International Journal of Future Generation Communication and Networking
Vol. 13, No. 3, (2020), pp. 4049–4055

Use of Carbon Fibre to Evaluate Mechanical Properties of Concrete

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Abstract

Concrete is the large used construction material. It is difficult to find out another material of construction, which is as versatile as concrete. Concrete is seemingly simple but actually complex material. Crack formation in reinforced concrete structures will takes place due to low tensile strength of concrete. Wider cracks may not only destroy the aesthetics of structure, but also expose steel reinforcement to the environment leading to corrosion. Cracking in reinforced concrete members also causes a significant increase in deflection. This is a result of the reduction in bending stiffness at cracked section. Reinforced concrete structures with high strength deformed bars and designed using limit state method was found to have larger crack widths. Bending is one of the reasons for flexural cracks. These cracks appear in the tension face & extend vertically in a small region over interior supports & in mid span regions of continuous beams. Cracking usually near elastic neutral axis, because of diagonal tension caused due to dominant shear force. One viewpoint is that cracks reduce the service life of structures. The tensile strength of concrete is about 10 percent of the compressive strength, but in the design of reinforced concrete structural elements, this strength is neglected. as we know Steel reinforcement is provided to carry the tensile stresses in a member due to applied loads. It is anticipating that cracks will develop in a reinforced concrete member under service loads. we know that in tension zone, the steel reinforcement is engaged primarily when a crack occurs, and design of reinforced concrete structures is carried out based on the fact that significant portions of the structure are cracked.

Keywords— *Concrete, fibres, cube and cylinder, compressive strengths, tensile strength*

I. INTRODUCTION:

The use of fibres in concrete to improve pre- and post-cracking behaviour has gained popularity. Since 1967, different fibre types and materials have been successfully used in concrete to improve its physical properties and durability. A number of independent research results showing the ability of fibres to improve durability and physical properties of concrete supports this. heedless of origin, cracking, when induced by chemical, mechanical, or environmental processes, results in deteriorated and less-durable concrete. The increased permeability caused by cracking can expedite other deterioration processes such as freezing-and-thawing damage, again resulting in less-durable concrete. Fibre-reinforced concrete (FRC) is concrete with the addition of distinct reinforcing fibres made of steel, glass, synthetic (nylon, polyester, and polypropylene), and natural fibre materials. At appropriate dosages, the addition of fibres may provide increased resistance to plastic and drying shrinkage cracking, reduced crack widths, and enhanced energy absorption and impact resistance. The major advantage derived from the use of FRC is improved concrete durability. Common lengths of discrete fibres range from 10 mm (3/8 in.) to a maximum of 75 mm (3 in.). They are normally added

ISSN: 2233-7857 IJFGCN

to the concrete during the batching operation but alternately can be added at the job site. It is important that sufficient mixing time should be provided after fibres are added to a mixture. Most common composite material used in concrete confining is fibre-reinforced polymers (FRP). These type of materials, which consist of glass, carbon or aramid fibres set in a suitable resin to form a rod or grid, are well accepted and should provide highly durable concrete reinforcement. The durability is a function of both the resin and the fibre, while the amount and type of fibre are keys to determining the mechanical properties of FRP. All fibre reinforced polymers materials have a straight line response to failure with no plasticity. A number of footbridges and highway bridges have been built, mainly in Japan and North America.

II. REVIEW OF LITERATURE

All over the world, many researches are inventing the materials, which can be suitably added in concrete for enhancing its properties. A compressive review of researcher used plastic in different form in making concrete this discussed in this section.

Dr. Deborah & D.L Chung (2016) In this paper the use of short pitch-based carbon fibres (0.05% of weight of cement, 0.189 vol. % concrete), together with a dispersant, chemical agents and silica fume, in concrete with fine and coarse aggregates resulted in a flexural strength increase of 85%, and a flexural toughness increase of 205%, a compressive strength increase of 22%, and a material price increase of 39%. The slump was 4 in at a water/cement ratio of 0/50 (I think it is 0.5). as we know The air content was 6 %, so the freeze-thaw durability was increased, even in the absence of an air entertainer. we know that The aggregate size had little effect on the above properties. The minimum carbon fibre content was 0.1 vol. %.

Zeng-Qiang Shi, D.D.L. Chung (2016) This paper deals use of Self-Monitoring Concrete for Traffic monitoring. Concrete is made Self-Monitoring by addition of Carbon Fibres. Traffic monitoring is an essential part of traffic control and management, involves real-time monitoring and requires strain sensors, which may be optical, electrical, magnetic, or acoustic. The sensors are conventionally attached to or embedded in the highway for which traffic monitoring is de-sired. The sensors suffer from (1) their sensing ability being limited to their immediate vicinities, (2) they are not sufficiently durable, and (3) they are too expensive for wide-spread use. A new technology involves the use of concrete itself as the sensor, so that no embedded or attached sensor is needed. Because the structural material is also a sensor, the whole structure is sensed and the sensor (just concrete) is durable and inexpensive. Hence, all three problems for conventional sensors are removed by the use of this self-monitoring concrete.

D.D.L. Chung This is a review of cement-matrix composites containing short carbon fibres. These composites exhibit attractive tensile and flexural properties, low drying shrinkage, high specific heat, low thermal conductivity, high electrical conductivity, high corrosion resistance and weak thermometric behaviour. Moreover, they facilitate the catholic protection of steel reinforcement in concrete, and have the ability to sense their own strain, damage and temperature. Fibre surface treatment can improve numerous properties of the composites. Conventional carbon fibres of diameter 15mm are more effective than 0.1mm diameter carbon filaments as reinforcement, but less effective for radio wave reflection (EMI shielding). Carbon fibre composites are superior to steel fibre composites for strain sensing, but are inferior to steel fibre composites in the thermometric behaviour.

ACI Committee E-701 This document is an introductory document on the topic of commonly used materials for reinforcement of concrete. This primer obscures the basic

ISSN: 2233-7857 IJFGCN

properties and uses of these materials. It is targeted at those in the concrete industry not involved in designing with or specifying these materials. This bulletin provides some of the information important to understanding why reinforcement is placed in concrete. we know that Most of the concrete used for construction is a combination of concrete and reinforcement that is called reinforced concrete. Steel is the most common material used as reinforcement, but other materials such as fibre-reinforced polymer (FRP) are also used. The reinforcement must be of the right kind, of the right amount, and in the right place in order for the concrete structure to meet its requirements for strength and serviceability. From the above Literature, It is observe that researchers did the research on the parameters affecting the mechanical properties of Carbon Fibre Reinforced Concrete. In this work the effect of various volume fraction of the Carbon Fibre on the Carbon Fibre Reinforced Concrete.

A**CI Committee 544 (Chairman- Nemkumar Banthia)** This document addresses the physical properties and durability of fibre-rein-forced concrete (FRC). The effects of fibre reinforcement are evaluated for various physical, short-term, and long-term benefits they impart to the concrete mixture. A variety of test methods, conditions, and properties are reported. The various properties listed, in addition to the wide variety of the choices available in formulating matrix systems, allow performance-based specification of concrete materials using fibres to become a viable option. This document provides a historical basis and an overview of the current knowledge of FRC materials for tailoring new, sustainable, and durable concrete mixtures This Report is divided into three sections. The first section discusses the physical properties of FRC in terms of electrical, magnetic, and thermal properties. Rheological properties, which affect fibre dispersion and distribution, are discussed using both empirical and quantitative rheology. Mechanisms of creep and shrinkage and the role of various fibre types in affecting both plastic shrinkage cracking and restrained shrinkage cracking are also addressed. Second section deals with areas where concrete durability is affected by the addition of fibres. Third section gives a series of applications where FRC use resulted in beneficial durability

D.D.L. Chhung This is a review of cement-matrix composites containing short carbon fibre. These composites exhibit attractive tensile and flexural properties, low drying shrinkage, high specific heat, low thermal conductivity, high electrical conductivity, high corrosion resistance and weak thermoelectric behaviour. besides, they facilitate the cathodic protection of steel reinforcement in concrete, and have the ability to sense their own strain, damage and temperature. Fibre surface treatment can improve numerous properties of the composites. as we know Conventional carbon fibre of diameter 15mm are more effective than 0.1mm diameter carbon ®laments as a reinforcement, but are much less effective for radio wave reflection (EMI shielding). Carbon fibre composites are superior to steel fibre composites for strain sensing, but are inferior to steel fibre composites in the thermoelectric behaviour.

OBJECTIVES

The main objectives of this research proposal are to evaluate the possibility of using carbon fibre in concrete. The following were also proposed.

A. Check the compression strength of concrete block when carbon fibre can be used as core part of concrete block.
B. As partial substitute for the fine aggregate in concrete composites.
C. To investigate the mechanical behaviour of the components by using carbon fibres.
D. To determine the percentage of carbon fibre which gives more strength when compared to control concrete.

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III. MIX MATERIALS

The material details are as follows:

A. Cement

In this research paper locally available cement which is of the ordinary Portland cement type (53 grade) was used throughout the work. Specific gravity of cement was 3.09.

B. Fine Aggregate

Locally available fine aggregate used was 4.75 mm size confirming to zone II with specific gravity 2.67. The testing of sand was conducted as per IS: 383-1970.Water absorption and fineness modulus of fine aggregate was 1.35% and 2.806 respectively.

C. Coarse Aggregate

Coarse aggregate used was 20mm and less size with specific gravity 2.80. Testing of coarse aggregate was conducted as per IS: 383-1970. Water absorption and fineness modulus of coarse aggregate was Nil and it is 6.203 respectively.

D. Water

The water used was potable, colourless and odourless that is free from organic impurities of any type.

E. Carbon Fibre

Table No. 1. Different types of fiber

Fibre type	Tensile strength, MPa	Tensile modulus, GPa	Fibre diameter, µm	Relative alkali stability
Asbestos	600 to 3600	69 to 150	0.02 to 30	Excellent
Carbon	590 to 4800	28 to 520	7 to 18	Excellent
Aramid	2700	62 to 130	11 to 12	Good
Stainless steel	1000	200	50 to 85	Excellent
Polyester	800 to 1300	up to 15	10 to 50	Good
Rayon	450 to 1100	up to 11	10 to 50	Fair
Polyvinyl alcohol	800 to 1500	29 to 40	14 to 600	Good
Carbon steel	1000	200	50 to 85	Excellent
Polyethylene	400	2 to 4	40	Excellent
Polyethylene pulp (oriented)	N/A	N/A	1 to 20	Excellent

IV. RESULT AND DISCUSSION

Mix Design

Mix design carried out for M20 grade of concrete by IS 10262:2009, having mix proportion of 1:1.50:2.92 with water cement ratio of 0.40. The partial replacement of Fine aggregate by 0.5 % to 2.0 % of PET fibre. Chemical admixtures are not used in the work.

Compressive, Flexural and Split Tensile Strength

Concrete prepared with different percentage replacement of fine aggregate by 0.5 % to 2.0 and cured under normal condition as per recommendations of IS and were tested at 3,7 days and 28 days for determining the compressive, flexural and split tensile strength compared with the test results of conventional concrete.

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A. Compressive Strength

A cube compression test is performed on standard cubes of of size 150 x 150 x 150 mm after 3, 7 and 28 days of immersion in water for curing. The compressive strength of specimen is calculated by the following formula:

$$fcu = Pc / A$$

Where = Failure load in compression, KN
A = Loaded area of cube,

Table No. 2 Compression Test Results for 28Days

Sr. No.	% Weight of Fibre	C/S Area mm2	Avg. Comp. Strength 3 days (N/mm2)	Avg. Comp. Strength 7 days (N/mm2)	Avg. Comp. Strength 28 days (N/mm2)
1	0	22500	18.10	23.41	34.13
2	0.5	22500	18.28	23.77	37.65
3	1	22500	18.34	25.25	38.65
4	1.5	22500	19.32	29.41	39.81
5	2	22500	20.20	28.26	41.81
6	2.5	22500	19.25	24.82	34.16

B. Spilt Tensile Strength

The cylindrical specimens of diameter 150 mm and length 300 mm were cast with PET bottle fibres of aspect ratio 25 in volume fraction 0.0%, 0.5%,1.0%,1.5%, and 2.0%. And the specimen loaded for ultimate compressive load under UTM for each mix. The split tensile strength test was carried out as per IS: 516-1979. This test was carried on specimens at the 28 days of curing. The split tensile stre416ngth of cylinder is calculate by the following formula:

$$ft = 2P / \pi D L$$

Where,
f_t=split Tensile strength, MPa
P=Load at failure, N
L =Length of cylinder, mm
D =Dia. Of cylinder, mm

Table No. 3 Split Tensile Test Results for 28Days

Sr. No.	% Of PET Fiber	Load at Failure (KN)	Tensile Strength (N/mm^2)	Average Tensile Strength 28 days N/mm^2
1	0	233	4.27	3.11
		209	4.30	
		218	4.31	
2	0.5	224	4.33	3.31
		238	4.35	
		241	4.38	
3	1	256	4.45	3.74
		270	4.50	
		268	4.48	
4	1.5	272	4.52	3.95
		281	4.55	

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		284	4.54	
5	2	263	4.45	3.80
		272	4.41	
		243	4.47	
6	2.5	264	3.73	3.60
		252	3.56	
		248	3.51	

C. Flexural Strength

Three beam section of size 150x150x750mm were casted and cured for 28 days. The flexural strength is determined by the

$f_{cr} = P_f L / bd^2$

Where,
f_{cr} = Flexural strength, MPa
P_f = Central load on two-point loading system, N
L = Span of beam, mm
b = Width of beam, mm d = Depth of beam, mm

Table No. 4 Flexural strength Results for 28Days

Sr. No.	% of carbon Fibre	Load at Failure (KN)	Flexural Strength (N/mm^2) $0.7\sqrt{fck}$	Average Flexural Strength/mm^2
1	0	27.94	5.79	6.07
		31.03	6.43	
		28.87	5.99	
2	0.5	32.96	6.84	6.77
		31.22	6.47	
		33.86	7.02	
3	1	31.98	6.63	7.07
		34.37	7.13	
		35.90	7.45	
4	1.5	37.92	7.86	7.68
		35.23	7.31	
		37.78	7.84	
5	2	35.14	7.29	7.75
		39.47	8.19	
		37.58	7.79	
6	2.5	30.94	6.42	6.71
		35.09	7.28	
		31.02	6.43	

V. Conclusions

From the analysis of this results following conclusions are drawn:

1. The compressive strength of concrete is increases by 11.56 % as compared to the normal concrete at the age of 3 days by the addition of 2% carbon fibre; further increase in percentage of carbon fibre compressive strength of CFRC is decreases. The compressive strength of concrete is increases by 26.08 % as compared to the normal concrete at the age of 7 days by the addition of

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1.5% carbon fibre; further increase in percentage of carbon fibre compressive strength of CFRC is decreases.

The compressive strength of concrete is increases by 22.50 % as compared to the normal concrete at the age of 28 days by the addition of 2% carbon fibre; further increase in percentage of carbon fibre compressive strength of CFRC is decreases.

2. The split tensile strength of plain cement concrete increased by 27.00 % as compared to the normal concrete at the age of 28 days by the addition of 1.5 % carbon fibre. All results of split tensile strength were more than 10% of characteristics compressive strength.

3. The flexural strength of CFRC increases by 27.67 % as compared to the normal concrete at the age of 28 days by the addition of carbon fibre. The flexural strength of CFRC is increased with increased in % of carbon fibre up to 2%.

4. All beam specimens are failed in pure bending zone; no shear failure were recorded.

ACKNOWLEDGMENT

We take this opportunity with great pleasure to express our deep sense of gratitude towards our guide. Mr. S.U. Balte for her valuable guidance, encouragement and co-operation extended to us during this project work. We are so thankful to our HOD Mr. I.M. Jain, Department of Civil Engineering for providing departmental facilities for this work. We would also like to thank Dr. R.S. Prasad, Principal, Sinhgad Institute of Technology and Science for their help, support and cooperation during this project work. We would also like to thank the Sinhgad Technical Educational Society for providing access to the institutional facilities for our project work.

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ISSN: 2233-7857 IJFGCN