To study feasibility of Carbon Fiber in Concrete

Abhishek Upadhyay[1], Ankush Pandey[2], Chanchal Singh[3] & Dhruv Bhardwaj[4]

[1-4]Department of Civil Engineering, A.D.G.I.T.M., New Delhi-110043, India

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***Abstract*—**Carbon fibers or carbon Fibers (alternatively CF, graphite fiber or graphite Fiber are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

Keywords— Carbon Fiber, Compressive Strength, Fiber reinforced concrete

Introduction (CARBON FIBER)

In the era of skyscrapers and multi-storey buildings the responsibility upon Civil engineering construction has increased enormously due to the structural and durability requirements. This has led to tremendous research work by engineers upon various construction material and one of such material is carbon fiber.

Carbon fibers or **carbon fibers** (alternatively CF, graphite fiber or graphite fiber are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms.

Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

The fibers used were chopped carbon fibers which are uniformly and randomly distributed in the concrete mix. Four different fiber content were chosen 0% , 1% and 2% for each mix.

Properties of Carbon Fiber

A. *Physical Properties*

Length: 5-15 mm

Density: 1950 kg/m^3

Diameter: 5-10 micron

Color: Brownish Black

Elastic Modulus: 10000-11000 kg/m^3

B. *Chemical Properties*

Resistant to Acid & Alkali.

High heat Tolerance.

No toxic reaction with air or water.

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C. *Mechanical Properties*

- Carbon Fibers are non-hygroscopic in nature which makes it moisture resistant.

D. ***Authors and Affiliations***

*a) **Abhishek RN Upadhyay** pursuing Bachelor's Degree in Civil Engineering from ADGITM ,Indraprastha University, Delhi.He is currently working on "Carbon Fiber Reinforced Concrete" as a research project*

*b) **Ankush Pandey** pursuing Bachelor's Degree in Civil Engineering from ADGITM ,Indraprastha University, Delhi.He is currently working on "Carbon Fiber Reinforced Concrete" as a research project*

*c) **Chanchal Singh** pursuing Bachelor's Degree in Civil Engineering from ADGITM ,Indraprastha University, Delhi.He is currently working on "Carbon Fiber Reinforced Concrete" as a research project*

*d) **Dhruv Bhardwaj** pursuing Bachelor's Degree in Civil Engineering from ADGITM ,Indraprastha University, Delhi.He is currently working on "Carbon Fiber Reinforced Concrete" as a research project*

E. ***Results and observation***

1) Laboratory tests related to the compressive strength of concrete after introduction of carbon Fiber in different quantities and under different conditions were performed..The primary objective to perform these tests was to evaluate the characteristics of carbon fiber reinforced concrete and its advantageous effect.
The tests were performed according to the guidelines of IS 516:1959 to determine the compressive strength of concrete.

Mix Design for M25 grade concrete (IS 10262:2009)

Proper design of concrete mixture is essential to obtain appropriate proportioning of ingredients that will produce concrete of high durability and performance during the designed life of a structure.

Step 1. Design stipulations for proportioning

1. *Grade designation: M25*
2. *Type of cement: OPC 53 grade confirming to IS 8112*
3. *Maximum nominal size of aggregates: 20 mm*
4. *Maximum water cement ratio: 0.4*
5. *Workability: 100 mm (slump)*
6. *Exposure condition: Mild*
7. *Degree of supervision: Good*
8. *Type of aggregate: Crushed angular aggregate*
9. *Chemical admixture: Super Plasticizer* ***PCE (Polycarboxylic Ether)***

Step 2. Test data for materials

1. *Cement used: OPC 43 grade confirming to IS 8112*
2. *Specific gravity of*
   Cement : 3.12
   Coarse aggregate : 2.70
   Fine aggregate : 2.67
3. *Water absorption of*
   Coarse aggregate: 0.86 percent
   Fine aggregate : 1.72 percent
4. *Free (surface) moisture of*
   Coarse aggregate: Nil (absorbed moisture full)
   Fine aggregate : Nil
5. *Sieve analysis of*
   Coarse aggregate: Conforming to Table 2 of IS: 383
   Fine aggregate : Conforming to Zone II of IS: 383

Step 3. Target strength for mix proportioning

fck = fck + 1.65 s Where fck = Target average compressive strength at 28 days,
fck = Characteristic compressive strength at 28 days,
s= Standard deviation
From Table 1 standard deviation, s = 4N/mm²
Therefore target strength = 25 + 1.65 x 4 = 31.5 N/mm²

Step 4. Selection of water cement ratio

From Table 5 of IS: 456-2000, maximum water cement ratio = 0.5
Based on experience adopt water cement ratio as 0.4
0.4< 0.5, hence ok

Step 5. Selection of water content

From Table-2, maximum water content = 186 liters
Estimated water content for 100 mm slump = 186 + 6/100 x186 = 197 liters
*Water reduced by use of superplasticizer by more than 20% adopting 30% water reduction, water required= 197*0.7= 138 liters*

Step 6. Calculation of cement content

Water cement ratio = 0.4
Cement content = 1140/0.4 = 345 kg/m³
From Table 5 of IS: 456, minimum cement content for severe exposure condition = 300 kg/m³
Hence OK

Step 7. Proportion of volume of coarse aggregate and fine aggregate content

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62. Aggregates are assumed to be in SSD.

In the present case water-cement ratio is 0.42. Therefore. volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.08. the proportion of volume of coarse aggregate is increased by 0.016 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.42 = 0.636

Step 8. Mix calculations

For 1m3 of concrete,

1. Cement=345kg/m³

2.Water=138kg/m³

3.Coarse Aggregate= 1104 kg/m³

4.Fine Aggregate= 728 kg/m³

5. Chemical Admixture (Master Glenium 51) = 1.38 kg/m³

6. Water-Cement Ratio= 0.4

Mix Design for M30 grade concrete (IS 10262:2009)

Proper design of concrete mixture is essential to obtain appropriate proportioning of ingredients that will produce concrete of high durability and performance during the designed life of a structure.

Step 1. Design stipulations for proportioning

10. *Grade designation: M30*
11. *Type of cement: OPC 53 grade confirming to IS 8112*
12. *Maximum nominal size of aggregates: 20 mm*
13. *Maximum water cement ratio: 0..35*
14. *Workability: 100 mm (slump)*
15. *Exposure condition: Mild*
16. *Degree of supervision: Good*
17. *Type of aggregate: Crushed angular aggregate*
18. *Chemical admixture: Super Plasticizer* ***PCE (Polycarboxylic Ether)***

Step 2. Test data for materials

6. *Cement used: OPC 43 grade confirming to IS 8112*
7. *Specific gravity of*
   Cement : 3.12
   Coarse aggregate : 2.70
   Fine aggregate : 2.67

8. *Water absorption of*
   Coarse aggregate: 0.86 percent
   Fine aggregate : 1.72 percent
9. *Free (surface) moisture of*
   Coarse aggregate: Nil (absorbed moisture full)
   Fine aggregate : Nil
10. *Sieve analysis of*
   Coarse aggregate: Conforming to Table 2 of IS: 383
   Fine aggregate : Conforming to Zone II of IS: 383

Step 3. Target strength for mix proportioning

fck = fck + 1.65 s Where fck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days,

s= Standard deviation

From Table 1 standard deviation, s = 5 N/mm²

Therefore target strength = 30 + 1.65 x 5 = 38.25 N/mm²

Step 4. Selection of water cement ratio

From Table 5 of IS: 456-2000, maximum water cement ratio = 0.5

Based on experience adopt water cement ratio as 0..35

0.35< 0.5, hence ok

Step 5. Selection of water content

From Table-2, maximum water content = 186 liters

Estimated water content for 100 mm slump = 186 + 6/100 x186 = 197.16liters

Water reduced by use of super plasticizer by more than 20% adopting 30% water reduction,

*water required= 197*0.7= 138 liters*

Step 6. Calculation of cement content

Water cement ratio = 0.35

Cement content = 1140/0.35 = 395 kg/m³

From Table 5 of IS: 456, minimum cement content for severe exposure condition = 300 kg/m³

Hence OK

Step 7. Proportion of volume of coarse aggregate and fine aggregate content

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II)

for water-cement ratio of 0.50 =0.62. Aggregates are assumed to be in SSD.

In the present case water-cement ratio is 0.42. Therefore. volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.08. the proportion of volume of coarse aggregate is increased by 0.016 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio). Therefore. Corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.42 = 0.636

Step 8. Mix calculations

For 1m3 of concrete,

1. Cement=395kg/m³

2. Water=138kg/m³

3. Coarse Aggregate= 1225 kg/m³

4. Fine Aggregate= 755 kg/m³

5. Chemical Admixture (MasterGlenium 51) = 1.57 kg/m³

6. Water-Cement Ratio= 0.35

Compressive strength for M20 grade Concrete

S No.	Type of Concrete	Avg. Strength (7 days)	Avg. Strength (28 days)
1.	Normal Concrete	14.4 N/mm²	21.39 N/mm²
2.	1% CFC	19.19 N/mm²	31.34 N/mm²
3.	2% CFC	18.56 N/mm²	30.173 N/mm²

Compressive strength for M25 grade Concrete

S No.	Type of Concrete	Avg. Strength (7 days)	Avg. Strength (28 days)
1.	Normal Concrete	18.01 N/mm²	26.67 N/mm²
2.	1% CFC	24.31 N/mm²	35.81 N/mm²
3.	2% CFC	23.14 N/mm²	35.45 N/mm²

Compressive strength for M30 grade Concrete

S No.	*Type of Concrete*	*Avg. Strength (7 days)*	*Avg. Strength (28 days)*
1.	*Normal Concrete*	*22.76 N/mm²*	*34.04 N/mm²*
2.	*1% CFC*	*30.27 N/mm²*	*44.93 N/mm²*
3.	*2% CFC*	*29.31 N/mm²*	*43.23 N/mm²*

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