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An Experimental Study On the Strength Properties of Graphene Oxide Concrete with Partial Replacement of Coarse Aggregate by Recycled Coarse Aggregate

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***Abstract*: In order to reduce the construction waste in the civilizing world, we need to think for alternative cost effective and relatively easier technological methods to reduce construction waste. It is seen that 60%-67% of coarse aggregate are present in the concrete demolished waste. Concrete waste is broken into pieces and used as recycled coarse aggregate. As the world's population increases the natural resources get depleting. The concern with need of raw materials and production of large amount of waste has led to several studies and solution for this problem is use of recycled aggregate in concrete. Use of recycled aggregates reduce the need of landfill and Cost. The preliminary tests such as water absorption, specific gravity and crushing strength are conducted for recycled aggregate and compared with natural aggregate. Graphene oxide is an allotrope of carbon. From past studies using graphene oxide, there is an appreciable increase in compressive, flexural and split tensile strength of concrete. An attempt has been made to study the strength properties by graphene oxide in varying percentage 0%, 0.05%, 0.1%.0.15% and 0.2% of cement and replacing partially natural aggregate by recycled aggregate in 0, 10, 20 and 30 percent.**

***Keywords*: Concrete waste, Compressive strength, Graphene oxide, Flexural strength, Split tensile strength.**

1. Introduction

Incorporation of reinforcing materials into concrete has become a common practice to increase the mechanical properties of concrete. Steel, glass, polymer and carbon have been considerably used to grow fibre reinforced composites over the past several decades. Recently, carbon nano structures such as carbon nano tubes, carbon nano fiber and graphene have gain attention from many concrete researches because of their exceptional mechanical performance. Many researchers reported that, these nano materials improve the mechanical properties of ordinary Portland cement by controlling nano size cracks before further expansion.

Graphene oxide is formally called as graphitic acid. Graphene is an allotrope form of carbon as 2D nuclear scale honeycomb cross section in which one particle shapes every vertex. Graphene oxide has numerous remarkable properties. Graphene oxide was synthesized by oxidation of graphite. Although there are many experimental and theoretical models, the real structure of graphene oxide still remains controversial a consequence.

Demolition of old structure and construction of new one is common due to change in purpose, structural deterioration, rearrangement of cities expansion of traffic. In USA the waste produced from building demolition alone is approximately 123 million tons per year (Malesev et al. 2010). About 850 million tons of construction and demolition waste are generated in European union each year (Malesev et al. 2010).Globally a vast amount of concrete waste is derived from the demolition of old concrete structure, most commonly this concrete waste is disposed to landfills thus causing sustainable environmental load and health hazard(Malesev et al 2010).Further the shortage of land and the increase charges for landfill worsen this environmental problem thus utilization of concrete waste in sustainable development may all alleviate problems. In concrete, the coarse aggregate usually occupies about 70% of the total volume of concrete. Therefore, the demand for coarse aggregates is huge in the construction industry. The increased extraction of coarse aggregates from the natural resources is required to meet this high demand. The increasing use of natural coarse aggregate (NCA) creates an ecological imbalance. Thus, the use of alternative coarse aggregates is vital in construction industry. One of the means to achieve this is to use the recycled concrete aggregate (RCA).

2. Objectives

- To determine the mechanical properties of concrete such as compressive, flexural and split tensile strength.
- To reduce construction wastes in environment.
- To increase strength in concrete by adding graphene oxide in various percentage.

3. Materials and Methods

- Cement
- Fine aggregate

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- Coarse aggregate
- Graphene oxide
- Recycled concrete aggregate
- Water

4. Methodology

- Preliminary test for materials.
- Mix design is carried out for M-20 concrete for partial replacement of graphene oxide and recycled aggregates.
- Use of graphene oxide in various percentage such as 0%, 0.05%, 0.1%, 0.15% and 0.2% of cement in preparing M-20 grade concrete.
- Cubes of 150 mm x 150 mm x 150 mm, beams of 100 mm x 100mm x 500mm and cylinders of 150 mm diameter and 300 mm height specimens were prepared.
- Specimens are tested for compressive, flexural and split tensile strengths after 28 days of curing
- The percentage quantity of graphene oxide added which gives the maximum strength is taken as a constant for further work.
- For constant quantity of graphene oxide, the design mixes were carried out for M-20 grade concrete with varying percentage of recycled coarse aggregate such as 0%, 10%, 20% and 30% of natural aggregate.
- Specimens were tested for compressive and flexural strength after 28 days of curing.

5. Results and Discussion

Table 1
Test results of cement

S. No.	Tests	Result	IS:12269-1987
1	Normal consistency	28 %	26 – 33 %
2	Initial setting time	Min	>30 min
3	Final setting time	320 min	< 600 min
4	Specific gravity	3.10	3.15

Table 2
Test results of fine aggregate

S. No.	Test	Result	IS: 383-1970
1	Specific gravity	2.62	2.5 to 3.0
2	Grading zone	Zone ll	-
3	Moisture content	1.80	6.0

Table 3
Test results of coarse aggregate

S. No.	Test	Result	IS: 2386 (Part - 4) 1964
1	Specific gravity	2.80	2.5-3.0
2	Crushing value	28.5%	< 30%
3	Impact value	25.52%	< 30%

Table 4
Test results of recycled coarse aggregate

S. No.	Test	Result	IS: 2386-1963
1	Specific gravity	2.90	2.5 to 3.0
2	Impact value	23.10%	<30%
3	Crushing value	25.80%	<30%
4	Water absorption	0.70%	<3.5%

A. Test on hardened concrete varying percentage of graphene oxide with natural aggregate

Table 5
Compressive strength test

S. No.	Percentage addition of graphene oxide	Compressive load at failure (KN)	Compressive Strength (MPa)	% Increase/Decrease in Compressive strength w.r.t. (Ref. mix)
1	0.00 (Ref. mix)	550	24.45	-
2	0.05	946	42.08	+72.10
3	0.10	716	31.90	+30.47
4	0.15	685	30.45	+24.53
5	0.20	622	27.57	+12.76

Table 6
Flexural strength test

S. No.	% Addition of recycled aggregate	Flexural load at failure (KN)	Flexural strength (MPa)	% Increase/decrease in flexural strength w.r.t. (ref. mix)
1	00 (Ref. mix)	12.03	4.81	-
2	10	14.00	5.60	+ 16.42
3	20	13.20	5.28	+9.77
4	30	11.50	4.60	-4.36

Table 7
Split tensile strength test

S. No.	% Addition of graphene oxide	Split tensile load at failure (KN)	Split Tensile strength (MPa)	% Increase / decrease in split tensile strength w.r.t. ref. mix
1	0.00 (Ref. mix)	230.00	3.25	-
2	0.05	391.33	5.536	+70.33
3	0.10	325.33	4.602	+41.60
4	0.15	308.20	4.36	+34.15
5	0.20	285.26	4.025	+23.84

B. 0.05% of graphene oxide with varying percentage of natural aggregate

Table 8
Compressive strength test

S. No.	% Addition of recycled aggregate	compressive strength load at failure (KN)	compressive strength (MPa)	% Increase / decrease in compressive strength w.r.t. ref. mix
1	0.00 (Ref. mix)	550	24.45	-
2	0.05	946	42.08	+72.10
3	0.10	716	31.90	+30.47
4	0.15	685	30.45	+24.53
5	0.20	622	27.57	+12.76

Table 9
Flexural strength test

S. No.	% Addition of recycled aggregate	Flexural load at failure (KN)	Flexural strength (MPa)	% Increase/decrease in flexural strength w.r.t. ref. mix
1	00 (Ref. mix)	12.03	4.81	-
2	10	14.00	5.60	+ 16.42
3	20	13.20	5.28	+ 9.77
4	30	11.50	4.60	- 4.36

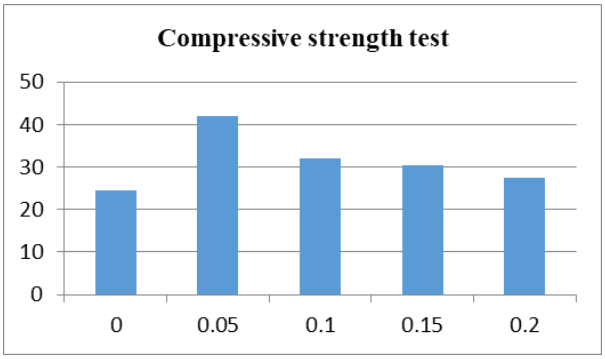

Fig. 1. Compressive Strength (MPa) vs. % addition of graphene oxide

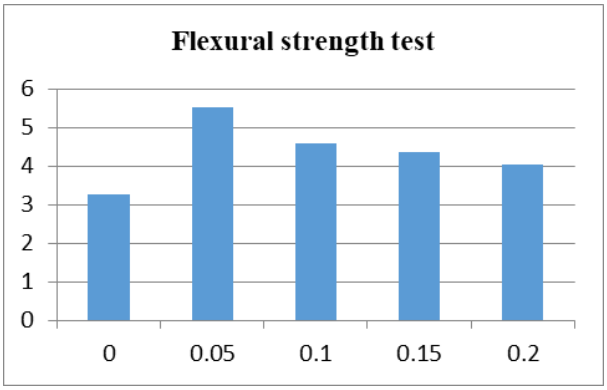

Fig. 2. Flexural Strength (MPa) vs. % Addition of recycled aggregate

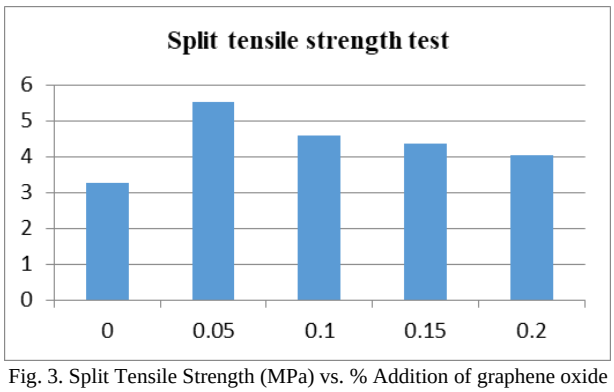

Fig. 3. Split Tensile Strength (MPa) vs. % Addition of graphene oxide

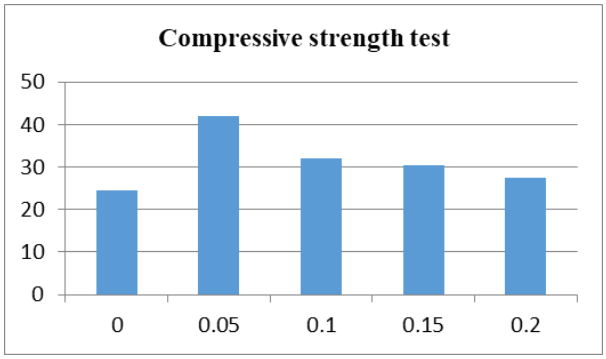

Fig. 4. Compressive Strength (MPa) vs. % addition of graphene oxide

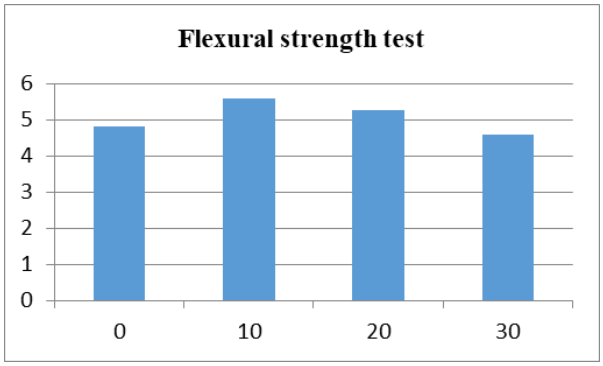

Fig. 5. Flexural Strength (MPa) vs. % Addition of recycled aggregate

6. Conclusion

From the present studies, the following conclusions were drawn.

- Addition of graphene oxide in concrete increases on the load carrying capacity of concrete.
- 0.05% addition of graphene oxide to cement results in increase in the mechanical properties of concrete such as compressive, flexural and split tensile strength by 72.10%, 72.97% and 70.15% respectively.
- The test result reveals that, maximum compressive, flexural and split tensile strength were obtained at 0.05% addition of graphene oxide by weight of cement.
- 30% replacement of natural coarse aggregate by recycled coarse aggregate with 0.05% of graphene oxide by weight

of cement increases the compressive strength by 72.10% and decrease flexural strength by 4.36%.

- Thus, Usage of recycled aggregate reduces the impact of waste on environment.

7. Scope for Future Work

From past studies and results, it is recommended that with different percentages of Graphene oxide and recycled coarse aggregates with natural aggregates should be prepared to achieve the adequate strength of the concrete and to reduce the usage natural aggregate.

- GGBS can be used as partial replacement for cement with 0.05% of graphene oxide.
- Durability property of recycled aggregate to natural aggregate with various percentage addition of recycled aggregate can be studied.

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