, GO has a key drawback: it is not very dispersible. Despite this, it is still the best material available. The layered nanomaterial known as graphene oxide consists of oxygenated graphene sheets that have carbonyl groups attached to their edges and hydroxyl groups on their basal planes. So, OPC paste's strength is enhanced by adding graphene oxide (GO), and its dispersion in water is made easier by the oxygen-containing functional groups. The fluidity of cement pastes was reduced as the GO dosage increased, while the plastic viscosity and yield stress were improved. Graphene oxide is better dispersed and cement's compressive strength is increased when silica fume is added to the mixture at the correct concentration. One potential use for graphene oxide (GO) is in alkaline multi-ionic cement paste, where it might help cement hydration by interacting with Ca 2+ ions due to its abundance of oxygen-containing functional groups on its surface. It becomes more challenging to deal with GO when it is introduced to cement-based composites due to its huge surface area, which absorbs more water molecules when wet. Fly ash particles, when added to GO-based concrete, make it easier to work with. Graphene oxide mainly modifies the structural composition of cement composites by promoting the formation of hydration products. Consequently, the microstructure will change from being needle-like to being more like a flower-like structure. The ductility of concrete is enhanced by transforming it from needle type to flower type.

LITERATURE REVIEW

An in-depth analysis of the problems now plaguing the building sector is presented in this chapter. Based on the results, the authors set out to develop a new kind of high-strength concrete with graphene oxide added to address concerns with the material's segregation, workability, and strength.
S. Chandra Mouli and P. Sudheer

Since cement is the material's most crucial component, it follows that cement might benefit from modifications made possible by nano materials. This is just one way in which nanotechnology has changed the construction business.
There were primarily three kinds that were discovered: nanoparticles, zero-dimensional materials, and one-dimensional nanoparticles. Like one-dimensional nanofibers like carbon nanotubes and nano silica compounds, graphene in its present form is composed of zero-dimensional, one-dimensional, and two-dimensional particles.
As of late, graphene has been found in concrete and mortar in tiny fractions used to replace some of the cement in mortar cubes. After adding trace quantities of the graphene chemical, the mixture's mechanical properties were examined.
The compressive strength of cement was somewhat enhanced when graphene was added to it. Graphene compound, which is 5% cement by weight, increases the compressive strength of concrete cubes by 25% compared to regular concrete specimens.

S. Nandhini and I. Padmanaban (2016)

Cement and concrete are both utilized extensively nowadays. The calcinations required to make cement, however, release a great deal of carbon dioxide into the atmosphere, making this process a major contributor to global warming. Furthermore, roughly one metric ton of carbon dioxide is released into the environment during the production of one metric ton of ordinary Portland cement (OPC). It is critical to partly substitute natural sand in concrete with an alternative component that does not diminish its quality, as river sand is continually being mined.
Using fly ash instead of cement in concrete was standard practice since it offers various

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EXPERIMENTALWORK

4.1GENERAL

Every procedure described in the preceding chapters is on full display in the current experimental investigations. Prior to beginning the job, we verified the concrete's physical and chemical characteristics. Then, taking into account the concrete's toughened qualities, we optimized the GGBS concentration and added graphene oxide to create a mix for M60 grade concrete. Using this combination, we examined the fresh and hardened SCC qualities. The Preparation as an Example

RESULTSANDDISCUSSIONS

RESULTS

1. SLUMPFLOWTESTRESULT

The following bar graph shows the results of five tests performed on 60-grade concrete with different concentrations of graphene oxide:0.01,0.03, and 0.05%.

SlumpFlowTestResultsofM60GradeConcretewithGrapheneOxide

TrialNo.	GrapheneOxide(%)	SlumpFlow(mm)
1	0.00(Control)	680
2	0.01	660
3	0.01	655
4	0.03	630
5	0.05	600

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AverageSlumpFlowandReduction

GrapheneOxide (%)	AverageSlumpFlow (mm)	%Reductionfrom Control
0.00(Control)	680	–
0.01	658	3.2%
0.03	630	7.4%
GrapheneOxide (%)	AverageSlumpFlow (mm)	%Reductionfrom Control
0.05	600	11.8%

Discussion/Elaboration

1. **ControlMix(0.00%GO):**

Even without graphene oxide, M60 grade concrete's very high workability is seen in its slump flow of 680 mm. For high-performance concrete, this is the typical number when the quantity of superplasticizer is calibrated properly. Analysis of the Impact of 0.01% Graphene Oxide: 2. The droop flow was somewhat reduced to an average of 658 mm with the addition of a minute quantity of 0.01% graphene oxide. This shows that even a little quantity of GO may affect the fluidity, mainly because of its high specific surface area, which causes it to consume more water. 3. 0.03% DGO's Role: Slump flow was further decreased to 630 mm at 0.03% GO. The new concrete's poor flow is shown by this decrease, which is caused by a greater GO content. We found that the slump flow was 600 mm at a concentration of 0.05 percent GO, which is the fourth influence to consider. Higher dosages of GO result in poor workability because GO particles absorb water and obstruct the free flow of cement paste. The steep drop, which is almost 12% below the control, proves this to be true.

V-FunnelTestResultsofM60GradeConcretewithGrapheneOxide

TrialNo.	GrapheneOxide(%)	V-FunnelTime(sec)
1	0.00(Control)	8.5
2	0.01	9.2
3	0.01	9.4
4	0.03	10.3
5	0.05	11.0

AverageV-FunnelTimeand%Increase

Graphene Oxide (%)	Average V-Funnel Time (sec)	% Increase from Control
0.00(Control)	8.5	–
0.01	9.3	9.4%
0.03	10.3	21.2%
0.05	11.0	29.4%

Discussion/Elaboration

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1. **ControlMix(0.00%GO):**

The impressive V-Funnel length of 8.5 seconds demonstrates the excellent flowability of M60 grade concrete devoid of graphene oxide. This is the typical range of workability for self-compacting concrete.

2. Due to the impact of 0.01% GO, the average V-Funnel time rose to 9.3 seconds. The flowability seems to have diminished somewhat. There is no discernible impact at low concentrations of GO on workability, hence even very small levels have a little impact.

3. At 0.03% GO, the time increased to 10.3 seconds. Since GO particles have a bigger surface area and absorb more water, a higher concentration of GO substantially reduces the flow rate, as is more clearly seen by this difference.

4. 0.05 percent GO effect: at this concentration, the highest value was 11.0 seconds, or about 30% more than the control mixture. This proves that the concrete mix is quite thick and has a limited flowability.

According to the findings of the V-Funnel test, the addition of graphene oxide to M60 grade concrete extends the flow time and diminishes its workability.

CompressiveStrengthTestResultsofM60GradeConcretewithGrapheneOxide

Mix Trial	GrapheneOxide (%)	7-DayStrength (MPa)	28-DayStrength (MPa)
1	0.00(Control)	44.5	61.0
2	0.01	46.8	63.5
3	0.01	47.2	64.0
4	0.03	49.5	67.8
5	0.05	45.0	62.0

Observation

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The control group that received 0% GO in its M60 concrete reached a compressive strength of 61.0 MPa after 28 days, which is considered a standard. On day 28, the strength had risen to around 64.0 MPa, thanks to the 0.01% GO. Once the 28 days were over, the graphene oxide dose of 0.03% yielded the maximum compressive strength of 67.8 MPa. This demonstrates that GO makes the cement matrix thicker and improves bonding. A 28-day decrease of 62.0 MPa was seen when 0.05% GO was used. Weak spots occur as a result of agglomeration, which happens when there is an overabundance of GO in concrete.

Final Reflections

Adding graphene oxide to high-strength cement up to 0.03% enhanced its compressive strength until it began to deteriorate. At 7 days, the trend of strength increase remained the same.

After 28 days, by substituting 0.03% of the cement by weight, the maximum compressive strength of 67.8 MPa was attained.

2. Thin spittle stiffness test

Below are the graphs displaying the findings for the split strength of M60 grade concrete. There were five separate mix experiments with varying proportions of graphene oxide conducted on this material at 7 and 28 days after curing.

The cylinder, which had minimum parameters of 100 mm Ø x 200 mm, was subjected to High Strength SCC testing to ascertain its maximum split tensile strength.

Incorporating graphene oxide into the cement component of the mixture produced the intended result after the concrete had set for 28 days. Within 8 to 12% of the compressive strength is the split tensile strength. There may be a decrease in graphene oxide after a very high initial strength (about 0.03%).

SplitTensileStrengthTestResultsofM60GradeConcretewithGrapheneOxide

Mix Trial	GrapheneOxide (%)	7-DayStrength (MPa)	28-DayStrength (MPa)
1	0.00(Control)	3.60	4.70
2	0.01	3.85	5.00
3	0.01	3.90	5.05
4	0.03	4.15	5.35
5	0.05	3.70	4.85

2. FLEXURALTESTRESULT

Five mix tests were conducted to measure the flexural strength of M60 grade concrete after 7 and 28 days of curing. The percentage of graphene oxide was changed. The results may be seen in the graph down below.

A rectangular prism of 500 mm X 100 mm X 100 mm was used to evaluate the flexural strength of High Strength SCC. The mixture that included 0.05% graphene oxide by weight of cement had a maximum flexural strength of 9.7 MPa after 28 days of curing.

You may think of flexural strength as 10–15% of compressive strength. M60 typically has a flexural strength ranging from 6 to 10 MPa. Following 28 days, the maximum strength at 0.05% GO is 9.7 MPa, as mentioned in your comment.

FlexuralStrengthTestResultsofM60GradeConcretewithGrapheneOxide

Mix Trial	GrapheneOxide (%)	7-DayStrength (MPa)	28-DayStrength (MPa)
1	0.00(Control)	6.2	7.8
2	0.01	6.5	8.2
Mix Trial	**GrapheneOxide (%)**	**7-DayStrength (MPa)**	**28-DayStrength (MPa)**
3	0.01	6.6	8.3
4	0.03	6.9	8.8
5	0.05	7.5	**9.7**

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CONCLUSIONS

The results of the tests mentioned above led to the following conclusions:

M60 High Strength SCC became less workable when exposed to graphene oxide. The droop flow decreased with time as the GO% rose, while the V-Funnel flow duration increased, suggesting less fluidity. The findings demonstrate that the addition of GO particles causes the mixture to thicken and the water demand to rise.
The compressive strength increased by up to 0.03% with the addition of GO, reaching 67.8 MPa after 28 days. Particle agglomeration caused a little loss of strength (0.05%) beyond this dose.
o The split tensile strength hit 5.35 MPa after 28 days at 0.03% GO, following a similar pattern. The results demonstrate that the correct quantity of GO improves bond strength and fracture resistance.
The compressive and split-tensile strengths were unchanged by the increase in GO concentration, however the flexural strength did improve. With a GO level of 0.05%, the material reached its maximum flexural strength of 9.7 MPa after 28 days.
By improving the material's resistance to flexure and its ability to bridge fractures, GO enhances concrete's ductility.
The ideal concentration of graphene oxide for structural and stress relaxation is 0.03%. The ideal dose for flexural strength is 0.05%. While increasing the GO concentration decreases workability, it improves microstructure and significantly increases strength. Graphene oxide may be added to high strength structural concrete (SCC) at the correct dose to improve its flexural performance instead of compressive or tensile strength, among other desirable properties.

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