Effect of Fire Exposure on The Mechanical Properties of Fibre-reinforced Concrete of Variety of Natural Fibres

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PROJECT REPORT APPROVAL

The thesis titled "Effect of fire exposure on the mechanical properties of Fibre-reinforced concrete of variety of natural fibres" submitted by Arafat-Al-Azmine and Tanvir Rana Emon , St. No. 190051203, 190051218 has been found as satisfactory and accepted as partial fulfillment of the requirement
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DECLARATION OF CANDIDATE

I, Tanvir Rana Emon & Arafat-Al-Azmine hereby declared that our undergraduate research work in the thesis has been performed by us under the supervision of assistant professor Mohammad Zunaied-Bin-Harun and this work has not been submitted anywhere for any purpose only for thesis report submission and on work for publication.

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DEDICATION

We both teammates dedicate this thesis work special loving and gratitude to our loving parents and very special thanks to our sister throughout our journey. we always appreciate everyone who were besides us during our whole journey. we would love to express our for most gratitude to our grandparents.

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"*In the name of Allah, Most Gracious, Most Merciful*"

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ABSTRACT

Keywords: Rapid Chloride penetration Test, Compressive Strength, Fire Exposer, Ultrasonic Pulse Velocity, Binder Content.

In this experimental procedure attempts made to know influence of different fiber on concrete and the effects on Mechanical properties. In this experimental procedure we used same type of 12mm downgrade aggregate and w/c ratio 0.35 for JUTE FIBRE, 0.32 for BANANA FIBRE , 0.31 for COCONUT FIBRE. We have conducted 14 days and 28 days compressive strength.. Our binder content 550 kg/m3. Our S/A ratio 0.40 .. We used super high performance super plasticizer and admixture. We used total three fibres length 25mm alkali-treated 5% solution of NAOH for one day. Our mix proportion was 1% and 2% for each fibre we used two cases and each case carries 10 cylinders. By this we have casted 60 cylinder with six cases. We have conducted Rcpt Test on the 28 day initially we calculated the physical properties of the fibres and aggregates.

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Chapter 1 Introduction

1.1 General

The fibre addition of concrete give numerous benefits.

Application of fibers to concrete offers numerous benefits, such as prevention of sudden failure, improvements in fracture energy, reduction of crack width, decreases in shrinkage, and increases in flexural and tensile strength and toughness Fiber reinforced concrete is used in applications with heavy-duty concrete requirements such as bridges, floors, tunnels, mining, precast.

The background of the study involves examining how fire exposure impacts the mechanical properties of fiber-reinforced concrete containing a diverse range of natural fibers. This research aims to understand the behavior of these materials under fire conditions to enhance their structural resilience and performance in real-world applications.

1.2 Literature Review

Regarding carbonation- and chloride-induced corrosion of SFRC, and proposes a deterioration theory for cracked SFRC exposed to chlorides and carbonation. [1]

How to improve the Strength of concrete by using various fibers. Fibers are generally used in concrete to improve the tensile strength of the concrete. In fiber Reinforced Concrete (FRC) various types of fibers can be used such as polypropylene, cellulose, carbon, jute, PET.[2]

How fiber dosage affects the mechanical parameters of high-performance fiber reinforced concrete.[3]

Slump flow and j-ring flow(workability) test is the UHPFRC from the local available. Major outcomes of this study are:1) The contribution of different fiber type and amount on the strength and workability properties of UHPFRC. [2]

Incorporated short discrete Coconut Fibers (CF), BARCHIP Fibres(BF) and Glass Fibers (GF) into HSC to enhance the performance of concrete while kept the binder content at moderate level.[3]

Influence of bamboo fiber on the mechanical properties of high strength concrete. The fiber was taken 0%, 0.5%, 1% and 1.5% against the weight of cement The test carried out at 28 and 56 days it was seen that after 28 and 56 days when fiber amount increased COMPRESSIVE STRENGTH gets lower and tensile strength gets higher.[4]

Both HFRC with calcareous and siliceous have higher normalized compressive strength at 450 degree Celsius and 600 degree Celsius.[5]

1.3 Outline

To find out the several effects and influence of different fiber types on high strength concrete adding jute fibre, banana fibre, coconut fiber and also the fire exposure effects on the concrete quality... And Investigating how different natural fibers impact the mechanical strength and durability of the concrete mixtures.

Assessing the performance of these fiber-reinforced concrete materials under simulated fire conditions to understand their behavior and potential vulnerabilities. Identifying any changes in the structural integrity, such as strength, stiffness, and ductility, chloride penetration after exposure to fire. Developing strategies to enhance the fire resistance and overall performance of fiber-reinforced concrete containing diverse natural fibers for use in practical applications.

1.4 Research Gap

APPLYING FIRE EXPOSURE OF HEAT 450 DEGREE CELCIUS,600 DEGREE CELCIUS TO JUTE FIBER, BANANA FIBER, COCONUT FIBER CONCRETE THE CHANGE IN MECHANICAL PROPERTIES(COMPRESSIVE STRENGTH,TENSILE STRENTH), PERMEABLE POROSITY AND THE AFTER EFFECTS OF FIRE EXPOSURE.

1.5 Observation from Literature Review

1. As much as compressive strength depends on the water content of concrete, UPV tends to follow the relation in similar fashion. Low water content not only increases compressive strength of concrete but also increases the velocity count due to more dense mass.

2. As concrete gains strength while aging, it also gives more velocity count relating velocity with compressive strength.

1.6 Objective of The Study

To find out the several effects and influence of different fiber types on high strength concrete adding jute fibre, banana fibre, coconut fiber and also the fire exposure To find out the several effects and influence of different fiber types on high strength concrete adding jute fiber, banana fiber, coconut fiber and also the fire exposure effects on the concrete quality. And Investigating how different natural fibers impact the mechanical strength and durability of the concrete mixtures. Assessing the performance of these fiber-reinforced concrete materials under simulated fire conditions to understand their behavior and potential vulnerabilities. Identifying any changes in the structural integrity, such as strength, stiffness, and ductility, chloride penetration after exposure to fire. Developing strategies to enhance the fire resistance and overall performance of fiber-reinforced concrete containing diverse natural fibers for use in practical applications.

1.7 Scope of The Study

The scope of the study involves experimenting the effect of variation in strength controlling parameter the change in pulse velocity. The values of rapid chloride penetration test the strength change in fire exposure and changing upv.

1.8 Age

Age is one of the most fundamental parameters on which the strength and the upv, fire exposure effect relies on and our rcpt test has been done on the 28 day. With age concrete mature solid mass develops with hydration in our experimental procedure we used 14 and 28 days to test compressive strength ans upv. As our concrete includes appropriate amount of fibre percentage the concrete maturity on the 7 day will not be proper and exceptable. That’s why skiped 7 day test.

1.9 W/C Ratio

W/C plays a vital role in the contest of gaining strength and pulse velocity W/C and age of concrete considered as main parameter to find out the relationship of ultrasonic pulse velocity and compressive strength of concrete. In our experimental procedure the ranges of w/c considered 0.31 ,0.32 and 0.35. This w/c ratio plays a vital role in the measurement of compressive strength , ultra-sonic pulse velocity , at the age 14 and 28 days. The result analysis will be later.

Chapter 2 Methodology

2.1 Working Procedures

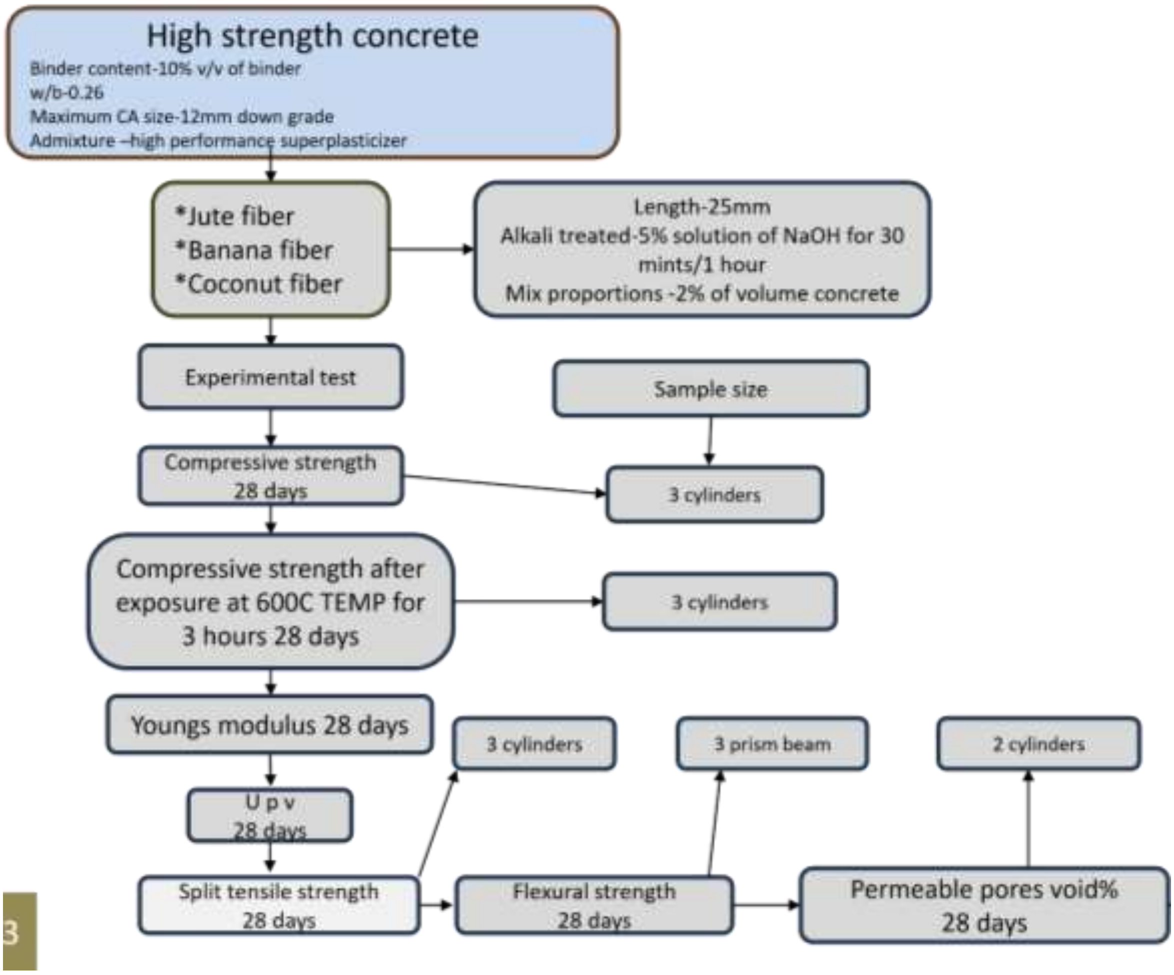


Figure 1 : Working Procedure

2.2 Specimen Plan

As binding material, ordinary portland cement (OPC) has been used. We have casted total 60 cylinders. The case numbers are 6. Each case included 10 cylinders These are jute 1%,jute 2 %,coconut 1%,coconut 2%,banana 1%,banana 2%.In the period of 1 month,we have completed our casting.

2.3 Coarse Aggregates

In this experiment we have only used 12 mm downgrade aggregates and crushed stones as coarse materials.

Figure 2: Coarse aggregate

2.4 Fine Aggregate

In this study, we have used Sylhet sand as our fine material.

Figure 3 : Fine Aggregate

2.5 Physical Properties Calculations

2.5.1 Absorption Capacity

Absorption capacity for jute				
	Dry wt.	Wet wt.	Consumed water	Absorption capacity %
Trial-01	3.39	9.4	6.01	63.93617
Trial-02	2.9	7.9	5	63.291139
Trial-03	3.2	8.5	5.3	62.352941
				63.193417

Table 1 Absorption Capacity of Jute

Absorption capacity for banana				
	Dry wt.	Wet wt.	Consumed water	Absorption capacity %
Trial-01	4.1	7.85	3.75	47.770701
Trial-02	3.72	6.39	2.67	41.784038
Trial-03	3.29	5.88	2.59	44.047619
				44.534119

Table 2 : Absorption Capacity of banana

Absorption capacity for coconut				
	Dry wt.	Wet wt.	Consumed water	Absorption capacity %
Trial-01	3.8	9.9	6.1	61.616162
Trial-02	3.6	8.8	5.2	59.090909
Trial-03	3.1	8.5	5.4	63.529412
				61.412161

Table 3: Absorption Capacity of coconut

2.5.2 Specific Gravity

Specific gravity for jute						
	Dry wt.	Wet wt.	Initial volume(ml)	Final volume(ml)	Specific gravity	Unit wight(Kg/m3)
Trial-01	3.39	9.4	150	154.7	1.278723	
Trial-02	2.9	7.9	150	153.8	1.315789	
Trial-03	3.2	8.5	150	154.5	1.177778	
					1.25743	1257.43022

Table 4: Specific Gravity of Jute

Specific gravity for banana						
	Dry wt.	Wet wt.	Initial volume(ml)	Final volume(ml)	Specific gravity	
Trial-01	6	12.9	200	205	1.38	
Trial-02	5.5	10.5	200	204	1.25	
Trial-03	5.2	9.8	200	203.5	1.314286	
					1.314762	1314.7619

Table 5: Specific Gravity of banana

Specific gravity for coconut						
	Dry wt.	Wet wt.	Initial volume(ml)	Final volume(ml)	Specific gravity	
Trial-01	3.8	9.9	200	204.5	1.355556	
Trial-02	3.6	8.8	200	204.2	1.238095	
Trial-03	3.1	8.5	200	203.5	1.542857	
					1.378836	1378.83598

Table 6 : Specific Gravity of coconut

Specific gravity of cement						Unit Weight
w1	w2	w3	w4	Gk	SG	
49.2	101.9	160.7	128.4	0.81	3.1893	3189.300412

Table 7: Specific Gravity of cement

Specific gravity of FA					Unit Weight
w1	w2	w3	w4	SG	
635	1365	1965	1520	2.561403509	2561.403509

Table 8: Specific Gravity of FA

Specific gravity of CA						Unit Weight
Dry wt. A	(SSD) B	Wt. in water C	Bulk SG	Bulk SG(SSD)	Apparent SG	
696	700	440	2.676923	2.692308	2.71875	2718.75

Table 9: Specific Gravity of CA

2.5.3 Physical Properties Total Calculations

Aggregate/ Fiber type	Specific Gravity	Weight(kg)	Fineness modulus	Absorption capacity %	Amount needed(KG) for 2%
Fine aggregate	2.56	679.98	2.4		20.3994
Course aggregate	2.72	1079.74	6.8		32.3922
Cement	3.18	550	-		16.5
Water	1	143	-		4.29
Jute	1.25743022	1257.43022	-	63.193417	0.738264742
Banana	1.3147619	1314.7619	-	44.534119	0.771925427
Coconut	1.37883598	1378.83598	-	61.412161	0.809544715

Table 10: Physical properties calculation

2.6 Mix Design Calculation

Mix design and calculation for 0.015m3

S/A =0.4

CEMENT CONTENT =550 Kg/m3

W/C = 0.35, 0.32,0.31

cement need = 8.25KG

FA need =10.20 kg water need =2.145 kg purpose 10 cylinder

cement specific gravity =3.18

unit weight=3180kg/m3

FA Specific Gravity = 2.56

Unit WT = 2560kg/m3

Water Specific Gravity 1

unit WT = 1000kg/m3

JUTE SPECIFIC GRAVITY =1.25

UNIT WT =1257.43 kg/m3

BANANA SPECIFIC GRAVITY =1.31

UNIT WT=1314.76kg/m3

COCONUT SPECIFIC GRAVITY =1.37

UNIT WT= 1378.83 Kg/m3

Total volume in terms of 1%, 2% fiber adding

volume for 1%=0.00014678m3

volume for 2% 0.000293m3

AMOUNT NEEDED FOR 1%

JUTE FIBRE NEED =0.00014678 *1257=0.184kg

BANANA FIBRE NEED= 0.00014678 * 1314.76=0.192kg

COCONUT FIBER NEED= 0.00014678 *1378.83=0.202kg

AMOUNT NEEDED FOR 2%

JUTE FIBRE NEED =0.000293 *1257= 0.36kg

BANANA FIBRE NEED= 0.000293 * 1314.76= 0.385kg

COCONUT FIBER NEED= 0.000293*1378.83= 0.404 kg

2.7 Fibre Types

Figure 4: Different Types of Fibres

2.8 Unit Weight calculation

Aggregate/fiber type	Specific gravity	Unit weight (Kg /m3)	Fineness modulus	Absorption capacity %		
Fine aggregate	2.56	2560	2.4	1.2		
Coarse aggregate	2.72	2720	6.8	0.9		16.19 kg
Cement	3.18	3180				8.25 kg
Water	1	1000				2.145 kg
Jute	1.25	1257.43		63.193	0.000293*1257.43	0.36kg
Banana	1.31	1314.76		44.51	0.000293*1314.76	0.40 kg
Coconut	1.37	1378.83		61.41	0.000293*1378.83	0.404 kg

Table 11: Unit Weight Calculations

2.9 Complete Mix Design

Concrete Mix-Design		
Sp Gravity of FS, Gf_s	2.56	
Sp Gravity of Course CA, G_{ca}	2.71	
Sp Gravity of Cement, G_c	3.18	
Sp Gravity of Water, G_w	1	
Maximum Size of Aggregate, MSA (mm)	12	
Water to Cement Ratio, W/C	0.31	
Sand to Aggregate Ratio, FA/A	0.40	
CA (%)	100.00	
FS (%)	100.00	
Air (%)	2	
% Volume of Aggregate (kg/m^3 Concrete)	66	
Unit Weight of Water (kg/m^3)	1000	Amount for 0.015
Total Weight of CA (kg/m^3)	1084.12	16.26179
Weight of FS in (kg/m^3 Concrete)	675.84	10.1376
Binder content of Cement in (kg/m^3 Concrete	550.00	8.25
Weight of Water in (kg/m^3 Concrete)	170.50	2.5575

CA	FS	C	W	Air	Total
0.40	0.26	0.17	0.17	0.02	1.02

Wc	Ww
0.172956	0.1705

Wfa	675.84	Vfs	0.264
Vca	0.372544		
Wca	1009.594		

Concrete Mix-Design						
Sp Gravity of FS, G_{fs}	2.56					
Sp Gravity of Course CA, G_{ca}	2.71					
Sp Gravity of Cement, G_c	3.18					
Sp Gravity of Water, G_w	1		Wfa	675.84	Vfs	0.264
Maximum Size of Aggregate, MSA (mm)	12		Vca	0.367044		
Water to Cement Ratio, W/C	0.32		Wca	994.6893		
Sand to Aggregate Ratio, FA/A	0.40					
CA (%)	100.00					
FS (%)	100.00					
Air (%)	2					
% Volume of Aggregate (kg/m^3 Concrete)	66					
Unit Weight of Water (kg/m^3)	1000	Amount for 0.015				
Total Weight of CA (kg/m^3)	1084.12	16.26179				
Weight of FS in (kg/m^3 Concrete)	675.84	10.1376				
Binder content of Cement in (kg/m^3 Concrete	550.00	8.25				
Weight of Water in (kg/m^3 Concrete)	176.00	2.64				

CA	FS	C	W	Air	Total
0.40	0.26	0.17	0.18	0.02	1.03
		Wc	Ww		
		0.172956	0.176		

Concrete Mix-Design						
Sp Gravity of FS, G_{fs}	2.56					
Sp Gravity of Course CA, G_{ca}	2.71					
Sp Gravity of Cement, G_c	3.18					
Sp Gravity of Water, G_w	1		Wfa	675.84	Vfs	0.264
Maximum Size of Aggregate, MSA (mm)	12		Vca	0.350544		
Water to Cement Ratio, W/C	0.35		Wca	949.9743		
Sand to Aggregate Ratio, FA/A	0.40					
CA (%)	100.00					
FS (%)	100.00					
Air (%)	2					
% Volume of Aggregate (kg/m^3 Concrete)	66					
Unit Weight of Water (kg/m^3)	1000	Amount for 0.015				
Total Weight of CA (kg/m^3)	1084.12	16.26179				
Weight of FS in (kg/m^3 Concrete)	675.84	10.1376				
Binder content of Cement in (kg/m^3 Concrete	550.00	8.25				
Weight of Water in (kg/m^3 Concrete)	192.50	2.8875				

CA	FS	C	W	Air	Total
0.40	0.26	0.17	0.19	0.02	1.05
		Wc	Ww		
		0.172956	0.1925		

Physical Properties calculation					
Aggregate/ Fiber type	Specific Gravity	Weight(kg)	Fineness modulus	Absorption capacity %	Amount needed(KG) for 2%
Fine aggregate	2.56	679.98	2.4		10.1997
Course aggregate	2.72	1079.74	6.8		16.1961
Cement	3.18	550	-		8.25
Water	1	143	-		2.145
Jute	1.25743022	1257.43022	-	63.193417	0.383042417
Banana	1.3147619	1314.7619	-	44.534119	0.400506979
Coconut	1.37883598	1378.83598	-	61.412161	0.420025429

Aggregate/ Fiber type	Unit Weight	Weight
Fine aggregate	2560	16.26179
Course aggregate	2720	10.1376
Cement	3180	8.25
Water	1000	2.5575
Jute	1257.4302	0.3830424
Coconut	1378.836	0.4200254

Table 12: Complete Mix Design

Chapter 3 Result and Analysis

3.1 UPV and Compressive Strength Test Results

3.1.1 Banana Fibre 1% 14 days

Cylinder 1:

D 101.8,

102.2,101.9

L 202 W 4.241kg

4.209 kg, 4.162kg

UPV 4512m/s

44.4us strength 29.03 MPA

235.1 kN

Cylinder 2:

D102.1, 101.5,101.9

202

W4.209 kg

UPV 44.2us 4593m/s

strength 244.2KN

30.87 MPa

Cylinder 3:

102,101.9,101.9

W 4.162kg

upv42.9us

4732m/s strength

29.76 MPa

236.0KN

3.1.2 Banana Fibre 1% 28 days

Cylinder 1

D- 100.99,102.68

W- 4.198 kg

Upv -43.4us,

4677m/s Strength- 278.9KN 35.53 MPa

CYLINDER-2

D 99.76,101.8

W- 4.168kg

Upv- 4754m/s, 42.7us

Strength- 282.4 KN

35.77 MPa

CYLINDER-3

D-102.59, 101.46

W - 4.227kg

Upv- 41.4us 4903m/s

Strength- 253.8KN

31.65 MPa

3.1.3 Banana Fibre 2% 14 days

Cylinder 1

D- 100.99,102.68

W- 4.198 kg

Upv -43.4us, 4677m/s

Strength- 278.9KN 35.53 MPa

CYLINDER-2

D 99.76,101.8

W- 4.168kg

Upv- 4754m/s, 42.7us

Strength- 282.4 KN 35.77 MPa

CYLINDER-3

D-102.59, 101.46

W - 4.227kg

Upv- 41.4us 4903m/s

Strength- 253.8KN

31.65 MPa

3.1.4 Banana Fibre 2% 28 days

CYLINDER-1

D-101.97, 101.6

W- 4.086 Kg

upv-4972m/s ,44.4us

Strength- 200.3 KN

25.15 MPa

CYLINDER-2

D- 102.8, 101.7

W- 4.141kg

Upv – 44.9 us ,4521m/s

Strength- 191.9 KN

24.37 MPa

CYLINDER-3

D-101.98, 102.89

W-4.267kg

Upv - 45.1 us ,4501 m/s

Strength- 204.4 KN

25.94 MPa

3.1.5 Jute Fibre 1% 14 days

cylinder1:

D. 101.75, 101.04, 101.58

L. 202 ,W 3914.2 gm

UPV: 47.5us ,4274m/s

strength: 302.7KN

38.55 MPa

Cylinder 2:

D. 101.94, 101.68,101.96

L 203, W.3781.2gm

UPV: 49 m 4143 m/s

Strength: 272.7KN

34.74 MPa

3.1.6 Jute Fibre 1% 28 days

cylinder 1 :

D.101.6, 101.7, 101.9

L 202 ,W3.855 kg

upv 44.9, ms 4521m/s

strength 43.23 MPA ,340KN

CYLINDER-2

D-101.04

L 202, W-4 kg

upv 44.4 ,us 4572 m/s

strength 355.3 KN

45.16 MPa

3.1.7 Jute Fibre 2% 14 days

CYLINDER-1

D- 101.7 W-3.736 Kg

Upv- 48.4 us, 4194 m/s

Strength- 215.5 KN ,27.45 MPa

CYLINDER-2

D- 102.47 ,W-3.677 Kg

Upv- 47.4 us , 4283 m/s

Strength - 231.1KN, 29.35MPa

CYLINDER-3

D-102.57

W- 3.688 Kg, Upv- 46.9us ,4328 m/s

Strength- 36.6 KN 30.13 MPa

3.1.8 Jute Fibre 2% 28 days

CYLINDER-1

D- 102.67, W-3.736 Kg

Upv- 48.4us 4194 m/s

Strength - 215.5KN, 27.45 MPa

CYLINDER-2

D- 101.8 W-3.677 Kg

Upv- 47.4 us, 4283 m/sec

Strength - 231.1KN, 29.35MPa

CYLINDER-3

D-101.9

W- 3.688 Kg

Upv- 46.9us,4328 m/sec

Strength- 236.6 KN ,30.13MPa

3.1.9 Coconut Fibre 1% 14 days

Cylinder 1

D-101.35, 101.44

W- 4.90 kg

upv - 40.9 4963m/s

Strength --- 398.7kN ,49.66 MPa

Cylinder 2

D--101.87,102.2

W-4.178 Kg

Upv- 41.1 4939m/s

Strength-445.4 KN, 56.73 MPa

Cylinder 3

D-100.64, 102.84

W-4.119 Kg

upv - 40.9 49.63 m/s

Strength - 481.3 KN ,60.70 MPa

3.1.10 Coconut Fibre 1% 28 days

Cylinder 1

D 102.9,101.6

W 4.14 kg

UPV 42.44us

Strength 490 KN 61.65 MPa

Cylinder 2

D 102.7, 102.4

W 4.11 kg

UPV 41.9us

Strength 510 KN 64.97 MPa

Cylinder 3

D 101.7, 101.9

W 4.09 kg

UPV 40.9us

Strength 428 KN 63.97 MPa

3.1.11 Coconut Fibre 2% 14 days

Cylinder 1

D-102.4, 101.3,102.6

W-4.162 Kg

upv - 41.4us ,4903m/s

Strength -401.5KN 51.01MPa

Cylinder 2

D-102.11, 101.61

W-4.106kg

upv - 40.6 ,us 5000m/s

Strength - 423.5KN 53.66MPa

3.1.12 Coconut Fibre 2% 28days

Cylinder 1

D 101.9,101.6

W 4.16 kg

UPV 40.44us

Strength 58.50MPa 412.1 KN

Cylinder 2

D 101.8,101.7

W 4.16 kg

UPV 41.44us

Strength 398.5 KN ,60.35 MPa

3.2 Compressive Strength After Fire Exposure

3.2.1 Compressive Strength After Fire Exposure at 450 Degree Celsius

Figure 5:Jute 1 %

(Strength 24.2 MPa,190 KN)

Figure 6: Jute 2%

(Strength 16.13 MPa,270 KN)

Figure 7: Coconut 1 %

(Strength 40.76 MPa, 322.9KN)

Figure 8: Coconut 2 %

(Strength 31.36MPa, 246.6 KN)

Figure 9: Banana 1 %

(Strength 19.11 MPa, 150.5 KN)

Figure 10: Banana 2 %

(Strength 15.89 MPa, 124.85 KN)

3.2.2 Compressive Strength After Fire Exposure at 600 Degree Celsius

Figure 11: Jute 1 %

(Strength 17.66 MPa,139 KN)

Figure 12: Jute 2%

(Strength 12.48 MPa, 98.1KN)

Figure 13: Coconut 1 %

(Strength 25.38 MPa, 199.2KN)

Figure 14: Coconut 2 %

(Strength 22.77 MPa, 178.7KN)

Figure 15: Banana 1 %

(Strength 11.36MPa,89.2KN)

Figure 16: Banana 2 %

(Strength 12.76 MPa, 100.2 KN)

3.2.3 Strength Loss Comparison with Normal and Heated Concrete (450°c)

JUTE FIBRE 1% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of jute 1% at 14 days 36MPA average strength at 28 days 44.5 MPa. But after fire exposure we have got the strength 24.20 MPa from this result we have got after fire exposure jute 1% fiber loss 45.51 % of its compressive strength.

JUTE FIBRE 2% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of jute 2% at 14 days 24.5MPA average strength at 28 days 33.97 MPa but after fire exposure we have got the strength 16.13 MPa From this results we have got after fire exposure jute 2% fiber loss 52.51 % of its compressive strength.

COCONUT FIBRE 1% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of coconut 1% at 14 days 55.7MPA average strength at 28 days 64.86 MPA. But after fire exposure we have got the strength 40.76 MPa from this result we have got after fire exposure coconut 1% fiber loss 37.15% of its compressive strength.

COCONUT FIBRE 2% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of coconut 2% at 14 days 52.45MPA average strength at 28 days 59.56 MPa. But after fire exposure we have got the strength 31.36 MPa from this result we have got after fire exposure coconut 2% fiber loss 47.34% of its compressive strength.

BANANA FIBRE 1% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of BANANA 1% at 14 days 29.97 MPA average strength at 28 days 34.31 MPa but after fire exposure we have got the strength 19.11 MPa. From this result we have got after fire exposure BANANA 1% fiber loss 44.30% of its compressive strength.

BANANA FIBRE 2% NORMAL TEMPERATURE AND HEATED 450°c

At normal temperature 25°c we have got the average compressive strength of BANANA 2% at 14 days 22.66MPA average strength at 28 days 25.15 MPa but after fire exposure we have got the strength 15.89Mpa. From this result we have got after fire exposure BANANA 1% fiber loss 63.18% of its compressive strength.

3.2.3 Strength Loss Comparison with Normal and Heated Concrete (600°c)

JUTE FIBRE 1% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of jute 1% at 14 days 36MPA average strength at 28 days 44.5 MPa but after fire exposure we have got the strength 17.66 MPa. From this result we have got after fire exposure jute 1% fiber loss 60.32 % of its compressive strength.

JUTE FIBRE 2% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of jute 2% at 14 days 24.5MPA average strength at 28 days 33.97 MPa. But after fire exposure we have got the strength 12.48Mpa. From this result we have got after fire exposure jute 2% fiber loss 63.27% of its compressive strength.

COCONUT FIBRE 1% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of coconut 1% at 14 days 55.7MPA average strength at 28 days 64.86 MPa. But after fire exposure we have got the strength 25.38Mpa. From this result we have got after fire exposure coconut 1% fiber loss 60.87% of its compressive strength.

COCONUT FIBRE 2% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of coconut 2% at 14 days 52.45MPA average strength at 28 days 59.56 MPa. But after fire exposure we have got the strength 22.77Mpa. From this result we have got after fire exposure coconut 2% fiber loss 61.77 % of its compressive strength.

BANANA FIBRE 1% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of BANANA 1% at 14 days 29.97 MPA average strength at 28 days 34.31 MPa. But after fire exposure we have got the strength 11.36 MPa. From this result we have got after fire exposure BANANA 1% fiber loss 66.89% of its compressive strength.

BANANA FIBRE 2% NORMAL TEMPERATURE AND HEATED 600°c

At normal temperature 25°c we have got the average compressive strength of BANANA 2% at 14 days 22.66MPA average strength at 28 days 25.15 MPa. But after fire exposure we have got the strength 12.76Mpa. From this result we have got after fire exposure BANANA 1% fiber loss 49.26% of its compressive strength.

3.3 Working Procedure and Setup of RCPT Test

3.3.1 Setup of RCPT Test

Figure 17: Setup of RCPT Test

3.3.2 Working Procedure of RCPT Test

STEP 1 :

Prepare Samples: Cut cylindrical samples from the concrete specimen. Prepare Solution: Prepare the NaCl solution according to the specified concentration.

STEP 2:

Assemble Apparatus: Set up the RCPT apparatus with the sample holder, electrodes, and electrical connections.

STEP 3:

Immerse Samples: Submerge the samples in the NaCl solution within the sample holder.

STEP 4:

Apply Voltage: Apply a voltage across the electrodes as per the test parameters.

STEP 5:

Measure Current: Record the electrical current passing through the sample over the specified time period.

STEP 6:

Calculate Results: Calculate the electrical conductivity and express it in coulombs passed or in terms of electrical resistance.

STEP 7:

Analyze Results: Interpret the results to assess the concrete's resistance to chloride ion penetration.

3.3.3 RCPT Results

FIBER CONTENT	I0(A)	I30(A)	I60(A)	I90(A)	I120(A)	I150(A)	I180(A)	I210(A)	I240(A)	I270(A)	I300(A)	I330(A)	I360(A)	COULOMB VALUE
JUTE 1%	0.229	0.278	0.317	0.337	0.356	0.357	0.358	0.367	0.367	0.376	0.379	0.387	0.388	7537
JUTE 2%	0.282	0.337	0.384	0.402	0.404	0.403	0.4	0.395	0.394	0.395	0.403	0.404	0.404	8395
COCONUT 1%	0.115	0.121	0.136	0.14	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.145	2336
COCONUT2%	0.12	0.125	0.136	0.142	0.148	0.151	0.151	0.151	0.149	0.148	0.144	0.142	0.14	3377
BANANA 1%	0.159	0.169	0.18	0.181	0.184	0.182	0.18	0.179	0.17	0.17	0.168	0.162	0.162	4365
BANANA 2%	0.241	0.262	0.293	0.302	0.301	0.291	0.282	0.282	0.28	0.277	0.275	0.273	0.271	6075

Table 13: RCPT Results

3.4 Analysis

3.4.1 Compressive Strength Comparison Between (14 Days and 28 Days)

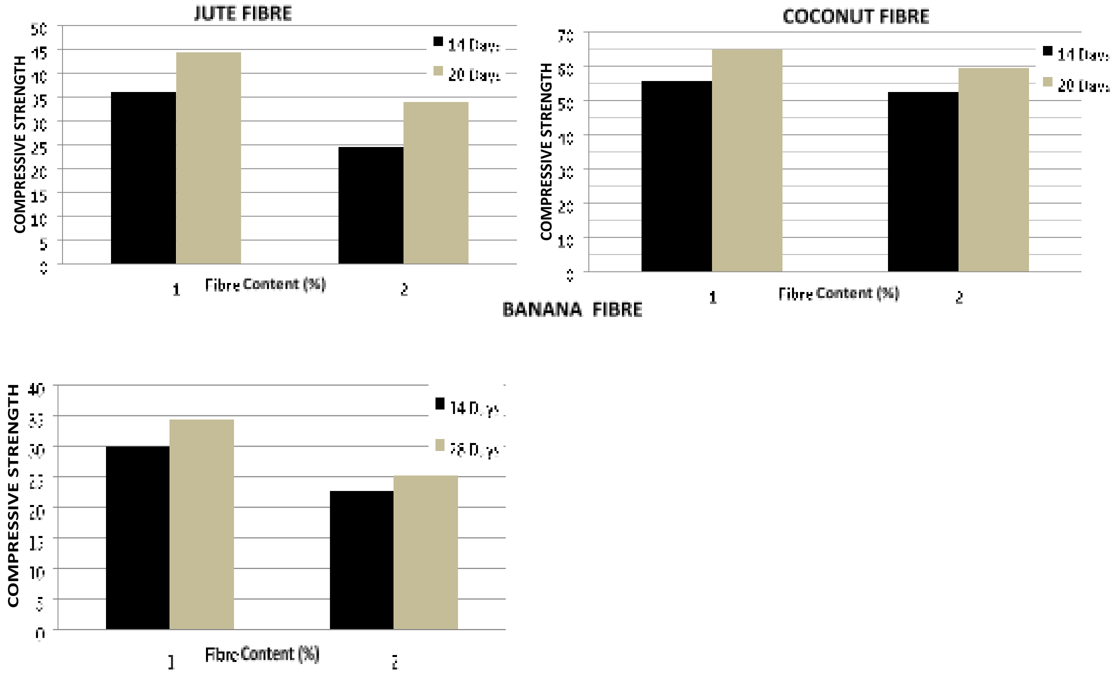


Figure 18: Compressive Strength Comparison Between 14 Days and 28 Days

3.4.1.1 Comments on compressive strength comparison:

1. Jute Fiber:

The compressive strength is around 20 MPa at day 14 and becomes about 45 MPa at day 28. There has been a considerable increase in strength during this period, more than doubling.

- 2% Fiber Content: Shows a significant but proportionately smaller increase over the 1% fiber content, starting at roughly 35 MPa at 14 days and rising to approximately 50 MPa at 28 days.

2. The coconut fiber:

In the case of 1% fiber content, the compressive strength is approximately 60 MPa at 14 days and 28 days, indicating an essentially constant strength over time.

2% Fiber Content: Shows a very minor rise throughout the 14 days, starting at around 62 MPa at day 14 and increasing significantly to about 65 MPa at day 28.

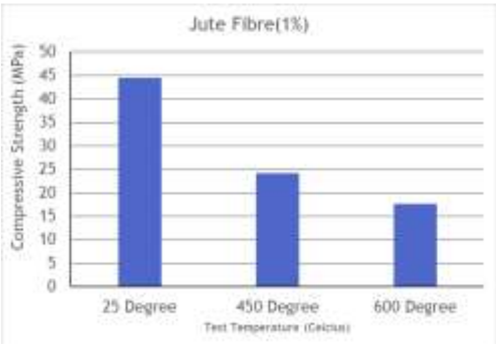
3. Banana Fiber: -

1% Fiber Content: After 14 days, compressive strength increases moderately to approximately 17 MPa and reaches around 22 MPa.

2% Fiber Content: Has a very mild gain in comparison to the other fibers, starting at around 25 MPa at 14 days and rising to about 27 MPa at 28 days.

Banana fiber, on the other hand, increases somewhat, but not as much as jute fiber.

3.4.2 Comparison Between Normal Temperature Strength and Heated Strength



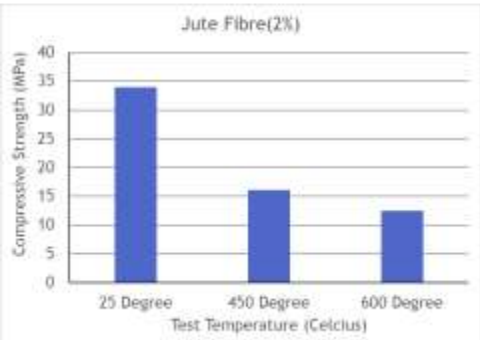


Figure 19: Comparison Between Normal Temperature Strength and Heated Strength (Jute)

3.4.2.1 Comments on Normal Temperature Strength and Heated Strength(jute fibre):

1. jute Fiber (1%): -

25 Degrees Celsius: At this typical temperature, the strength reaches its maximum, around 45 MPa.

450 Degrees Celsius: At this higher temperature, there is a noticeable loss in strength, with the compressive strength reaching just 15 MPa.

600 Degrees Celsius: Due to the high temperature, the strength further drops to around 5 MPa, showing a significant decline.

2. Jute Fiber (2%):

At 25°C Just like with the 1% fiber content, the strength reaches its maximum at room temperature, or about 35 MPa.

At 450 degrees Celsius, there is a noticeable drop in strength to roughly 12 MPa, indicating that the added fiber content has no effect on strength retention at high temperatures.

At 600 degrees degrees Celsius: At this severe temperature, the strength decreases even further to roughly 8 MPa, demonstrating a marginally better retention than the 1% fiber content but still a considerable loss from the room temperature strength.

Overall Comparison: The maximum strength values are shown by both the 1% and 2% fiber concentrations at room temperature (25 degrees Celsius).

For both fiber content levels, there is a noticeable drop in compressive strength when the temperature is raised to 450 degrees and subsequently 600 degrees.

The marked temperature decrease suggests that the potential of jute fiber to improve the thermal resistance of concrete may be limited, especially at temperatures as high as 600 degrees Celsius.

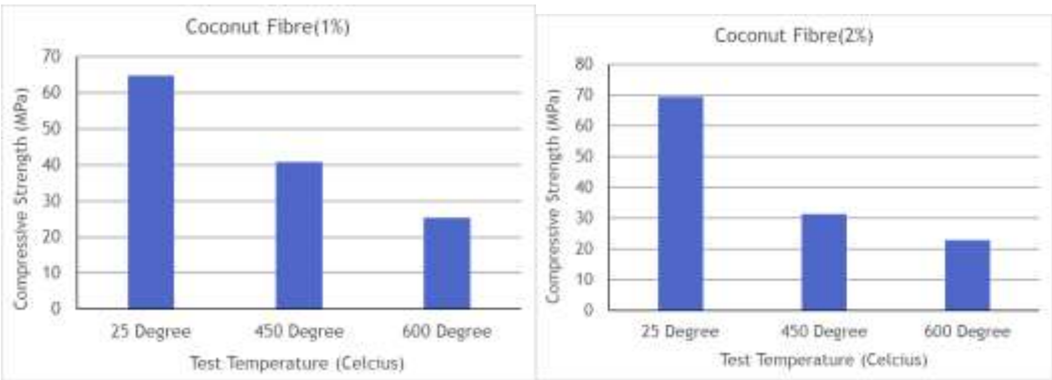


Figure 20: Comparison Between Normal Temperature Strength and Heated Strength (Coconut)

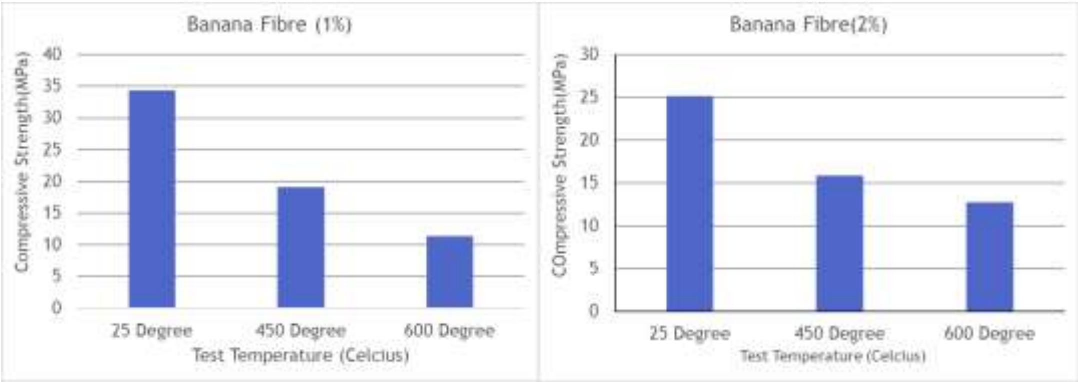


Figure 21: Comparison Between Normal Temperature Strength and Heated Strength (Banana)

3.4.2.2 Comments on Normal Temperature Strength and Heated Strength (Coconut and Banana Fibre):

Coconut Fiber:

1.Coconut fiber(1%):

Maximum strength at 25 degrees Celsius, or around 65 MPa. At 450 degrees Celsius, strength significantly decreases to around 35 MPa. 600 degrees Celsius: Significant strength loss is seen at this high temperature, with a further fall to around 10 MPa.

2. Coconut Fiber (2%): At 25 °C; begins at around 60 MPa. At 450°C, the pressure drops to around 30 MPa. A further decrease to around 20 MPa is seen at 600 degrees Celsius, indicating a little better retention at higher fiber content (relative to 1% at the maximum temperature), but still a significant drop.

1.banana fiber (1% of the total): At 25 °C, there is around 35 MPa of strength.Reduces to around 15 MPa at 450 degrees Celsius. At 600 degrees Celsius, the strength further decreases to about 5 MPa, demonstrating a considerable loss of strength at higher temperatures.

2. 2% of Banana Fiber: At 25 °C, About 25 MPa. At 450°C, the pressure drops to around 10 MPa. The strength retention at 600 degrees Celsius decreases somewhat to around 8 MPa, indicating that while increasing fiber content somewhat improves strength retention at high temperatures, it still experiences a significant reduction.

Condensed version of observations: Compressive strength for both kinds of fibers peaks at room temperature and sharply decreases at 450 and 600 degrees Celsius. When compared to banana fiber, coconut fiber appears to hold up better at higher temperatures, particularly when the fiber concentration is 2%.All varieties exhibit a noticeable decrease in strength at high temperatures (600 degrees), with both fibers exhibiting noticeably less strength when measured at normal temperature. This suggests that these natural fibers have a limited capacity to withstand heat, even if they can improve the characteristics of concrete at room temperature.

3.4.3 Comparison of the Fibre Condition(Before and After Fire Exposure)

Jute Fibre	Coconut Fibre

As we have investigated at Initial condition fiber was visible	After fire exposure fibers were burnt.	Same visible fibers	Burnt Fibres

Initial Condition was visible

Burnt Fibres

3.4.4 UPV Test Results Comparison

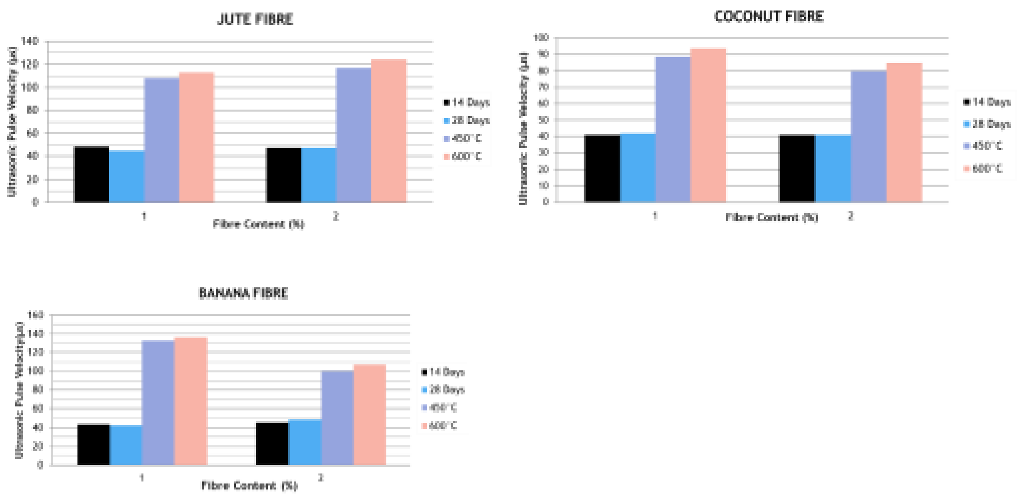


Figure 21 : UPV Vs Fibre Content(%)

3.4.4.1 Comments on UPV Test Results:

1. 1% Fiber Content

- 14 Days: UPV is around 130 km/s.

- 28 Days: UPV is slightly lower at about 120 km/s.

- 450°C: UPV drops significantly to around 60 km/s.

- 600°C: Further reduction in UPV to about 45 km/s.

2. 2% Fiber Content

- 14 Days: UPV is higher at about 135 km/s.

- 28 Days: Remains approximately the same at 135 km/s.

- 450°C: Reduction in UPV to around 80 km/s.

- 600°C: Drops to about 55 km/s.

Coconut Fiber

1. 1% Fiber Content

   - 14 Days: UPV is about 85 km/s.

   - 28 Days: Similar to 14 days, around 85 km/s.

   - 450°C: Slightly reduced UPV to about 80 km/s.

   - 600°C: Substantial decrease to around 55 km/s.

2. 2% Fiber Content

   - 14 Days: UPV is about 80 km/s.

   - 28 Days: Increases slightly to about 90 km/s.

   - 450°C: Drops to around 70 km/s.

   - 600°C: Further reduction to about 50 km/s.

Banana Fiber

1. 1% Fiber Content

   - 14 Days: UPV starts at about 140 km/s.

   - 28 Days: Increases to about 150 km/s.

   - 450°C: Drops to around 80 km/s.

   - 600°C: Further reduction to about 55 km/s.

2. 2% Fiber Content

   - 14 Days: UPV is around 135 km/s.

   - 28 Days: Decreases slightly to 130 km/s.

- 450°C: Reduction in UPV to about 70 km/s.
- 600°C: Further reduction to about 50 km/s.

In summary, Jute Fiber exhibits relatively high UPV at normal temperatures and experiences significant drops at high temperatures. 2% fiber content retains UPV better than 1% under high heat. Coconut Fiber exhibits moderate UPV values with noticeable reductions at elevated temperatures. It also shows a slight increase in UPV at 2% fiber content prior to heating. Banana Fiber exhibits the highest UPV values at normal temperatures and, unlike jute and coconut fibers, generally starts from a higher baseline.

3.4.5 RCPT Values Comparison

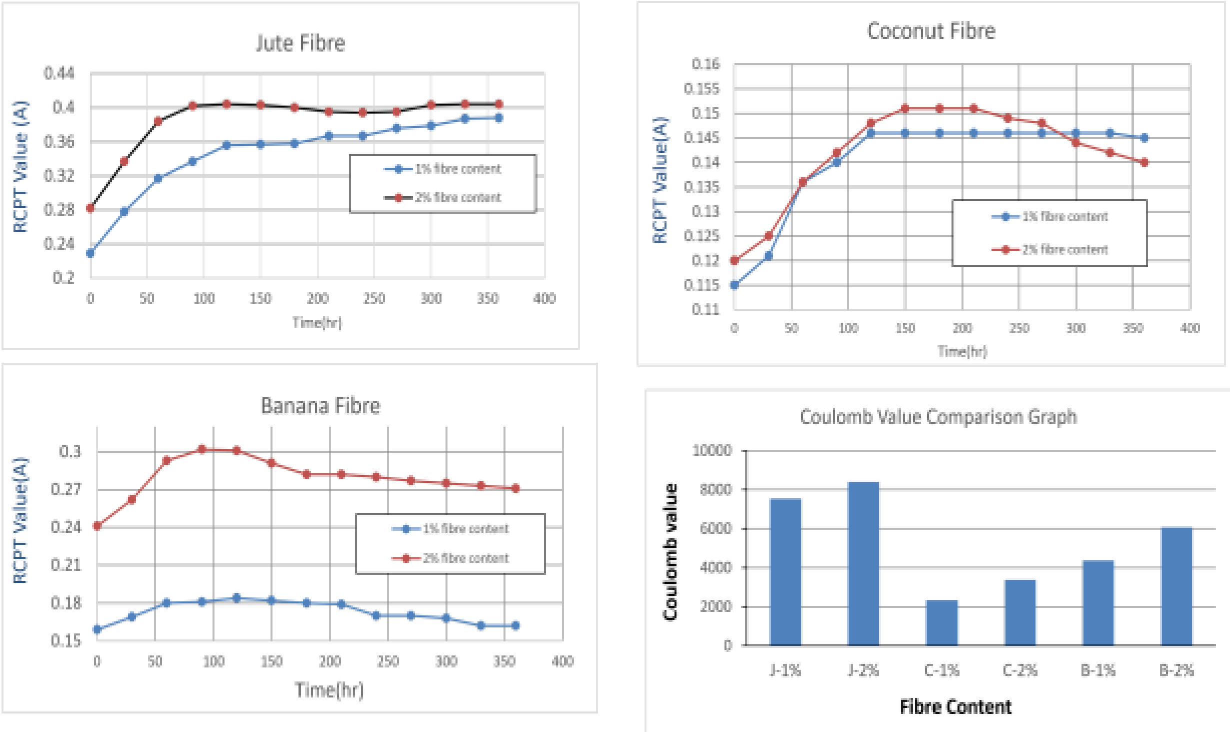


Figure 22: RCPT Values Comparison

3.4.5.1 Comments on UPV Test Results:

Jute Fiber

The graph shows RCPT values over time for 1% and 2% jute fiber content:

1% Fiber Content: Starts from a lower RCPT value and gradually increases, stabilizing around 0.32 A after 350 hours.

2% Fiber Content: Begins slightly higher than the 1% content, showing an increasing trend and stabilizing at a slightly higher value of approximately 0.36 A after 350 hours.

Coconut Fiber

This graph shows the RCPT values over time for 1% and 2% coconut fiber content:

1% Fiber Content: Begins at around 0.12 A, rises to a peak of about 0.145 A at around 150 hours, and then gradually declines to stabilize at around 0.14 A.

2% Fiber Content: Starts at a slightly higher value than 1%, peaking at around 0.155 A and stabilizing close to 0.15 A, indicating higher initial chloride permeability which slightly improves over time compared to the 1% content.

Banana Fiber

This graph shows the RCPT values for 1% and 2% banana fiber content:

1% Fiber Content: Starts from around 0.18 A, increases quickly to stabilize at around 0.24 A after 350 hours.

2% Fiber Content: Begins higher than 1% content at about 0.21 A, and it shows a similar rising trend, stabilizing at about 0.27 A, which is higher than the 1% content, suggesting that more fiber content might increase the chloride permeability initially but also provides better resistance as it stabilizes.

Coulomb Value Comparison Graph

This bar chart compares the total coulomb values:

Jute 1% (J-1%): Shows the highest total coulomb value around 9000.

Jute 2% (J-2%): Shows a decrease compared to 1% but still high at around 8000.

Coconut 1% (C-1%): Has significantly lower total coulombs around 3500, indicating better resistance to chloride penetration.

Coconut 2% (C-2%): Displays even better performance than 1%, with a further reduced total of around 3000.

Banana 1% (B-1%): Coulomb values rise again to around 7000.

Banana 2% (B-2%): Shows slightly better performance than 1%, with a value close to 6000

The Jute fiber exhibits a relatively high UPV at normal temperatures, but it decreases significantly at high temperatures. 2% of the fiber content keeps UPV better than 1% under high heat. The Coconut fiber, on the other hand, shows moderate UPV values with a noticeable reduction at elevated temperatures. It also shows a slight increase in UPV at 2% of the fiber content prior to heating. Finally, the Banana fiber has the highest UPV values at normal temperatures, but it generally starts from a higher baseline compared to the jute and coconut fibers.

3.4.6 Discussion

In the RCPT test, we got the highest values of columb jute at 2% and jute at 1%. So, jute fibre shows the highest penetration. Then compressive strength is higher for coconut fibre. on the 14th and 28th days. Consequently, jute fibre and banana fiber. We have investigated how, after the fire exposure, the compressive strength decreased for every fiber. After applying 450 degrees Celsius temperature and strength loss reach 50%, and for 600 degrees Celsius, We have applied a total two temperatures: 450 degrees Celsius and 600 degrees Celsius. Before the fire exposure, we tested the compressive strength test, and after cracking, our three types of fibre were visible, but after the fire exposure, they were burned. And ultrasonic pulse velocity increases with the period of time or being similar. The highest ultrasonic pulse velocity we have for coconut fiber Jute fibre is 1% on the RCPT values. jute fibre 1% and jute fibre 2% having the major (A) values. Lowest (A) values for coconut and banana fibres.

3.4.7 Conclusion

We have conducted several tests as Physical properties test, Compressive strength test, Ultrasonic pulse velocity test and Rapid Chloride penetration test and fire exposure test.

The major outcomes from those results the compressive strength in 28 days for all the fibers were more than the strength of 14 days.

And another major outcome was the compressive strength of coconut fiber is the highest among all the fibers after the exposure at 450 Degree Celsius and 600 degree Celsius the compressive strength losses approximately half of its strength because there was a negligible amount of calcium silicate hydrate and The fibers are not visible after the exposure which indicates these were burnt which is a major outcome and The UPV values obtained were consequently Proper from the Analysis of literature And RCPT test results show a high penetration of the fiber concrete and major value was obtained from jute 2% which shows the highest penetration.

References

[1] V. Marcos, A. Michel, A. Solgaard, C. Edvardsen, and G. Fischer, "Mechanical performance and corrosion damage of steel fibre reinforced concrete – A multiscale modelling approach," *Constr. Build. Mater.*, vol. 234, p. 117847, Feb. 2020, doi: 10.1016/j.conbuildmat.2019.117847.

[2] H. R. Sobuz, D. J. Oehlers, P. Visintin, N. M. S. Hasan, M. I. Hoque, and A. S. M. Akid, "Flow and Strength Characteristics of Ultra-high Performance Fiber Reinforced Concrete: Influence of Fiber Type and Volume-fraction," *J. Civ. Eng. Constr.*, vol. 6, no. 1, Art. no. 1, Mar. 2017.

[3] M. Ramli, W. H. Kwan, and N. F. Abas, "Strength and durability of coconut-fiber-reinforced concrete in aggressive environments," *Constr. Build. Mater.*, vol. 38, pp. 554–566, Jan. 2013, doi: 10.1016/j.conbuildmat.2012.09.002.

[4] A. Yusra, I. Y. Salena, I. G. Raka, and E. Saputra, "The Influence of Bamboo Fibers as Additive on the Mechanical Properties of High Strength Concrete," *J. Phys. Conf. Ser.*, vol. 1625, no. 1, p. 012013, Sep. 2020, doi: 10.1088/1742-6596/1625/1/012013.

[5] P. S. Song and S. Hwang, "Mechanical properties of high-strength steel fiber-reinforced concrete," *Constr. Build. Mater.*, vol. 18, no. 9, pp. 669–673, Nov. 2004, doi: 10.1016/j.conbuildmat.2004.04.027.

Chapter 5 Conclusion

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