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A Comprehensive Study on Geaphene Concrete: Properties, Applications, and Future Prospects

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Abstract: ***Graphene concrete is an emerging material that focuses on enhancement of conventional concrete's properties by combining graphene based nanomaterirals. It is a great example of sustainable and high-performance construction material. Graphene concrete offers promising solution to carbon emission and increases structural integrity. This paper explores the synthesis methods, mechanical and chemical properties, current applications, challenges, and test evaluations of graphene concrete, providing insights into its future potential in the constructiom industry.***
Keywords: Graphene, Nanomaterial, Compressive Strength, Carbon Emission, Testing.

I. INTRODUCTION

Concrete is a global construction material with its usage in almost every construction site. But the production of the concrete emits significant amount of global carbon dioxide mainly because of the cement manufacturing process. But incorporation of nanomaterials specifically graphene, has led to the development of a new class of high performance concrete that exhibit superior properties and contribute to sustainability.

Graphene is a single layer of carbon atoms arranged in a hexagonal lattice. It posses remarkable properties like high tensile strength, electrical and thermal conductivity, impermeability, and lightweight.Graphene is significantly used in many other fields and is also showing remarkable results in the concrete industries.

II. LITERATURE REVIEW

Introducing graphene in the field of concrete has surely introduced new paths of enhancing mechanical and functional properties of concrete. Numerous studies have evaluated that various forms of graphene oxide (GO), reduced graphene oxide (rGO), and graphene nanoplatelets (GNPs) influence the behavior of concrete.

According to Pan et al. (2015) incorporation of 0.05% GO (by weight of cement) the compressive and flexural strength of concrete increases by 30%. Also, studies have shown improved resistance to chloride attack and reduced permiability.

III. MATERIALS AND MEHODOLOGY

Graphene concrete is typically prepared by addition of graphene in water using ultrasonic mixing, then adding this mixture to the cement. This mix should be optimized such that proper dispersion of particles happen avoiding agglomeration.

Parameters studied include:

- Water-cement ratio: 0.40
- Graphene content: 0.05%, 0.1%
- Concrete mix: M25

IV. TESTING AND EVALUATION

To understand the performance of graphene concrete, few tests are conducter.

A. Compresive Strength test

The test is conducted to determine the load bearing capacity and the influence of graphene on strength using the compressive testing machine.

Table -1:Mix Design Description

Concrete Mix M25 (per m^3)			
Weight of Cement(kg)	Weight of Fine Aggrigate(kg)	Weight of Course Aggrigate(kg)	Weight of graphene(kg)
375	375	750	0
375	375	750	0.1875
375	375	750	0.375

Using these numbers concrete cubes of dimensions 150mm x 150mm x 150mm are casted in a controlled environment.
Observation: For M25 concrete addition of 0.05% graphene powder shows 18.73% increase in compressive strength, and addition of 0.1% graphene powder shows 23.54% increase in compressive strength

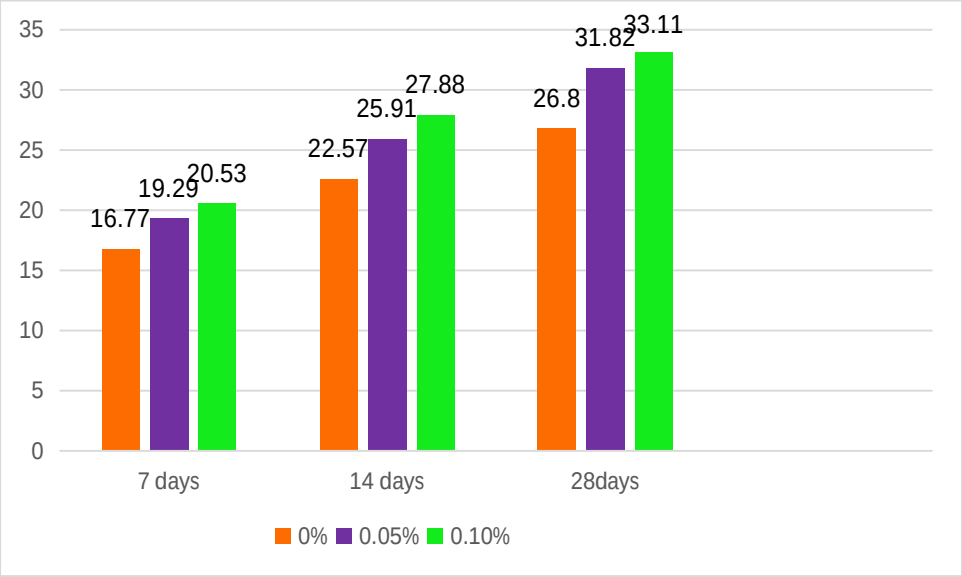

Chart -1: Compressive strength increase (N/mm^2)

B. Test for Workability

The slump cone test is used to workability and consistency of fresh concrete. Here, slump cone of height 300mm, bottom diameter 200mm, top diameter 100mmwas used. The concrete mix of each batch was put in three layers and tamped 25 times using a 16mm diameter, 600mm long rod, rounded at one end.

The slump of concrete mix with 0% graphene content had a slum of 95mm, concrete mix with 0.05% graphene content had a slump of 112mm, and the concrete mix with 0.1% graphene content had a slump of 168mm.

V. RESULT AND DISCUSSION

1) Increased compressive strength: The strength increase (in MPa as well as in percentage) in concrete is shown in the table below :

Table-2 : Comparitive increase in compressive strength

7 days of curing			
Percentage of graphene	Strength in MPa	Percentage increase in strength (%)	
0%	16.77	-	

0.05%	19.29	15.02	
0.1%	20.53	22.42	
14 days of curing			
0%	22.57	-	
0.05%	25.91	14.80	
0.1%	27.88	23.52	
28 days of curing			
0%	26.80	-	
0.05%	31.82	18.73	
%0.1	33.11	23.54	

2) Improved workability: The concrete mixture with 0.40 w/c ratio and 0% graphene showed 95mm slump (Medium workability), 0.05% graphene had a slump of 112mm (High workability), and 0.1% graphene had a slump of 168mm (High workability).

3) Graphene has a high scope of development in the field of concrete. But there are certain drawbacks of it currently. Due to its process of production graphene is an expensive material, it is difficult to disperse graphene uniformly as it is insoluble in water, also there is no standardization in mixing a testing methods for the same.

VI. APPLICATIONS

Graphene concrete is suitable for high performance infrastructure, load bearing structures, eco-friendly building projects, complex forms, congested rebar.

VII.CONCLUSIONS

Graphene concrete is a revolutionary step in construction materials. With enhanced mechanical performance, and sustainability, it has the potential to redefine the building and maintenance of structures. In future problems like limitation of applications due to cost and technical barriers may be reduced because of ongoing research and future industrial collaboration.

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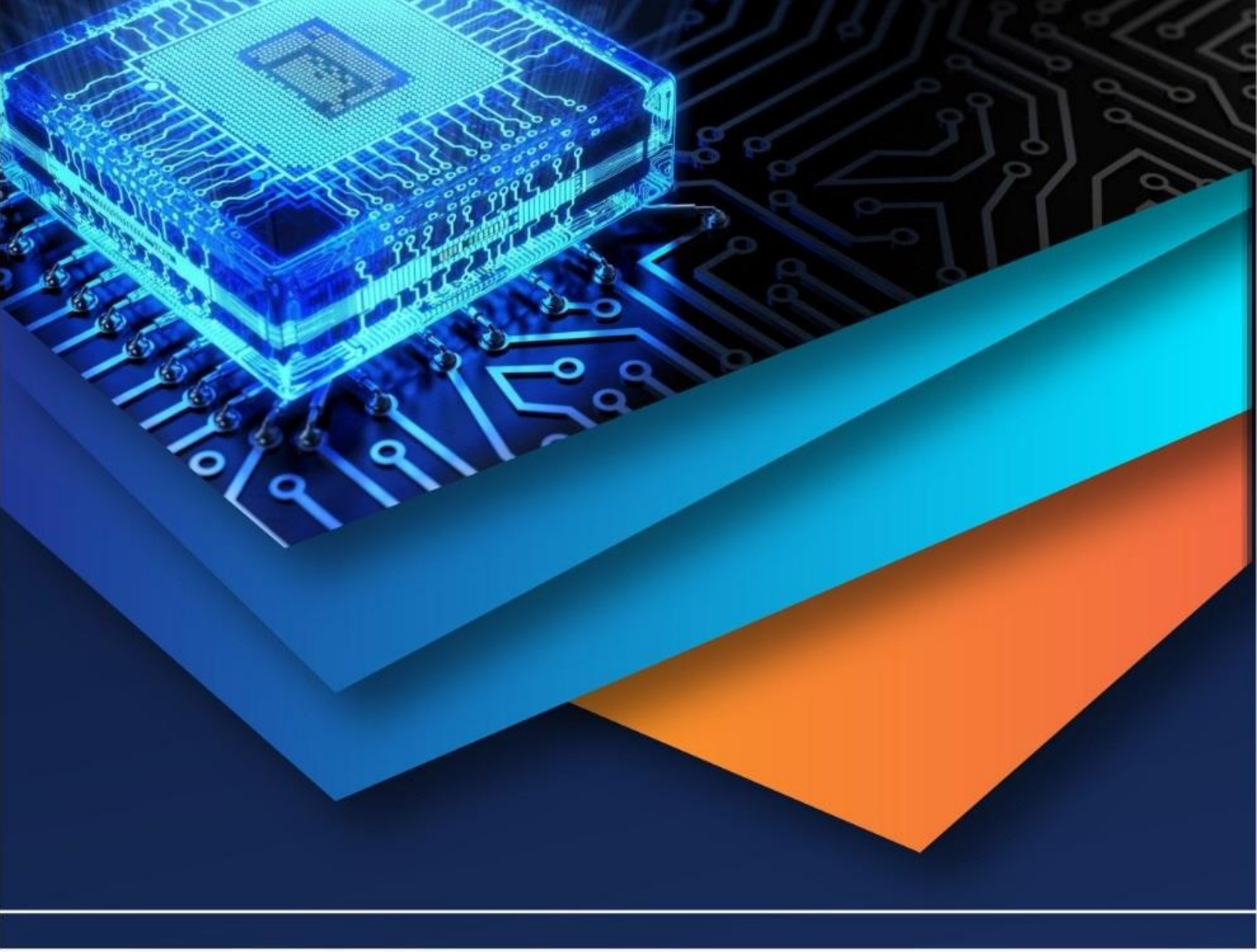

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