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EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF GRAPHENE CONCRETE

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Abstract*—Graphene is a new construction material which is added into the concrete as a partial replacement of cement. This paper presents the study on the mechanical properties such as compressive strength, split tensile strength, and flexural strength of graphene concrete. Specimens were cast with graphene with partial replacement such as 0%, 0.1%, 0.3%, and 0.5%, by weight of cement using a water-cement ratio of 0.5. Tests were performed at the age of 7, 14 and 28 days for compressive strength, split tensile strength, and at the age of 28 days flexural strength were tested. For flexural strength two point loading test were applied. Test results concluded that on increasing graphene content strength parameters also increasing.

***Keywords*—Graphene, Compressive strength, Split tensile strength, Flexural strength.**

I. INTRODUCTION

Concrete is the most widely used construction material in the world and Ordinary Portland Cement (OPC) is the major ingredient used in concrete. The production of cement releases large amount of carbon dioxide (CO2) to the atmosphere that significantly contributes to greenhouse gas emissions. It is estimated that one ton of CO2 is released into the atmosphere for every ton of OPC produced. In view of this, there is a need to develop sustainable alternatives to conventional cement utilizing the graphene, as partial replacement or as performance enhancer for OPC.

Concrete is a composite material of aggregates and binders where binding materials are primarily a combination of Portland cement, pozzolanic materials and water. Hydration of cement generates heat due to the exothermic nature of the hydration process. The phases mainly responsible for heat generation during the hydration process are tricalcium silicate (C3S), dicalcium silicate (C2S), tricalcium aluminate (C3A) and tetracalcium aluminoferrite (C4AF). The hydration process of Portland cement depends on several factors or parameters such as cement mineralogical composition, particle size distribution, water to cement ratio and curing temperature. Due to the exothermic nature of the reaction combinedwith poor heat dissipation in massive concrete elements, the hydration process results in a temperature gradient between the inner core and the outer surface of the element.

A. graphene

Graphene is a single layer (monolayer) of carbon atoms, tightly bound in a hexagonal honeycomb lattice.

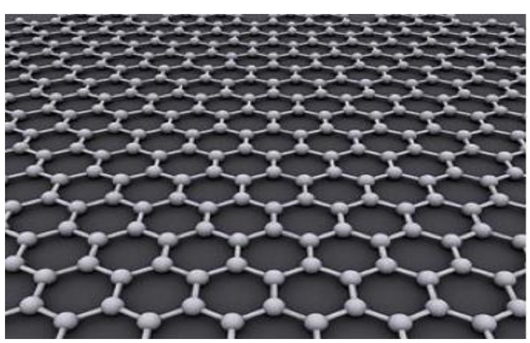


Fig.1.graphene two dimensional view

II. Experimental Investigation

A. Preparation of graphene

Graphene is formed by shear exfoliation of graphite powder with addition of acetone water and tea solution. Take 20 grams of graphite powder in shear exfoliation container, 500 ml of acetone water (70:30),and 40ml of tea solution is added to the graphite powder. The total mixture is grinding about 30minutes.then the graphite solution is filtered and the graphene particles are retained in filter paper and it should me dried.

TABLE I

Properties of graphene

Tests	Results
Specific Gravity	1.60

B. Cement

In this present work Birla Gold cement of 53 grade ordinary Portland cement (OPC) is used for casting cubes and cylinders and beams for all concrete mixes. The various tests conducted on cement are specific gravity, initial and final setting time, standard consistency and fineness tests.

TABLE II

Properties of Cement

Tests	Results
Standard Consistency	31%
Fineness	7%
Specific Gravity	3.10
Initial Setting Time	140 minutes
Final Setting Time	230 Minutes

C. Fine Aggregate

The sand used for this project was locally procured and conformed to grading zone II as per IS 383-1970.

TABLE III

Properties of Fine Aggregate

	Results
Specific Gravity	2.65
Bulk Density	1.6gr/cm^3
Grading Zone	II
Fineness modulus	2.89
% of Voids	39%
Void Ratio	0.57

D. Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20mm is used in the present work.

TABLE IV

Properties of Coarse Aggregate

	Results
Specific Gravity	2.89
Bulk Density	1.502gm/cm^3
Void Ratio	0.92
% of Voids	49.8%
Fineness Modulus	6.89

E. Water

Potable tap water is used for the preparation of specimens and for curing specimens.

F. Sizes of specimens

Size of cubes for compressive strength is 150X150X150mm, size of cylinders for split tensile strength is 150X300mm, and size of under reinforced beam for flexural strength is 1300X100X150mm.

G. Mix Design

Grade of concrete is M20, water cement ratio is 0.5,The mix design is done as per IS: 456-2000 and IS: 10262-2009.

TABLE V

Mix Design of M20 Grade Concrete

Materials	**Cement**	**Fine aggregate**	**Coarse aggregate**	**Water (lit.)**
Quantity (kg/m^3)	372	642.97	1192.42	186
Proportions	1	1.728	3.20	0.50

H. Reinforcement details

Singly reinforced beam ofa under reinforced section, 2bars 12mm dia at tension zone , 2bars 6mm dia at compression zone, and 6mm stirrups placing 90mm centre to centre.

I. Testing of Beam specimens

For flexural strength Two point loading test were applied.

Fig.2.Expermental setup

Fig.3.Flexural cracks

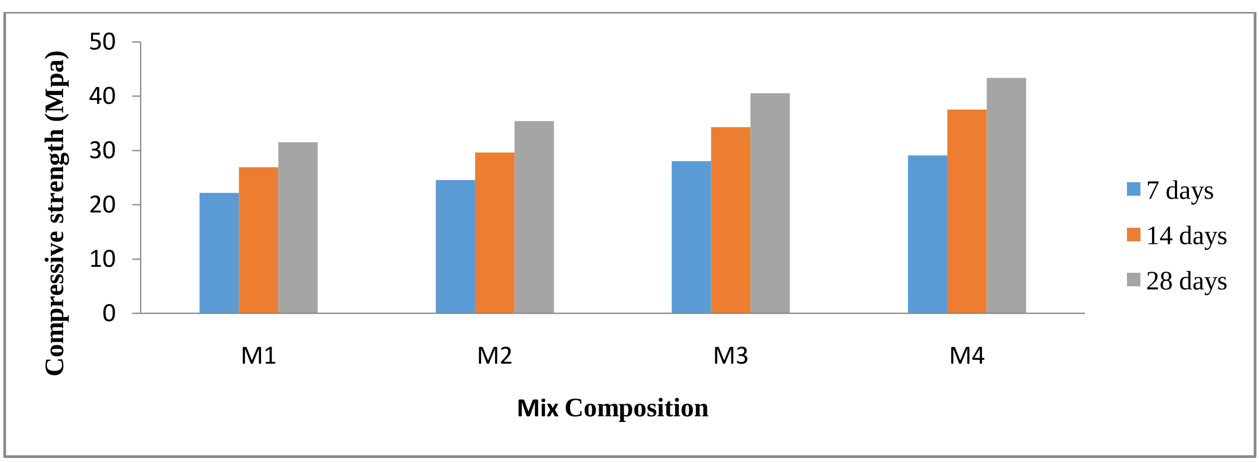
III. RESULTS AND DISCUSSIONS

1. *COMPRESSIVE STRENGTH:*

TABLE VI
Average Compressive strength (Mpa)

Graphene mix Composition		Average Compressive strength (Mpa)		
		7 days	**14 days**	**28 days**
0%	M1	22.22	26.91	31.53
0.1%	M2	24.57	29.62	35.44
0.3%	M3	28.02	34.27	40.55
0.5%	M4	29.12	37.54	43.41

Fig.4.Compressive strength for 7,14 &28 days

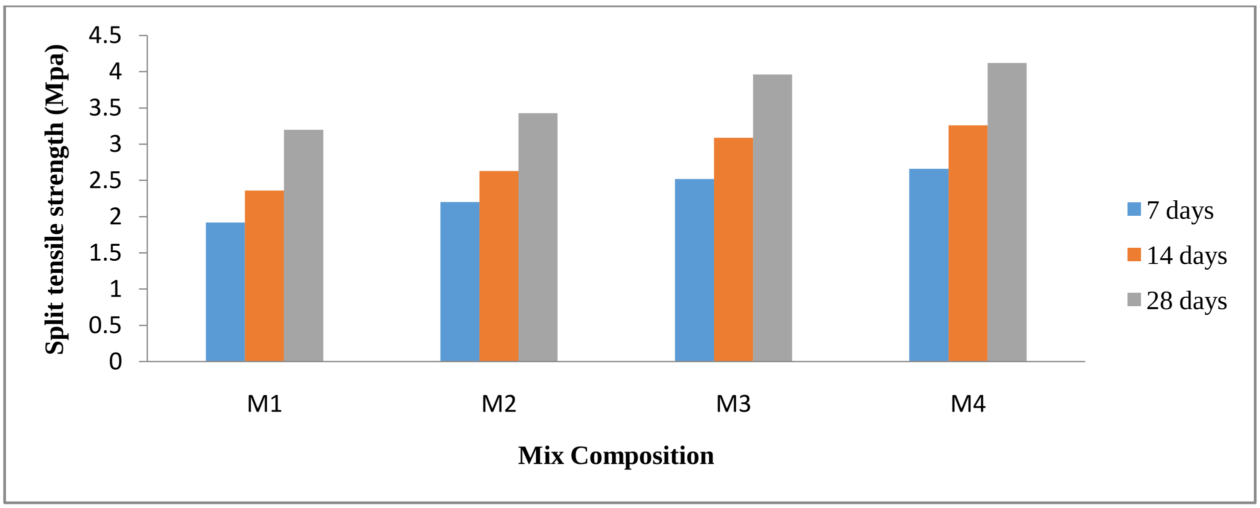


2. *SPLIT TENSILE STRENGTH*:

TABLE VII
Average Split tensile strength (Mpa)

Graphene mix Composition		**Average Split tensile strength (Mpa)**		
		7 days	**14 days**	**28 days**
0%	M1	1.92	2.36	3.2
0.1%	M2	2.2	2.63	3.43
0.3%	M3	2.52	3.09	3.96
0.5%	M4	2.66	3.26	4.12

Fig.5.Split tensile strength for 7,14 &28 days



3. *FLEXURAL STRENGTH*

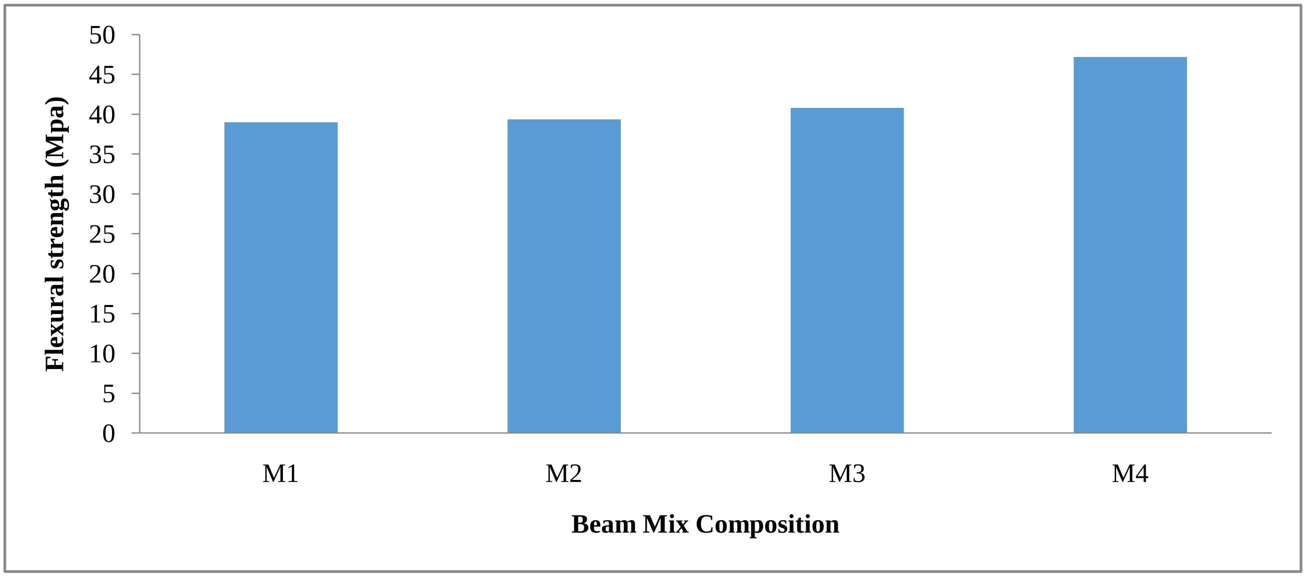
The flexural strength of the beam was obtained by the expression of PL/BD^2based on the bending stress equation (M/I = f/ y = E/R). Where P = ultimate load in tonnes, L = span of the beam in mm; B = width of the cross section in mm; D = overall depth of the beam inmm. By observing flexural strength of the beam is increasing by addition of graphene. Maximum flexural strength attained for M4 mix composition beam.

TABLE VIII

Flexural strength (Mpa)

Beam Mix Composition	Flexural strength (Mpa)
M1	39
M2	39.35
M3	40.81
M4	47.18

Fig.6.Split tensile strength for 7,14 &28 days



IV. CONCLUSION

Graphene is added as partial replacement of cement 0.1%, 0.3%, 0.5% is increases the mechanical properties of compressive strength, split tensile strength, of 7days, 14days, and 28 days of age of curing compared to normal conventional concrete.Graphene content of 0.5% as partial replacement of cement, it increases 36% of compressive strength, 28% of split tensile strength compared to conventional concrete, at the age of 28 days curing. Flexural strength of M4 graphene concrete beam is 21% increases compared to conventional concrete beam.

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