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Experimental Investigation on Concrete using Carbon Fibers and Partial Replacement of Cement with Metakaolin

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Abstract:

Major construction activities performed using concrete which is good in compression. The major draw backs of concrete are brittleness and crack formation which decreases the durability and strength. This paper reviews the some of the research published on different uses of adding carbon fibers and partial replacement of cement with metakaolin to the concrete. In this experimental investigation the focus on adding carbon fibers and replacing metakaolin with appropriate proportions on M30 grade i.e., different percentages (0.40, 0.80, 1.00, 1.20, and 1.60%) of carbon fiber reinforcement by the volume of concrete. Percentage of metakaolin as partial replacement with cement (5, 10, 15, 20 and 25%) to determine the properties of fresh and hardened concrete. The destructive methods of testing conducted on compressive and split tensile strength test. The specimens also tested and evaluated the strength by performing non-destructive tests such as ultrasonic pulse velocity and rebound hammer test.

Keywords: *Carbon fibers, compressive strength, metakaolin, split tensile strength.*

I. INTRODUCTION

Concrete is strong and versatile mouldable constructional material. Concrete paste or gel is formed when cement mixes with water which coats the fine and coarse aggregates. Coarse aggregate used as strength constituent material. Fine aggregate used as filler. Concrete takes cares of compression and lacks in tension. To give it good load bearing capacity we can add carbon fibers and partial replacement of metakaolin with cement.

The main unbiased of this project is to study the strength parameters for M40 grade concrete. By adding different percentages (0.40%, 0.80%, 1%, and 1.20%) for carbon fibers by the volume of the concrete and replacing cement with different percentages (5%, 10%, 15%, and 20%) of metakaolin.

II. MATERIALS USED

A. Cement

The tests were conducted on the OPC of 53 grade and the results are furnished in Table 1.

Table.1 Physical properties of cement

S.No	Properties	Value
1	Fineness	6%
2	Intial setting time	35minutes
3	Final setting time	460 minutes
4	Specific gravity	28%
5	Normal consistency	3.14

B. Fine aggregate

Particle size which is less than 4.75mm is used as fine aggregate from locally available source. Different tests were conducted on fine aggregate and in Table 2.

Table.2 Physical properties of fine aggregate

S.No	Properties	Value

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1	Specific gravity	2.69
2	Water absorption	0.45%

C. Coarse aggregate

Particle size which is greater than 4.75mm is used as coarse aggregate and its properties are presented in Table 3.

Table.3 Physical properties of coarse aggregate

S.No.	Properties	Value
1	Size	20mm
2	Specific gravity	2.72
3	Impact value	20.44
4	Water absorption	0.38%

D. Carbon fibers

Carbon fibers are usually combined with other material to form a composite. Carbon fiber of 12mm length is used. Carbon fibers have thermal conductivity, tough in nature and very low density. Carbon fiber increases the durability and strength of concrete heavily when compared to conventional concrete.

E. Metakaolin

Metakaolin particle size is smaller than the particle size of cement. The material is light weight concrete and high strength and high performance. In this study the OPC is replaced with 8-20% (by weight) and hence enhances the engineering properties. It is seen that the split tensile quality increment at 100°C temperature when contrasted with the quality at ordinary room temperature for substituting Metakaolin of 0 and 15%. The physical properties are presented in Table 4.

Table.4 Physical properties of coarse aggregate

S.No	Properties	Value
1	Bulk density	2.3
2	Particle shape	Spherical
3	Color	White
4	Specific gravity	2.5

III. CONCRETE MIX DESIGN AND MIX PROPORTIONS

The mix proportion for M40 grade of concrete designed and trial mixes were cast as per IS 10262-2009 and its mix proportion is 1:1.89:3.29 with water cementitious ratio as 0.38.

IV. TEST RESULTS

The tests are conducted to evaluate the strength of hardened concrete such as

1. Compressive strength.
2. Split tensile strength.
3. UPV test

The test results are presented in Table 5 & 6.

Table.5 Compressive and split tensile strength Test at 7 and 28 days

S.No	% of Carbon Fibers & Metakaolin	Compressive Strength		Split Tensile Strength	
		7 Days	28 Days	7 Days	28 Days
1	0+0	33.56	48.57	3.39	4.91
2	0.4+5	35.45	51.19	3.59	5.10
3	0.8+10	37.91	53.81	3.79	5.53
4	1+15	40.13	56.34	4.11	5.73
5	1.2+20	35.80	51.91	3.57	3.81
6	1.6+25	34.83	49.83	3.49	3.70

Table.6 Ultrasonic pulse velocity of concrete at 28 days

S.No	% of Carbon Fibers &Metakaolin	U.P.V Test Results at 28days (m/sec)
1	0+0	4450
2	0.4+5	4605
3	0.8+10	4703
4	1.0+15	4761
5	1.2+20	4672
6	1.6+25	4628

V. CONCLUSION

1. The addition of Metakaolin and carbon fibers has increased the strength values of concrete, both compressive strength and split tensile strength.
2. The maximum value of compressive strength is found to be 40.13N/mm^2 @ 1 + 15%, 56.34 N/mm^2 @ 1 + 15% addition of carbon fibers and metakaolin respectively for 7 and 28 days of curing.
3. The percentage increment of compressive strength of the reinforced concrete with respect to the conventional concrete is 19.57 for 7 days, 16.96% for 28days.

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4. The maximum value of split tensile strength is 4.11N/mm^2 @ 1 + 15%, 5.73N/mm^2 @ 1 + 15% addition of carbon fibers and metakaolin respectively for 7days, 28days of curing.
5. The Percentage increment of split tensile strength of the reinforced concrete with respect to the conventional concrete is 21.23% for 7days, 16.70% for 28days.
6. The addition of carbon fibers and metakaolin will increase the durability and strength of concrete when compared to conventional concrete
7. The addition of carbon fibers and metakaolin will decrease the shrinkage and creep of concrete when compared to conventional concrete.
8. The ultrasonic pulse velocity test results for conventional concrete is 4450m/sec for 28days.
9. The ultrasonic pulse velocity test results for carbon fibers and metakaolin concrete is found to be 4761m/sec at 28days.
10. The percentage increment of compressive strength of the carbonfiber and metakaolin concrete with respect to conventional concrete is 6.98% for 28days.

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