EXPERIMENTAL STUDY ON FLEXURAL BEHAVIOUR OF HYBRID FIBER CONCRETE WITH BANANA AND NYLON POLYAMIDE FIBERS

T.S.N.V.P Lakshmi[1], K.V Madhav[2]

[1]M.Tech Student, Department of Civil Engineering, D.M.S.S.V.H College of Engineering, Machilipatnam.
[2]Assistant Professor, Department of Civil Engineering, D.M.S.S.V.H College of Engineering, Machilipatnam.

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Abstract - *Concrete is good at providing reasonable compressive strength but it tends to brittle in nature and weak in tensile strength, minimum resistance to cracking and poor toughness. To overcome the deficiencies of concrete, fibers are added to enhance the performance of concrete. The purpose of this research is to find the compatibility between the conventional concrete and hybrid fiber concrete made with banana fibers and nylon polyamide fibers. The banana fibers of different ratio's 0%, 0.25%. 0.5%, 0.75% & 1 % and nylon polyamide fibers of different ratio's 0%, 0.5%, 1% & 1.5% by volume were added to concrete. Split tensile strength and compressive strength and flexural strength of the concrete is calculated by testing the cubes, cylinders and prisms respectively casted with both concrete mixers and compared between them. Beams are casted with concrete mixes having optimum strength values and their deflections are evaluated by testing them on universal testing machine. This study attempts gives a contribution for effective utilizations of natural resources in the construction field.*

Key Words: **Hybrid fiber concrete, Banana fiber, Nylon polyamide fiber, Universal testing machine, Flexural Strength, Split tensile strength and Compressive Strength.**

1. INTRODUCTION

Concrete is a heterogeneous mix of cement. Fine aggregate, coarse aggregate and water. Concrete is most widely used construction material in world. Plain cement concrete is good at providing reasonable compressive strength but it tends to brittle in nature and weak in tensile strength, minimum resistance to cracking and poor toughness. To overcome the deficiencies of concrete, fibers are added to enhance the performance of concrete. The addition of hybrid fibers makes the concrete more homogenous. Hybrid fibers are the combination of two or more fibers. In the study we use banana fibers and nylon polyamide fibers are used as hybrid fibers. The usefulness of hybrid fibers concrete in various civil engineering applications i.e., precast concrete pipe, highway pavement, airport runway, industrial flooring.

1.1 HYBRID FIBER CONCRETE

Mixing of two or more fibers rationally in the concrete mix adds the properties of the each fiber to composite exhibits a synergetic response. Fibers enhances the properties of elastic modulus and decreases the brittle ness of concrete. By this compressive and tensile strength of the concrete will increases and overcome the formation of cracks. This research explores the feasibility of the hybrid fiber cement with M25 grade of concrete.

2. MATERIALS USED

It is proposed to test cement concrete in which cement is added by certain percentages of hybrid fibers with carbon and polypropylene fibers. Materials required for this concrete preparation are as follows:

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Banana fibers
5. Nylon polyamide fibers
6. Water

2.1 Cement

The purpose of cement in the concrete is to bind the materials added in fresh concrete and hardens which gives strength to the concrete. It is a finely graded powder induces the heat of hydration process when combined with water. This process produces the bogues compounds, which give rise the strength and setting time of the concrete. The cement used in this research is ordinary portland cement of 53 grade. The physical properties obtained from the investigations are tabulated in Table 1 as per IS 4031.

Table 1: Test results of cement

S.No	Description	Values
1	Specific Gravity	3.06
2	Normal Consistency of the cement	28%
3	Initial Setting Time	32 min
4	Final Setting Time	540 min
5	Fineness of cement	97 %

2.2 Fine Aggregate

Fine Aggregate will be clean, strong, hard and deleterious substance and free of organic impurities. It can be added with other materials which can be suitable type with strength, density, shrinkage and durability of mortar.it will have high density and good workability and it will work in position without segregation and use of high water content. The properties of the fine aggregate are tabulated in Table 2 as per IS 2386.

Table 2: Test results of Fine Aggregate

S.No	Description	Values
1	Specific Gravity	2.36
2	Grading Zone	III
3	Fineness Modulus	3.3

2.3 Coarse Aggregate

The coarse aggregates are granular materials obtained from rocks and crushed stones and retained on 4.75 mm sieve. The properties of the coarse aggregate are tabulated in Table 3 as per IS 2386.

Table 3: Test results of Coarse Aggregate

S.No	Description	Values
1	Specific Gravity	2.85
2	Aggregate Size	20 mm

2.4 Banana Fiber

Banana fiber is a best fiber with relatively good mechanical properties. Banana fiber has favorable physical and chemical characteristics, which facilitate its use in textile and apparel products. The chemical structure of banana fiber is composed of cellulose, hemicellulose and lignin. The cross section of the banana fiber consists of a number of smaller fibers bundled together. These smaller fibers may vary from as few as 10 to about 100 individual fibers. Each of these individual fiber cells is similar in shape and size to cotton fibers, as far as cross sections are concerned. These fibers are bound with lignin and give a hemicelluloses structure.

Figure 1: Banana Fibers

2.5 Nylon Polyamide Fiber

. Nylon 66 is a polyamide fiber. It is derived from a diamine and a dicarboxylic acid. Nylon 66 may be synthesized by using poly-condensation reaction. Poly-condensation is polymerization reaction in which monomers combines and "a small molecule by-product is produced". The by-product is usually something like water, hydrochloric acid, or once in a while sodium chloride. The simplest poly-condensation for making nylon 66 is the reaction of a diamine and a diacid.

Figure 2: Nylon Polyamide Fiber

2.6 Water

Potable water, free from organic matter, slit, oil, chloride and acidic material as per Indian Standard was used for the entire concreting. As per IS 456, the pH value of the water mixed in concrete should be present in between 6.5 – 8.5.

3. TEST AND RESULTS

3.1 Hardened Concrete

Concrete is casted into cubes, cylinders and prisms as per IS 516 recommendations and curing should be done for 7days, 14days and 28 days. In each set 9 specimens are made i.e. 3 cubes, 3 cylinder and 3 prisms for each concrete mix of M25 grade concrete added with banana fibers and nylon polyamide fibers of different proportions. Test performed in this research are:

1. Compression Strength test
2. Split Tensile Test
3. Flexural Strength Test

The results of above test after curing period for 7days, 14days and 28 days are tabulated below

Table 4: Compression Strength of concrete added with Banana fibers

Design Mixes	COMPRESSION STRENGTH (N/mm²)		
	7 days	14 days	28 days
0%	20.05	26.25	31.85
0.25%	21.45	27.23	33.05
0.5%	22.05	28.52	34.23
0.75%	23.04	29.75	35.45
1%	18.75	25.63	30.65

Chart 1: Compression Strength of concrete added with Banana fibers

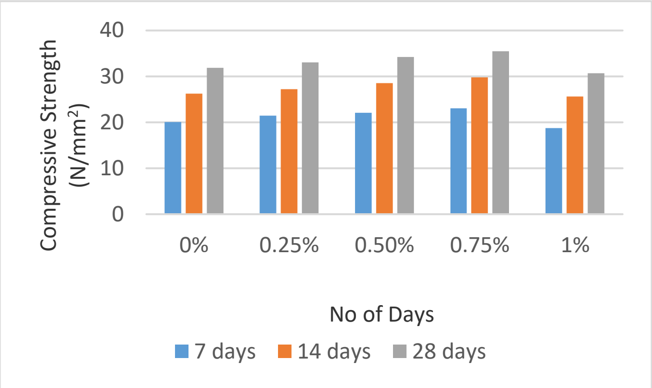


Table 5: Split Tensile Strength of concrete added with Banana fibers

Design Mixes	SPLIT TENSILE STRENGTH (N/mm²)		
	7 days	14 days	28 days
0%	2.23	2.92	3.60
0.25%	2.45	3.23	3.93
0.5%	2.58	3.41	4.06
0.75%	2.67	3.48	4.20
1%	2.18	2.86	3.53

Chart 2: Split Tensile Strength of concrete added with Banana fibers

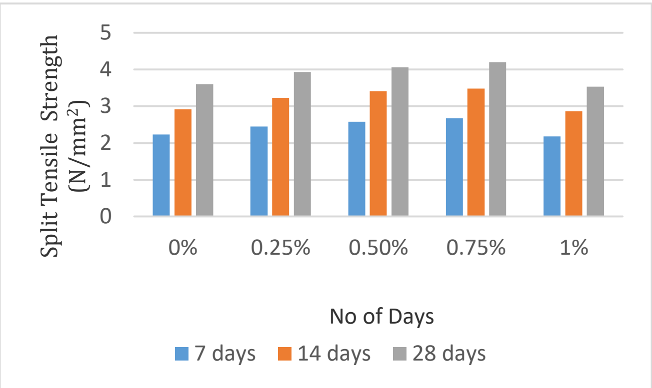


Table 6: Flexural Strength of concrete added with Banana fibers

Design Mixes	FLEXURAL STRENGTH (N/mm²)		
	7 days	14 days	28 days
0%	2.61	3.43	4.22
0.25%	2.70	3.52	4.33
0.5%	2.84	3.63	4.56
0.75%	2.91	3.82	4.95
1%	2.52	3.36	3.97

Chart 3: Compression Strength of concrete added with Banana fibers

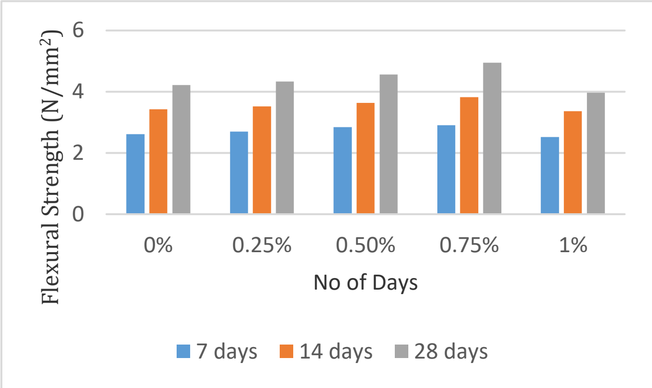


Table 7: Compression Strength of concrete added with Nylon Polyamide fibers

Design Mixes	COMPRESSION STRENGTH (N/mm²)		
	7 days	14 days	28 days
0%	20.05	26.25	31.05
0.5%	21.56	27.43	33.96
1%	22.32	28.96	35.21
1.5%	18.75	25.82	31.26

Chart 4: Compression Strength of concrete added with Nylon Polyamide fibers

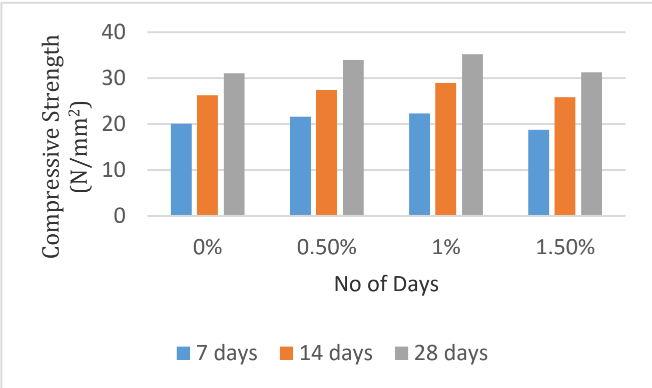


Table 8: Split Tensile Strength of concrete added with Nylon Polyamide fibers

Design Mixes	SPLIT TENSILE STRENGTH (N/mm²)		
	7 days	14 days	28 days
0%	2.23	2.92	3.60
0.5%	2.52	2.96	3.96
1%	2.67	3.46	4.22
1.5%	2.15	2.83	3.54

Chart 5: Split Tensile Strength of concrete added with Nylon Polyamide fibers

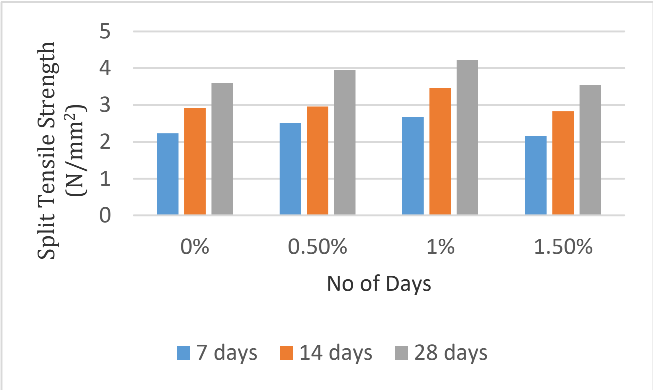
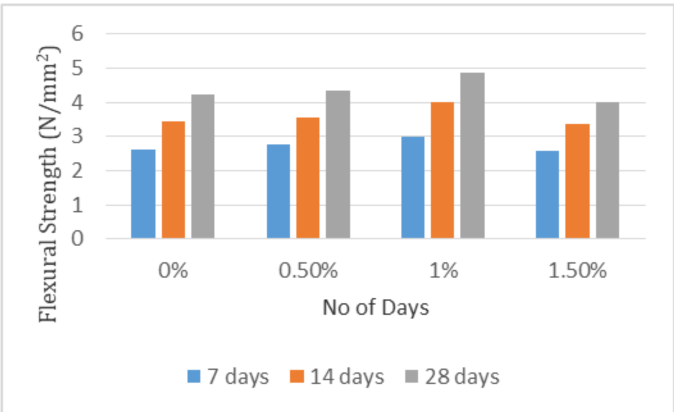


Table 9: Flexural Strength of concrete added with Nylon Polyamide fibers

Design Mixes	COMPRESSION STRENGTH TEST (N/mm^2)		
	7 days	14 days	28 days
0%	2.61	3.43	4.22
0.5%	2.75	3.54	4.36
1%	3.01	4.02	4.86
1.5%	2.58	3.36	4.02

Chart 6: Flexural Strength of concrete added with Nylon Polyamide fibers



Theoretical design of the beam under the assumed design load of 25kN is calculated to evaluated deflection of the beam and compared with the practical obtained results in Table 12.

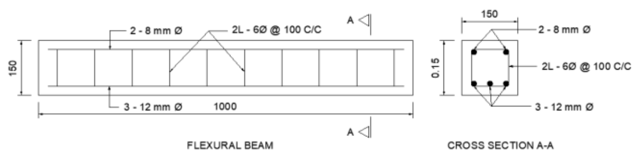


Figure 3: Beam Details

Three beams are casted with optimum values of strength results obtained from above tables and the deflections of each beam are evaluated using the universal testing machine and those values are represented in below tables and charts

Figure 4: Testing of beam in UTM

Table 10: Load Vs Deflection casted With Nominal Concrete

S.No	Load (kgf)	Deflection (mm)	Remarks
1	0	0	
2	500	0	
3	1000	0.02	
4	1500	0.03	
5	2000	0.03	
6	2500	0.04	
7	3000	0.05	
8	3500	0.06	
9	4050	0.09	First Crack
10	4500	0.16	
11	5000	0.21	
12	5500	0.35	
13	6000	0.39	
14	6500	0.42	
15	7000	0.45	
16	7150	0.49	Ultimate Crack Load

Chart 7: Load Vs Deflection casted With Nominal Concrete

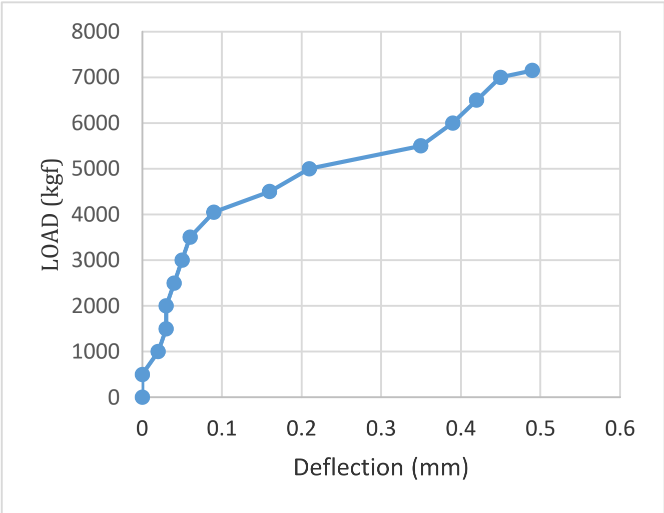


Table 11 Load Vs Beam casted by Hybrid fiber reinforced concrete with optimum value of Banana fibers and Nylon polyamide fibers

S.No	Load (kgf)	Deflection (mm)	Remarks
1	0	0	
2	500	0	
3	1000	0.01	
4	1500	0.02	
5	2000	0.03	
6	2500	0.05	
7	3000	0.05	
8	3500	0.06	
9	4000	0.08	
10	4750	0.12	First Crack
11	5000	0.23	
12	5500	0.87	
13	6000	1.03	
14	6500	1.53	
15	7000	1.93	
16	7500	2.01	

Chart 11 Load Vs Beam casted by Hybrid fiber reinforced concrete with optimum value of Banana fibers and Nylon polyamide fibers

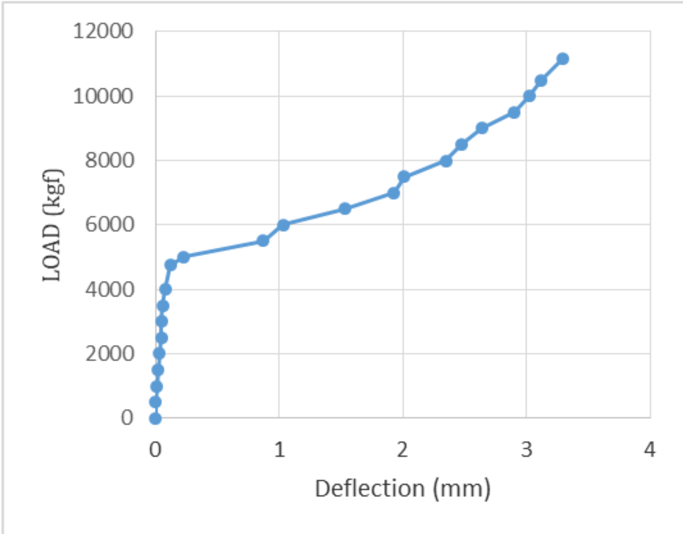


Table 12 Comparison of Beams casted with Nominal Concrete and Hybrid Fibre Concrete

Type of the Beam	Deflection (△)	Load (W)	Bending Stiffness (N/mm)
Theoretical Beam Design	0.095	36.42	383.368 x 10^3
Nominal Concrete Beam	0.09	39.71	441.22 x 10^3
Hybrid Fiber Concrete Beam	0.12	46.58	388.16 x 10^3

The deflections are 0.09, 0.12 and 0.095 for beam casted with nominal concrete, Hybrid fibre concrete and theoretical beam design respectively. By comparing the practical values obtained from the test results with the theoretical values from beam design, we observe that deflection of the normal concrete and hybrid fibre concrete is less than the theoretical value.

5. CONCLUSIONS

Based on the experimental study on Hybrid Fiber Reinforced Concrete with addition of Nylon polyamide and Banana fiber the following conclusions are drawn:

- Based on this experimental investigation, it is found that banana fiber can be added to the concrete and can be introduced as a functional construction material.
- As the banana fiber and Nylon polyamide fiber contents in the concrete increased up to 0.75 % and 1%

respectively, the compressive strength increment is observed. Further increasing of banana fiber beyond 0.75% the compressive strength decreases.

- By the comparison of nominal mix, the percentage increase in Compressive Strength, for concrete with banana fiber addition increases up to 6.9%, 8.5% and 6.7% for 7days, 14 days and 28 days respectively.
- By the comparison of nominal mix, the percentage increase in Split tensile Strength, for concrete with banana fiber addition increases up to 8.23%, 7.18`% and 6.42% for 7days, 14 days and 28 days respectively.
- By the comparison of nominal mix, the percentage increase in Flexural Strength, for concrete with banana fiber addition increases up to 7.21%, 7.85`% and 12.52% for 7days, 14 days and 28 days respectively.
- By the comparison of nominal mix, the percentage increase in Compressive Strength, for concrete with Nylon Polyamide fibers addition increases up to 10.17%, 9.35`% and 9.54% for 7days, 14 days and 28 days respectively.
- By the comparison of nominal mix, the percentage increase in Split Tensile Strength, for concrete with Nylon Polyamide fibers addition increases up to 16.4%, 15.60`% and 14.69% for 7days, 14 days and 28 days respectively.
- By the comparison of nominal mix, the percentage increase in Flexural Strength, for concrete with Nylon Polyamide fibers addition increases up to 13.28%, 14.67`% and 13.16% for 7days, 14 days and 28 days respectively.
- The First Crack of Hybrid fiber reinforced concrete beam with addition of Nylon polyamide fiber and Banana fiber has increased to 44.12kN when compared with normal concrete beam.
- The ultimate load resistance of Hybrid fiber reinforced concrete beam with addition of Nylon polyamide fiber and Banana fiber has increased to107.87kN when compared with normal concrete beam.
- By comparing the practical values obtained from the test results with the theoretical values from beam design, we observe that deflection of the normal concrete is 0.09 and hybrid fiber concrete is 0.12, which are less than the theoretical value.

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BIOGRAPHIES

K.S.N.V.P. Lakshmi [M.Tech]
Department of Civil Engineering,
D.M.S.S.V.H College of Engineering,
Machilipatnam. A.P

K.V Madhav M.Tech
Assistant Professor
Department of Civil Engineering,
D.M.S.S.V.H College of Engineering,
Machilipatnam. A.P