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Utilization of GGBS and Graphene as Partial Replacement of Cement in Concrete

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I. INTRODUCTION

Concrete is the most world widely used construction material. The increase in Demand of concrete more the new method and materials are being developed for production of concrete. Concrete is a mixture of cement, water, and aggregates with or without chemical admixtures. The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration. Since the production of this raw material produces lot of CO_2 emission. The carbon dioxide emission from the cement raw material is very harmful to the environmental changes. Nowadays many researchers have been carried out to reduce the CO_2. The effective way of reducing CO_2 emission from the cement industry is to use the industrial by products or use of supplementary cementing material such as Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), Silica Fume (SF) and Metakaolin (MK). In this present experimental Work, an attempt is made to replace cement by GGBS and GRAPHENE to overcome these problems.

II. OBJECTIVES

1) To use GGBS in concrete by partial replacement of cement and addition of Graphene.
2) To determine compressive strength of concrete.
3) To determine the workability of the concrete partial replacing the cement by GGBS and Graphene.
4) To provide economical construction material.
5) To provide safe guard to the environment by utilizing waste properly

A. Role of GGBS in concrete by partial replacement of cement.

Ground Granulated Blast Furnace Slag (GGBS) is a supplementary cementitious material commonly used in concrete production, offering a sustainable and effective way to improve the performance and properties of concrete. GGBS is a by-product of the iron and steel manufacturing process, obtained by quenching molten blast furnace slag with water or steam, followed by drying and milling into a fine powder. When introduced into concrete mixtures, GGBS serves as a partial replacement for Portland cement, typically substituting a portion of the cementitious material. This substitution not only utilizes a waste material that would otherwise be landfilled but also reduces the carbon footprint associated with concrete production.

CONSTITUENTS	%
SiO2	34.4
AL2O3	21.5
Fe2O3	0.2
CaO	33.2
MgO	9.5
K2O	0.39
Na2O	0.34
SO3	0.66

B. Use of Graphene

Graphene is a single layer of carbon atoms arranged in a hexagonal lattice. it's known for its remarkable properties such as high conductivity, strength and flexibility. Graphene has applications in various fields, including electronics, materials Science, and energy storage due to its unique combination of properties. The chemical formula of graphene is simply "c", representing a single layer of carbon atoms Introduction of graphene into concrete represents a significant advancement in the construction industry, offering the potential for enhanced strength, durability, and other desirable properties.Graphene, a single layer of carbon atoms arranged in a hexagonal lattice, possesses extraordinary mechanical, thermal, and electrical properties. When incorporated into concrete, it can revolutionize the performance of this ubiquitous building material. The process of introducing graphene into concrete typically involves dispersing graphene nanoplatelets or graphene oxide within the concrete mixture. These graphene additives are often employed in minute quantities, owing to their remarkable strength and conductivity. The dispersion process ensures uniform distribution throughout the concrete matrix, maximizing the benefits of graphene

Nanoparticles Name: Graphene Nanoparticles / Nanopowder (C, >95 wt%)

Name of the Product	Graphene Nanoparticles/ Nanopowde
Molecular formula	*C*
Manufacturing Method	*CVD*
Purity	>95 wt%
Colour	Greyish Black
Diameter	500nm -1micron
Thickness	0.8 – 1.6 nm
No of Layers	1 – 3 Layers
SSA	200 – 500 m2/g
State	Amorphous Powder

III. MATERIALS

1) *Cement:* Pozzolana Portland Pozzolana cement conforming to IS 8112: 1989 was used.The specific gravity of cement is 3.05 and fineness of cement is 225m^2/kg.
2) *Fine Aggregate:* Locally available river sand passing through 4.75 mm I.S .Sieve is used. The specific gravity of the sand is foundto be 2.75.
3) *Coarse Aggregate:* Crushed granite aggregate available from local sources has been used. To obtain a reasonably good grading, 60% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 40% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used in preparation of NAC The specific gravity of the combined aggregate is 2.70
4) *GGBS (Ground Granulated Blast Furnace Slag):* Ground granulated blast furnace slag, a co-product produced simultaneously with iron, molten blast furnace slag is cooled instantaneously by quenching in large volumes of cold water, known as granulation, to produce Granulated blast furnace slag. Range = 30% to 60% of cement content will be replaced with GGBS in concrete
5) *Graphene:* Graphene, a single layer of carbon atoms arranged in a hexagonal lattice, possesses extraordinary mechanical, thermal, and electrical properties. Range 0.01-0.1% of cement content will be replaced with Graphene in concrete
6) *Water:* Potable fresh water available from local sources was used for mixing and curing of specimens.

A. Preparation Of Concrete Mixture

By referring to IS 10262-2019 and IS 456-2000, the mix design is carried out for M30 grade of concrete. The required materials are batched based on the values obtained by mix design. At first, the mix design values are calculated for 1 m^3 volume and then it is computed for standard cube moulds of size 150x150x150 mm. The materials which are free from the organic impurities were sieved before batching and after that,the mixing is done. The calculated amount of materials is taken and dry mixing is done and then required amount of water is added and mixed thoroughly to make a concrete. In this work, hand mixing is used for mixing the materials.

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After casting, the cubes are demolded in the laboratory after 24 hours of casting. During demolding,the care should be taken so as to not affect the concrete cubes, as they may lead to the development of cracksdue to improper demolding. After demolding, the concrete cubes are kept in water for curing for 28 days. Thecompression tests are conducted on hardened concrete for 28 days.

B. *Fresh Concrete Test*

1) *Slump Cone Test:* Concrete slump test measures the consistency of fresh concrete before it sets. Itis performed to check the workability of freshly made concrete. The procedure for the test is as follows:
   a) Clean the internal surface of the mould and apply oil.
   b) Place the mould on a smooth horizontal non- porous base plate.
   c) Fill the mould with the prepared concrete mix in 4 approximately equal layers.
   d) Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlyinglayer.
   e) Remove the excess concrete and level the surface with a trowel.
   f) Clean away the mortar or water leaked out between the mould and the base plate.
   g) Raise the mould from the concrete immediately and slowly in vertical direction.
   h) Measure the slump as the difference between the height of the mould and that of height pointof the specimen being tested.

IV. RESULTS

A. *Slump Cone Test*

The concrete slump test measures the consistency of fresh concrete before it sets. It performed to check the workability of freshly made concrete, and therefore the case with which flows. It can also be used as an indicatorof an improperly mixed batch.

1) Very low workability: slump value 0-25mm.
2) Low workability: slump value 25-50mm.
3) Medium workability: slump value 50-100mm.
4) High workability: slump value 100-175mm.

Table 5.1 Slump cone Test for M30

SL NO	% of GGBS	Slump value(mm)
1	Normal concrete	105
2	30%GGBS	90
3	0.1% Graphene	110
4	30%GGBS & 0.1% Graphene	100

B. *Compressive Strength Test*

The compressive strengths for all mixes are presented in Table 1 and table 2 and table 3 From this, it canbe observed that in 28 days compressive strength increased with the increase in the percentage of 19.4 for 30% replacement of GGBS and 0.1% of graphene in concrete.

SAMPLE	@7 days (MPA)	@14 days (MPA)	@28 days (MPA)
ConventionalConcrete	17.23	21.47	30.24
30% replacement ofGGBS	19.23	23.87	33.16
Adding 0.1% ofGraphene	20.49	25.36	34.74
Both 30% GGBS Replaced and 0.1% of Graphene added	21.67	26.73	36.13

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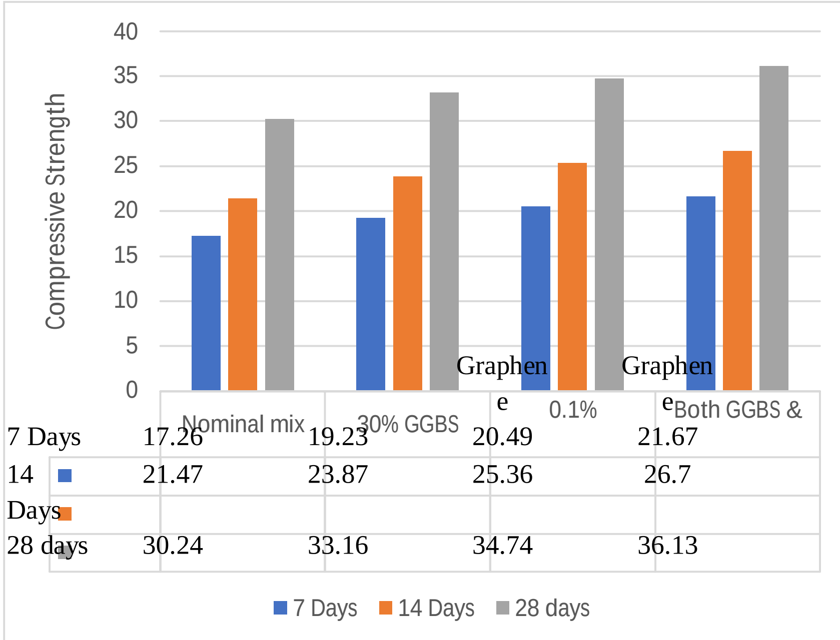

V. CONCLUSION

The following conclusions may be drawn from the present experimental work

1) The workability of concrete after mixed with GGBS and graphene is decreased compared with nominalconcrete.
2) The compressive strengths were increased up to 19.4% due to GGBS and Graphene replacement
3) The usage of GGBS up to 30% and 0.1% of graphene is beneficial for the concrete works.

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