Cement Partially Replaced With Fly Ash and Carbon Fiber in Light Weight Concrete

S.Manivel, Susmita SureshKakkanattu, V Satya Ramesh Potti

Abstract*: *Mechanical Strength properties of fiber reinforced light weight concrete are investigated and studied with normal concrete. Four concrete mixes were taken in different percentages of fly ash, carbon fiber and LECA. Fifty-Four cubes (six for each mixes) and Thirty six cylinders (four for each mixes) were tested. The investigation include 7 and 28 days of strength properties of concrete mixes. As the increase in percentage of fly ash and carbon fiber the compressive and split tensile values were decreased and vice versa. Light weight concrete gives low density than conventional concrete. Plastic shrinkage crack decreases with the percentage increase of LECA (Light Weight Expanded Clay Aggregate).

Keywords*: *Carbon Fiber, Fiber Reinforced Concrete, Flexural Strength, LECA

I. INTRODUCTION

Fiber reinforcement is provided to generally augment the mechanical properties of the cement matrix. One of the most typically used reinforcing material is carbon fiber due to its advanced mechanical properties[1]. Economic concerns have limited using carbon fibers .However, this qualifies the outcome of carbon-fiber-reinforced cement (CFRC) composites. Furthermore, the consistent variation in value due to development in carbon fiber production technology has expanded their utilization inside the construction enterprise. The prevailing work aims on the use of carbon fiber in light weight concrete to enhance its mechanical houses such as compressive strength, split tensile strength &flexural strength .Fly ash improves the workability, strength and durability of hardened concrete. Fly ash can be worn as a cost effective Supplementary Cementitious Material (SCM). The amount of cement in the concrete mix can be reduced with the addition of Portland cement.

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Typically Fly ash is replaced up to a percentage from 10%-30%.. Light weight concrete have low densities than concrete made with gravel or crushed stone. The primary objective of this project is to look at the different strength parameters which include compressive, tensile and flexural and compare the results with that of normal concrete for M40 grade of concrete mix.

II. THRUST OF STUDY

Reduction of water in the concrete conducts to improved strength, fly ash contain large or less reactive particle than Portland cement, significant period of moisturization can continue for six months leading to ultimate strength than concrete without fly ash. Fibers when added to a concrete mix controls the cracks due to plastic shrinkage. The significance of plastic shrinkage relies upon on the temperature, humidity and wind velocity that is it depends on the rate of evaporation of water from the concrete surface. The plastic shrinkage study is complicated due to its properties which determine whether such cracks will shape or no longer will depend on time and rapid change. Plastic shrinkage takes place at the surface of the concrete is exposed within the first few hours it has been placed.

III. MATERIALS AND CONCRETE MIXES

LECA (Light Weight Expanded Clay Aggregate) are wet for 24 hours prior to its use. Ordinary Portland cement 53 grade with a specific gravity of 2.96 was used. River sand with a specific gravity of 2.6 as fine aggregate, coarse aggregate of maximum size 20 mm and with a specific gravity of 2.7 were used for the making of Conventional concrete. In the investigational study of M40 the proportion is 1:1.98:3.2 the water cement ratio is taken as 0.45. In this study we replace cement with fly ash (10%, 20%, 30% and 40%) [2] with the addition of carbon fiber (1%, 2%, 3% and 4%) [5] and we also replace coarse aggregate with LECA (20%)[1].Fly ash having specific gravity of 2.1 , dampness of 0.15% is used to replace of cement partially in the concrete mix [2].Carbon fibers with 5-10 micrometer in diameter are used. The specific gravity of carbon fiber is 1.9.

IV. EXPERIMENTAL STUDY

An experimental study was designed to achieve the optimum through the following three stages:

1. Stage1: Studying the effect of fly ash by partially replacing it up to 40% with cement content. The compressive and split tensile strength is investigated after a curing period of 7 & 28 days.

2. Stage 2: Studying the effect of adding carbon fiber at percentages of 1,2,3 and 4% to partially replaced fly ash concrete in studying the mechanical properties that are compression & split tensile strength.
3. Stage 3: With the optimum value of fly ash as 10% and carbon fiber as 1 % coarse aggregate is partially replaced for 20% with LECA (light weight expanded clay aggregate) and the mechanical properties are studied which are compression and split tensile for 7 and 28 days and flexural strength for 28 days respectively.

V. PROPERTIES OF LIGHT WEIGHT EXPANDED CLAY AGGREGATE

The characteristics of light weight aggregate varies with the method of production and the raw materials used in the manufacturing process , their size, weight etc. The alteration of lightweight aggregate in the construction industry can limit the load applied on the foundation, reduce the size of structural members, fasten up the construction program. Light weight aggregates are permeableto the environment and the water absorption is more when compared to normal weight aggregates[9].The LWA used on this experimental work is a light-weight expanded clay aggregate [LECA] produced by means of bloating clay under high temperature firing of over 1200°C inside the rotary kiln [9].

LECA

Carbon Fiber

VI. RESULTS AND DISCUSSION

Varied tests were conducted in the carbon fiber reinforced light weight concrete and discussed.

Compressive Strength

a) Testing of Specimens: Cube specimens were tested in Compressive Testing Machine (CTM) to final strain and breaking load was acquired.

b) Result: The trial test for 30 cubes were done for 7 days and for the rest 30 cubes were done for 28 days. The compressive test calculations are shown in the table below. The compressive strength of the concrete cubes increase with the increment in the fiber content

Table.1 Compression Strength Results of Fiber Reinforced Light Weight Concrete

Concrete Mix	Fiber Reinforced Light Weight Concrete	Compressive Strength (N/mm^2)	
		7 days	28 days
Conventional Concrete	0	33.73	50.99
Optimum value of Carbon Fiber	1%	35.05	54.56
Optimum value of Fly ash	10%	39.42	68.90
Partial Replacement of LECA	20%	42.91	69.89

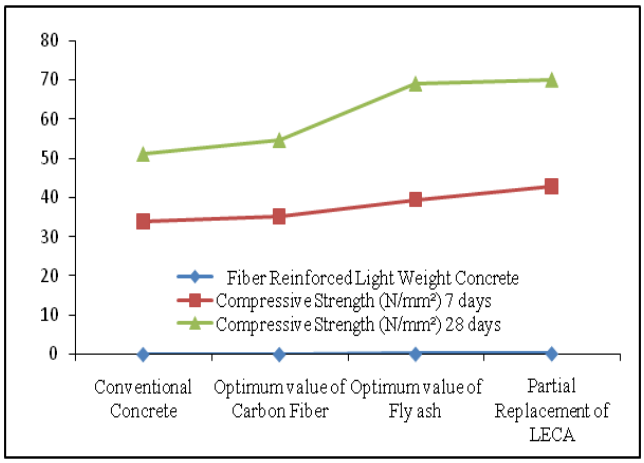

Fig.1 The graph represents the Split Tensile Strength value of fiber reinforced light weight concrete for 7 and 28 days with that of conventional concrete mix.

It is mentioned from the graph that the optimum value of carbon fiber in concrete mix is 1%, Fly Ash is partially replaced for an optimum value of 10% and 20% of coarse aggregates are replaced with LECA. The strength increases compared to that of conventional concrete. From the graph it is shown the increase in the compressive strength properties for Fiber Reinforced Light Weight M40 mix when differentiated with that of Conventional Concrete.

Split Tensile Strength

a) Testing of specimens: Concrete Cylindrical Specimens were tested in Compressive Testing Machine (CTM) to final strain and breaking load was acquired.

b) Result: The trial of 30 cylinder specimens were done after a curing period of 7 days and the rest 30 cylinder specimens were done After a curing period of 28 days. The split tensile test results are shown in the table below.

c) The split tensile strength increases with the increase in fiber content.

Table.2 Split Tensile Strength Results of Carbon Fiber Replacement

Concrete Mix	Fiber Reinforced Light Weight Concrete	Split Tensile Strength (N/mm²)	
		7 days	28 days
Conventional Concrete	0	2.14	3.63
Optimum value of Carbon Fiber	1%	2.26	4.20
Optimum value of Fly ash	10%	2.65	4.41
Partial Replacement of LECA	20%	2.76	4.71

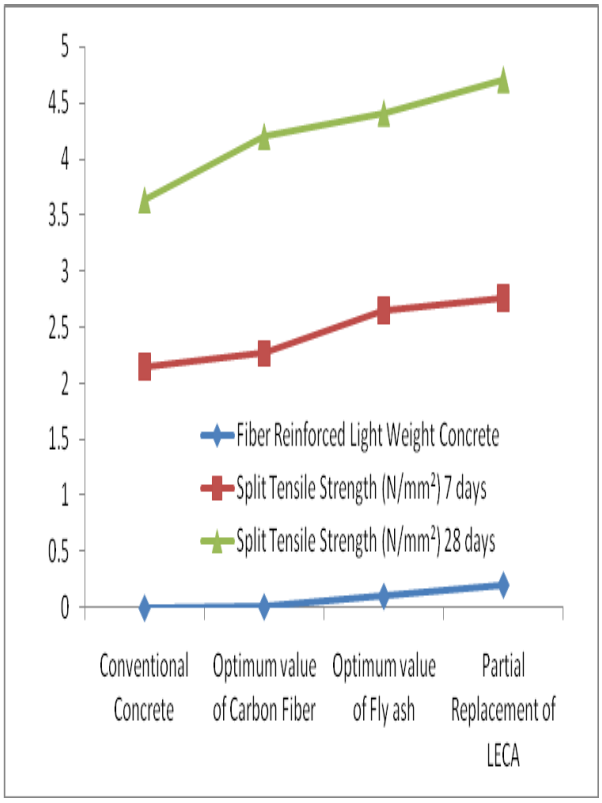

Fig.2 The graph represents the Split Tensile Strength of Fiber Reinforced Light Weight Concrete for 7 and 28 days with that of normal concrete

Flexural Strength

a) Testing of specimens: Concrete Beam Specimens were tested in the Flexural Testing Machine (FTM) to final strain and breaking load was acquired.

b) Results: The trial tests were carried out for 6 beams for 7 days and 6 beams for 28 days. The flexural tests results are shown in the table below.

Table.3 Flexural Beam Results

SNo	Load (kN)	Deflection (mm) (Conventional Beam)			Deflection (mm) (Fiber Reinforced Concrete Beam)		
		Left	Center	Right	Left	Center	Right
1	4	0.20	0.21	0.19	0.04	0.08	0.06
2	8	0.33	0.35	0.32	0.09	0.22	0.12
3	12	0.44	0.48	0.43	0.17	0.38	0.25
4	16	0.58	0.62	0.56	0.26	0.55	0.35
5	20	0.71	0.76	0.68	0.40	0.83	0.52
6	24	0.84	0.93	0.82	0.58	1.19	0.74
7	28	0.99	1.11	0.96	0.83	1.60	1.01
8	32	1.11	1.26	1.10	1.11	2.06	1.32
9	36	1.25	1.40	1.23	1.55	2.62	2.01
10	40	1.40	1.57	1.44	1.80	2.91	2.35
11	44	1.71	1.85	1.72	1.97	3.19	2.76
12	48	1.85	1.99	1.87	2.27	3.59	3.04
13	52	2.05	2.20	2.07	2.51	4.00	3.46
14	56	2.21	2.37	2.24	2.47	4.42	3.92
15	60	2.40	2.54	2.42	3.03	4.79	4.58
16	64	2.56	2.75	2.57	3.29	5.22	4.98
17	68	2.71	2.90	2.75	3.70	5.86	5.40
18	**72**	2.98	3.10	2.95	4.15	6.54	6.50
19	76	3.15	3.32	3.20			
20	80	3.38	3.56	3.42			
21	84	3.62	3.80	3.64			
22	88	3.86	4.06	3.84			
23	92	4.12	4.35	4.09			
24	96	4.33	4.60	4.25			
25	100	4.64	4.95	4.48			
26	**104**	5.08	5.54	4.80			

VII. CONCLUSION

The following findings were formed from the experimental results:

1. The mechanical properties of the concrete mix increases with the addition of carbon fiber when differentiated to that of conventional concrete.
2. Out of all the trial mix prepared the mix containing 1% of carbon fiber was found to have the maximum compressive strength and split tensile strength when compared to the conventional M40 concrete mix.
3. The mix containing 1% carbon fiber and 10% partial replacement of fly ash was found to have the maximum compressive and split tensile strength when studied withnormal concrete mix.
4. The most compressive strength was observed to be 42.91N/mm² for 7 days.

The most Split Tensile value was observed to be 2.79 N/mm² for 7 days.

REFERENCES

1. RN Raj Prakash, A Krishnamoorthi, "Experimental Study on Light Weight Concrete Using Leca." *International Code for Chem Tech Research*, ISN : 0974 -4290 Vol 10 No 8 pp 98-109.
2. Sakshi Gupta, Aakash , Abhimanyu Ramola , Jatin Arora , Anand Saini, (2017) "Partial Replacement of Cement by Fly Ash and Glass Fibre in Light Weight Fibre Reinforced Concrete." *International Journal of Engineering & Technology* ISSN : 2278-0181 Vol 6 Issue 07.
3. Marinela Barbuta , Roxana Bucur, Adrain Alexandru Serbanoiu , Sorin Scutarasu, Andrei Burlacu, (2017) "Combined Effect of Fly ash and fibers on properties of Cement Concrete." *Procedia Engineering* 1(81)280-284.
4. Parvis Soroushian , Mohamad Nagi, Abdulrahman Alhozaimy(1992): "Stastistical Variation in the Mechanical Properties of Carbon Fiber Reinforced Cement Composites." *ACI material Journal*.
5. Houssam A.Toutanji , TAahar EL-Korchi, R Nathan Katz,(1994) "Strength and Reliability of Carbon Fiber Reinforced Cement Composites." *Cement and Concrete Composites*(16)15-21.
6. T.J Kim and C.J Park, (1998) "Flexural and Tensile strength development of various shape carbon fiber : reinforced light weight cementitious compounds." *Cement and Concrete Research* Vol 28 No 7 pp 955-960.
7. Gang Xu, Xianming Shi: (2018) "Characterstics and applications of fly ash as a sustainable construction material: A state of the art review." *Resourses , Conservation and* Recycling 136,95-109.
8. Yasmin Hefni, Yehai Abd El Zaher, Mona Abdel Wahab: (2018) " Influence of Activation of Fly ash on Mechanical Properties of Concrete."*Construction and Building Materials* 172,728–734.
9. Tommy Y.Lo, H.Z. Cui: " Properties of Light Weight Aggregate for Light Weight Concrete Production."*Advances in Building Technology*, Volume 1 M. Anson, J.M. Ko and E.S.S. Lam (Eds.) © 2002 Elsevier Science Ltd. All rights reserved.

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