GRD Journal for Engineering | Volume 2 | Issue 5 | April 2017
ISSN: 2455-5703

Mechanical Properties of Pineapple Fibre Reinforced Concrete Subjected to High Temperature

Linto Mathew
PG Student
Department of Civil Engineering
Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

Dr. Mathews M. Paul
Professor
Department of Civil Engineering
Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

Abstract

Concrete is one of the most widely used construction material. Apart from its excellent properties, concrete is very poor in tensile strength. In order to improve the tensile properties, fibres are added to the concrete, which is known as fibre added concrete. This study is focused on the structural properties of Pineapple Leaf Fibre (PALF) added concrete at elevated temperature. PALF is abundantly available at low cost in tropical areas, especially in Kerala, India. In this study, PALF of specific aspect ratio will be randomly dispersed in concrete for the preparation of test specimens are used for various experimental tests.
Keywords- Concrete, Mechanical Properties, Fibre Reinforced, Pineapple Leaf Fibre, Elevated Temperature

I. INTRODUCTION

Concrete made with Portland cement is relatively strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. The use of fibers also alters the behavior of the fiber-matrix composite after it has cracked, thereby improving its toughness. The concrete without any fibers will develop the cracks due to plastic shrinkage, drying shrinkage and other reasons of changes in volume of concrete. In this study, specific amount of PALF is added to the concrete and after proper curing the specimens are tested after placing them in furnace at specific temperature for 60 minutes.

II. UTILIZATION OF CELLULOSE FIBERS

There is a wide variety of cellulose fibers that can be used to reinforce thermoplastics. These include wood fibers, such as steam-exploded fibers, and a variety of agro-based fibers such as stems, stalks, and bast, leaves and seed hairs. These fibers are abundantly available throughout the world, particularly in developing countries like India, and they come from renewable resources. Other large sources are recycling agro fiber-based products such as paper, waste wood, and point source agricultural residues such as rice hulls from a rice processing plant.

Cellulose fibers present many advantages compared to synthetic fibers which make them attractive as reinforcements in composite materials. They came from an abundant and renewable resource at low cost which ensures a continuous fiber supply and a significant material cost saving to the plastics industry. Cellulose fibers, despite their low strength, can lead to composites with high specific properties because of their low densities.

Unlike brittle fibers, such as glass and carbon fibers, cellulose fibers are flexible and will not fracture when processed over sharp curvatures. This enables the fibers to maintain the desired aspect ratio for good performance. Their non-abrasive nature permits a high-volume fraction of filling during processing, and this results in high mechanical properties without the usual machine wear problems associated with synthetic fibers especially glass and ceramic. Cellulose fibers are also non-toxic, easy to handle and present no health problems like glass fibers that can cause skin irritations and respiratory diseases when the fibrous dust is inhaled. They offer a high ability for surface modification, are economical, require low amounts of energy for processing, and are biodegradable. In terms of socio-economic issues, the use of cellulose fibers as source of raw materials is beneficial because it generates an economic development opportunity for non-food farm products in rural areas. These mentioned advantages are benefits and not likely to be ignored by the plastics industry for use in the automotive, building, appliance, and other applications. Table shows some of the basic mechanical properties of some cellulose fibers.

Table 1: Mechanical Properties of Some Cellulose Fibers

Fibre	*Diameter(μm)*	*Density(g/cm^3)*
Jute	*200*	*1.45*

Coir	*100-450*	*1.15*
Banana	*80-250*	*1.35*
Sisal	*50-100*	*1.45*
Sun hemp	*48*	*0.673*
Pineapple	*20-80*	*1.44*
Mesta	*200*	*1.47*

III. SCOPE

- To find the optimum amount of pineapple fiber reinforcement in conventional concrete, for a desired compressive strength of 25MPa.
- To find the mechanical properties of pineapple fiber reinforced concrete subjected to high temperature i.e., compressive strength, split tensile strength, flexural strength

IV. MATERIAL CHARACTERIZATION

The common ingredients of fiber added concrete are cement, coarse and fine aggregate, fibers, and water.

A. Ordinary Portland Cement (OPC)

Ordinary Portland cement of 53 grade conforming to IS specification [17] is used in this study. Tests were conducted on the cement like Specific gravity, consistency tests, fineness, initial time and final setting time, and Compressive strength at 28 days are found according to relevant Indian Standard Code.

B. Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids

C. Water

Combining water with cementations material to form cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio will yield a stronger, more durable concrete; while more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

D. Pineapple Fiber

Pineapple (Ananas comosus) is the third most important tropical fruit in the world after banana and citrus. Fiber from the raw pineapple leaves is used and thus it could be easily accessible and cheap. Treatment with NaOH is done before for imparting a greater strength on fiber. Thus, its use in construction industry would promote small scale industries in a larger way.

V. METHODOLOGY

In the first phase, raw materials were collected and the materials tests are to be conducted in the laboratory as per relevant Indian Standard codes. Basic tests were conducted on fine aggregate, coarse aggregate, and cement to check their suitability for making concrete.

In the second phase, the mix design of conventional M25 grade concrete were done as per IS code. The plain samples of cubes, cylinders and cubes is to be casted and cured 28 days in water pond and strength tests is to be conducted on specimens with designed mix to find out the compressive, splitting tensile and flexural strength. Cube specimens having 150x150x150mm, cylinder specimens of 150mm diameter and 300 mm height are to be casted. Beam specimens of size 100x100x500mm are subjected under two- point loading to study their flexural behavior. The specimens with plain samples are to be cured 28 days in water pond and a strength test is to be conducted.

In the third phase, Concrete mix of various fiber cement ratio (0.05%, 0.10%, 0.15%, 0.20% and 0.25%) to be made. The cube specimens with varying fiber cement ratio should be cured for 28 days at room temperature and strength tests will be conducted for obtaining the optimum content of fiber.

In the fourth phase, Concrete mix with optimum fiber cement ratio to be made. The fiber reinforced samples of cubes, cylinders and beams is to be casted and cured 28 days in water pond and after curing period specimens are heated to various elevated temperatures (200^{o}C, 400^{o}C, 600^{o}C) using hot air oven and maintained at corresponding temperature for 1hour and then allowed to cool under normal conditions and strength tests is to be conducted on specimens in order to find out the compressive, splitting tensile, and flexural strength. The values obtained will be tabulated for further comparison and analysis of data.

Table 2: Mixing Proportion for M25

Material	Calculated Quantity
Cement	388 kg/m^3
Fine aggregate	518 kg/m^3
Coarse aggregate	1180 kg/m^3
Water	250.5 $litres/m^3$

VI. CONTROL MIX RESULT

In the initial stage of the work, a control mix was selected as per trial and error so as to create the strength. The 7day and 28day strength was found out and the values obtained are tabulated in table 3. The initial mix was designed for a slump value of 150mm and characteristic compressive strength was obtained as 34.29MPa.

Table 3: Control Mix Results

Grade of Concrete	Mean Compressive Strength (MPa)	
	7^{th} Day	28^{th} Day
M25	22.81	34.29

VII. CONTROL MIX RESULT

In this stage, addition of pineapple fibers is done. The steel fiber used was of length 30mm and diameter 0.6mm and the aspect ratio of 50. In the present study, five variations of pineapple fibers are used. Pineapple fibers are added to the plane concrete by 0.05%, 0.10%, 0.15%, 0.20% and 0.25% of the quantity of cement. Compressive strength was found out after 7days of water curing.

A. Compressive Strength

The compressive strength of the casted specimens is found out after 28 days of water curing. The experiments are performed as per standards. The obtained values are tabulated as shown in table 4.

Table 4: Compressive Strength

F/C ratio (%)	Compressive Strength (MPa)	
	7^{th} D ay	28^{th} Day
0	22.81	34.29
0.05	26.01	38.35
0.1	27.31	40.53
0.15	26.15	38.35
0.2	25.72	37.34
0.25	24.84	37.05

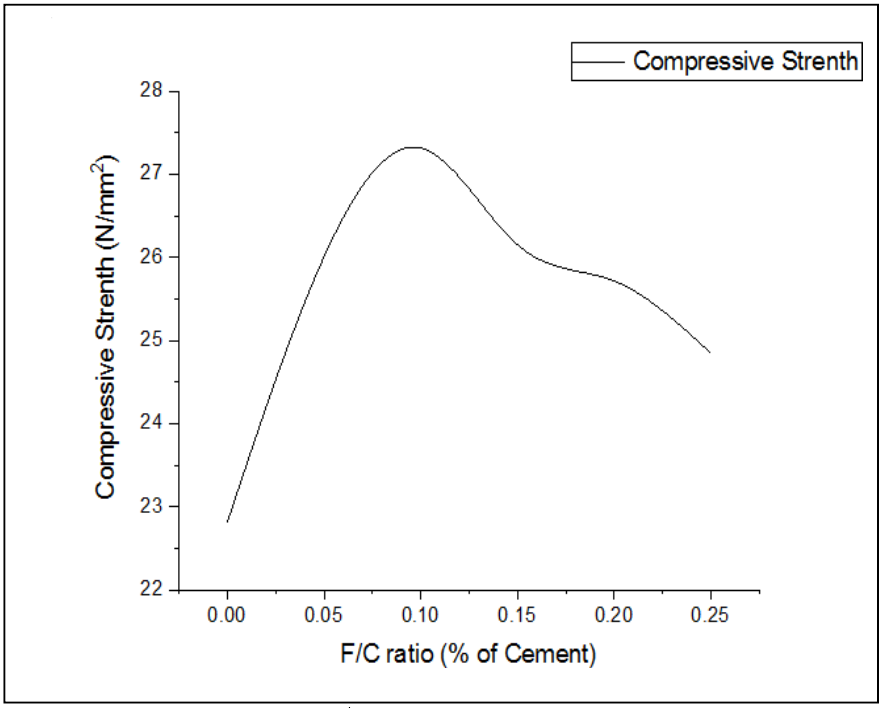

Fig. 1: 7^{th} Day Compressive Strength

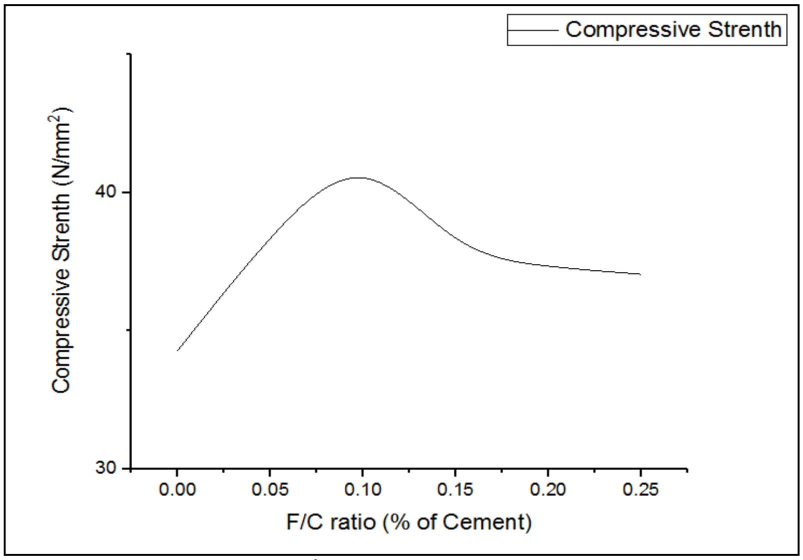

Fig. 2: 28th Day Compressive Strength

From the figures 1 and 2 it is clear that the maximum value was obtained for a mix containing 0.1% PALF. The compressive strength is found to be increasing from 0 to 0.1% and thereafter it gets decreased at 0.15% and it is continuing the declining nature. The highest value of compressive strength obtained for 0.1% PALF addition was found to be 27.31MPa after 7days of curing and 40.53MPa after 28days of curing. From the test result 0.1% f/c ratio is found as the optimum content. Therefore 0.1% f/c is used for preparation of specimens for testing at high temperature.

B. Split Tensile Strength

The split tensile strength of the casted specimens is found out after 28 days of water curing. The experiments are performed as per standards. The obtained values are tabulated as shown in table 4. Specimens are tested at both room temperature (28^{o}C) and an elevated temperature of 200^{o}C.

Table 4: Split Tensile Strength (MPa)

Temperature	*Sample 1*	*Sample 2*	*Sample 3*	*Average*
Room Temp.	*3.01*	*2.97*	*3.04*	*3.01*
200^{o}C	*2.69*	*2.67*	*2.73*	*2.70*
400^{o}C	*2.26*	*2.19*	*2.22*	*2.23*
600^{o}C	*0.71*	*0.74*	*0.66*	*0.70*

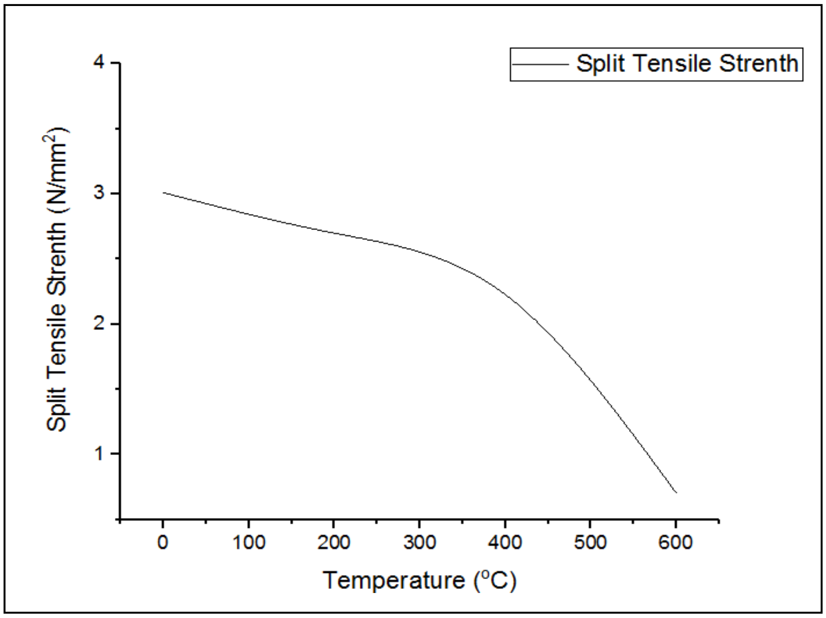

Fig. 3: Temperature V/S Split Tensile Strength

From the fig. 3 we can see that the tensile strength is decreasing with increasing in temperature. Till 400oC the rate of decrease is low compared to that between 400oC and 600oC. At 600oC tensile strength dropped by 75%.

C. Flexural Strength

The experimental setup was done as per IS: 516-1959. For the evaluating the flexural strength, beam specimen of 100 x 100 x 500 mm were used. The obtained strength results are tabulated as shown in table 5. Specimens are tested at both room temperature (28°C) and an elevated temperature of 200°C.

Table 5: Flexural Strength (MPa)

Temperature	*Sample 1*	*Sample 2*	*Sample 3*	*Average*
Room Temp.	*8.75*	*8.5*	*8.75*	*8.67*
200°C	*6.25*	*6.5*	*6*	*6.25*
400°C	*5*	*5.5*	*5.25*	*5.25*
600°C	*2.25*	*2*	*1.5*	*1.92*

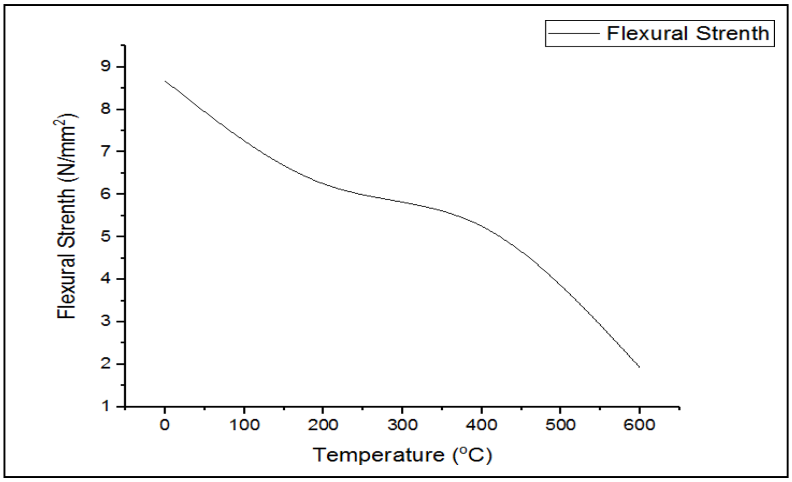

Fig. 4: Temperature V/S Flexural Strength

From the fig. 3 we can see that the flexural strength is decreasing with increasing in temperature. Till 400°C the rate of decrease is low. At 600°C tensile strength showing a sudden drop dropped by 75%.

VIII. CONCLUSIONS

From the test conducted, control mix compressive strength was obtained as 22.81 MPa for 7 days curing and 34.29 MPa for 28 days of curing. The compressive strength for various percentage addition of PALF had obtained. The peak 7th day compressive strength was obtained for concrete mix containing 0.10 % addition of PALF as 27.31 MPa and it was found to be 20% more than the control mix. And peak 28th day compressive strength was obtained for concrete mix containing 0.10 % addition of PALF as 40.53 MPa and it was found to be 18% more than the control mix. From this it is clear that by adding 0.1% pineapple fibre to M25 concrete we can replace M30 Concrete.

From the elevated temperature tests, it is clear that the split tensile strength and flexural strength are keep on decreasing as the temperature increases. Both split tensile strength and flexural strength are showing a decrease of 75% at 600oC respectively. This is mainly because when the specimens are subjected to an elevated temperature fibre inside the concrete got burnt. And therefore, the effect of fibre get decreased. Also, the rise in temperature causes the free water in concrete to change from a liquid state to a gaseous state. This change in state causes changes in the rate with which heat is transmitted from the surface into the interior of the concrete component.

ACKNOWLEDGEMENT

It is my privilege to express sincere thanks to my project guide, Dr. Mathews M. Paul, Professor, Civil Department, MACE for his valuable guidance and encouragement throughout my humble endeavour. Finally, I would like to express my gratitude to all my friends and classmates for their help.

REFERENCES

[1] L. Uma Devi, S. S. Bhagawan, Sabu Thomas "Mechanical Properties of Pineapple Leaf Fiber-Reinforced Polyester Composites", Journal of Applied Polymer Science 64(9), 1739 – 1748, 1996
[2] Santosh Kumar D S, Praveen B A, Kiran Aithal S, U N Kempaiah "Development of Pineapple Leaf Fiber Reinforced Epoxy Resin Composites", International Research Journal of Engineering and Technology Volume 2, Issue 3, 2015
[3] Romildo Dias Tolêdo Filho, Kuruvilla Joseph, Khosrow Ghavami & George Leslie England "The use of sisal fibre as reinforcement in cement based composites" Revista Brasileira de Engenharia Agrícola e Ambiental, v.3, n.2, p.245-256, 1999
[4] Luiz C. Roma Jr., Luciane S. Martello, Holmer Savastano "Evaluation of mechanical, physical and thermal performance of cement-based tiles reinforced with vegetable fibres", Construction and Building Materials Volume 22, Issue 4, Pages 668–674, 2008
[5] N. Pannirselvam, V. Nagaradjane and K. Chandramouli "Strength Behaviour of Fibre Reinforced Polymer Strengthened Beam", ARPN Journal of Engineering and Applied Sciences Vol. 4, No. 9, ISSN 1819-6608, 2009
[6] Elie Awwad, Mounir Mabsout, Bilal Hamad and Helmi Khatib "Preliminary studies on the use of natural fibres in sustainable concrete", Lebanese Science Journal, Vol. 12, No. 1, 2011
[7] Pushpendra Soni and Raksha Parolkar "Study & Analysis of Durability of Fiber Reinforced Concrete," International Journal of Engineering Sciences & Research Technology 745, ISSN: 2277-9655, 2015