Experimental Study of The Utilization of Banana Stem Fibre As A Filler In Construction Material

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I. INTRODUCTION

1.1 Introduction

Fibres are thread like materials which can be used for different purposes. Fibres produced by plants (vegetable, leaves and wood), animals and geological processes are known as natural fibres. Researchers have used plant fibres as an alternative source of steel and/or artificial fibres to be used in composites (such as cement paste, mortar and/or concrete) for increasing its strength properties.

Natural fibres are cheap and locally available in many countries. So their use as a construction material for increasing properties of composites costs a very little (almost nothing when compared to the total cost of the composites). Their use can lead to have sustainable development. Another benefit may also include the easy usage/handling of fibres due to their flexibility, because the problem arises when high percentage of fibres is to be used as in case of steel fibres. But for use of very high percentage of fibres, there is a need to invent a methodology for casting. Volume fraction and fibres content are two terminologies used for expressing the quantities of fibres in a given composites. Volume fraction can be the part of total volume of composite or the part of volume of any ingredient to be replaced. Fibers content can be the part of total weight of composite or the part of weight of any ingredient to be replaced. Researchers have emphasized on the selection of optimum quantity of fibres along with the optimum fibres length (for example, matrix/composite with 3% volume fraction of fibres and 4 cm fibres length can achieved maximum strength, any further increase/decrease in volume fraction and/or fibres length may decrease strength of matrix/composite). Fibres reinforced composites can be used for many civil engineering applications including roofing tiles, corrugated slabs, simple slab panels, boards and mortar etc.
Banana plant not only gives the delicious fruit but it also provides textile called the Banana fibre. It grows easily as it sets out young shoots and is most commonly found in hot topical climates. These fibre are obtain after the fruit is harvested & fall in the group of best fibers. Banana fiber is extracted from banana trees bark, the trunk is peeled. The brown-green skin is thrown away retaining the cleaner or white portion which will be processed in to knotted fibers.

Banana fibres are an abundant, low-cost, and generally underutilized resource. Often, they are produced as waste by-products of industrial or agricultural processes. In many countries, for example, flax is grown primarily for its oilseed, and the straw is discarded or burned as a waste material. However, the fibres within the straw is one of the most durable and strong natural fibres, making it an ideal candidate for an effective fibres reinforcement in concrete, similarly banana is grown for the fruit however the disposal of the stem is a major issue.

1.2 Extraction of banana fibre

Banana fibre is extracted, not on a commercial worthwhile scale anywhere in the country. For extraction of fibres from the pseudostem, the most common method followed in Indian villages is hand scrapping, i.e. to scrap the stem with blunt metal edge. The drawback of hand scrapping is that the fibreoutput is very low. The essentially hand driven process of extracting banana fiber is now set to change with the invention of the Banana Fiber Separator Machine. An easier and quicker way of extracting fibres is to use a machine extractor, called Raspador, Banana Fiber is extracted from Banana pseudostem sheaths. Some efforts to extract the fibre by conventional methods like Hand extraction are being made in state of Kerala but the quantity of fibre produced is quite small. In some banana growing countries of the world like Philippines, Uganda, China, and Indonesia systematic extraction of banana fibre is being carried out.

The plants are cut down as soon as the fruits are harvested. The trunk is peeled. Brown-green skin is thrown away retaining the cleaner or white portion which will be processed into knotted fibers. To extract the fibre, the pseudostem is cut at the bottom at an angle, and its sheaths are removed, as each series of leaf sheaths produces different grades of fibers. It would be desirable to separate them according to the classification mentioned above prior to the cleaning or stripping that would enable the artisans to market the fibres advantageously. The fibers are extracted through hand extraction machine composed of either serrated or non serrated knives.

The peel is clamped between the wood plank and knife and hand-pulled through, removing the non-fibrous material. The extracted fibers are sun-dried which whitens the fiber. Once dried, the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each fiber is separated and knotted to the end of another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This fiber can now be used for making various products..

Figure 1.2.1 Process of Manufacturing of Banana Fibre

Figure 1.2.2 - Banana Fibres (Dressed & Undressed)

Bastfibres, like banana, are complex in structure. They are generally lignocelluloses, consisting of helically wound cellulose micro fibrils in amorphous matrix of lignin and hemicelluloses. The cellulose content serves as a deciding factor for mechanical properties along with micro fibril angle. A high cellulose content and low micro fibril angle impart desirable mechanical properties for bastfibres. Lignin is composed of nine carbon units derived from substituted cinnamyl alcohol; that is, columbary, coniferyl, and syringyl alcohols. Lignin is associated with the hemicelluloses and plays an important role in the natural decay resistance of the lignocelluloses material. The composition of banana pseudo stem is as given in Table I.

1.3 Composition of Fibres

Table 1.1 – Composition of Fibres (11)

Sr. No	Component	% Percentage
1	Cellulose	31.27 ± 3.61
2	Hemicelluloses	14.98 ±2.03
3	Lignin	15.07 ± 0.66
4	Extractives	4.46 ± 0 .11
5	Moisture	9.74 ± 1.42
6	Ashes	8,65 ± 0 .1

1.4Characteristics of Banana Fiber

In most part of India, these banana trunks are thrown as agricultural waste because most of the people are ignorant about the extraction of the fibre and its utilization except Kerala where this fibre is partly used for manufacturing house hold articles. This present portion of article gives an evaluation of yield, structure and properties of banana fibres gathered from a few commercially cultivated varieties. Results indicate that variation exists in both structure and properties of fibres from different regions along the length and across the thickness of the trunk. Banana fiber is a natural fiber. It has its own physical and chemical characteristics and many other properties that make it a fine quality fiber.

Characteristics of Banana Fiber are as follows:

- Appearance of banana fiber is similar to that of bamboo fiber and ramie fiber.
- The chemical composition of banana fiber is cellulose, hemicelluloses, and lignin.
- It is a strong fiber.
- It has smaller elongation.
- It has somewhat shiny appearance depending upon the extraction.
- It is light weight.
- It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.

- It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.
- Its average fineness is 4 to 15 tex.

II. LITERATURE REVIEW

Harajli&Salloukh(1997) is said that, In addition to industrial fibers, natural organic and mineral fibers have been also investigated in reinforced concrete. Wood, Banana fibre, sisalfibre, jutefibre, bamboo fire, coconut fibre,asbestos and rockwool, are examples that have been used and investigated. The main aim of the research on sustainable materials is to investigate the use of natural fibers with cement/concrete mixes to improve the performance of construction components and reduce the depletion in natural resources.The demand for the agricultural fibers for concrete production would be a major incentive to Lebanese farmers to benefit from the social impact on the habitat level of living. In the preliminary program reported in this paper, cubes and standard flexural beams were tested to evaluate the structural and physical performance of concrete mixes prepared with different volumetric ratios of added fibers and different proportions of aggregates. Test results indicated that the use of natural fibers resulted in reducing the coarse aggregate quantity without affecting the flexural performance of concrete.**(12)**

Majid Ali, et al (2012) was explained that the properties of different natural fibres. These natural fibres were investigated by different researchers as a construction material to be used in composites (such as cement paste, mortar and/or concrete). The different researches carried out and the conclusions drawn are briefly presented. The aim of this review is to compile the available data of different natural fibres evaluated in last few decades, and thus, it can be used as a reference/guideline for the upcoming research of a particular fibre. Natural fibres are used to increase the strength properties of the composites. But all properties cannot be improved at the same time because fibres have their own characteristics.**(14)**

Krishna R. &Sandararajan (2005) is investigated the effect of variation in chemical composition on tensile strength of four natural fibres (coir, sisal, jute and. Cannabinus fibres), when subjected to alternate wetting and drying, and continuous immersion for 60 days in three mediums (water, saturated lime and sodium hydroxide). Chemical composition of all fibres changed for tested conditions (continuous immersion was found to be critical), and fibres lost their strength. But coir fibres were reported best for retaining a good percentage of its original tensile strength for all tested conditions**.(4)**

ElieAwwad, MounirMabsout, Bilal Hamad and HelmiKhatib, et al(2011) had explained that preliminary tests performed to produce a sustainable "green" concrete material using natural fibers such as industrial hemp, palm, and banana leaves fibers. Such material would increase the service life and reduce the life cost of the structure,and would have a positive effect on social life and social economy. The demand for the agricultural fibers for concrete production would be a major incentive to Lebanese farmers to benefit from the social impact on the habitat level of living. In the preliminary program reported in this paper, cubes and standard flexural beams were tested to evaluate the structural and physical performance of concrete mixes prepared with different volumetric ratios of added fibers and different proportions of aggregates. Test results indicated that the use of natural fibers resulted in reducing the coarse aggregate quantity without affecting the flexural performance of concrete.**(13)**

III. MATERIALS AND METHODOLOGY

3.1 Materials and Mixing of Natural Fibres Reinforced Concrete

Mix Proportions

Mix proportions for unprocessed natural fibres reinforced concrete cannot be generalized since there are a variety of natural fibres that can be used in conjunction with the other standard ingredients such as cement, pozzolans, fine aggregates, water, and admixtures. The types of natural fibres that can be used with these standard ingredients include: bagasse, sisal, jute, coconut, banana, and palm. A brief description for each of the constituents which is used for obtaining fibres reinforced concrete is outlined below.

Cement

Cement that meets the specification can be used. The type of cement recommended is Type I, although Type III (high-early strength) cement can be used in order to reduce hardening retardation caused by the glucose present in most natural fibres.

Aggregates

The aggregates should meet the gradation requirements specified by Standard Specification for Concrete Aggregates.

Water and Admixtures

The water to be used for the mix should be clean and of good quality. Admixtures such as accelerating agents may be used in order to decrease the influence of the glucose retardant. If mild steel rebars are not used as additional reinforcement, calcium chloride could be used. Water-reducing admixtures and high-range water-reducing agents can be added in order to increase the workability when plastering. The use of organic-micro biocide is encouraged, for the prevention of bacterial attack of organic fibres.

Fibres

The length of fibres may vary from 25 to 500 mm. Because fibres are natural materials, they are not uniform in diameter and length. Typical values of diameter for unprocessed natural fibres vary from 0.10 to 0.75 mm. The mechanical properties of fibres are summarized under Technical Properties.

Methods of Mixing

The two methods of mixing and placing are
(1) wet mix and (2) dry-compacted mix.

(1)Wet mix :

In the wet mix, a low volume fraction of fibres is used. The water to be added to the mix has to take into account the high natural water content in the natural fibres. The mixing procedure must comply with process and portions recommendations. Trial batches are recommended and a batching plant is required. The recommended mixing procedure is to add cement with water and additives to form slurry. Then the fine aggregates are added. Finally, fibres is added and dispersed into the slurry. The sampling is to be done according to standard practices. For compressive and flexural strength testing, standard tests are to be followed.

(2) Dry-compacted mix:

The dry-compacted mix is generally used for industrial or semi-industrial projects. In the dry-compacted mix, the volume fraction of fibres used is about 10 times the volume fraction used in wet mix. The fibres are in a saturated-surface dry condition for this type of mix. Trial batches are recommended. The recommended mixing procedure is to add fibres in saturated-surface-dry condition to the cement and aggregates and then adds a very limited amount of water. Mixing can be done by hand or with mixers. For compressive and flexural strength, standards as for normal concrete are to be followed.

3.2 Production methods of processed natural fibres reinforced concrete

The slurry-dewatering technique is commonly used for the production of processed fibres reinforced cements and concretes. In this method, the fibrous cement product is formed from dilute slurry (about 20 % solids) of fibres-cement or fibres-mortar. The excess water is removed from the slurry through the application of vacuum dewatering and pressure. The product is then cured in air or in an autoclave to develop its strength and other mechanical properties. Industrial production of this composite now occurs in Europe, Australia, North America, South America, Asia, and South Africa using Kraft wood fibres with good results.

3.3 Technical Properties

a. Properties of unprocessed natural fibres reinforced Concrete

The properties of unprocessed natural fibres reinforced concrete, like those of any fibres reinforced concrete, are affected by a large number of factors. The major ones are listed in the table below. Clearly, the type and length of fibres, as well as the volume fraction, are the most significant factors. Test results show that for natural fibres the minimum fibres addition to provide some improvement in the mechanical properties of the cement composite is about 3 volume-percent. The impact resistance is increased in most cases regardless of the fibres volume fraction, but other properties are not improved significantly and remain similar to plain concrete. The properties of fresh and hardened unprocessed natural fibres reinforced concretes are briefly discussed in the following sections.

b. Fresh concrete

The addition of unprocessed natural fibres to concrete leads to reduced workability due to the increased surface area and water absorption of the fibres. It is important, however, that the mix be workable. A mix that is too stiff or too dry could lead to an inadequately compacted final product which is likely to contain voids and/or honeycombs. A mix that is too wet will, on the other hand, lead to unnecessary strength reduction.

The other important aspect is “balling” of fibres. The extent to which balling may occur in a given mix is determined by the type and length of fibres used, the volume fraction of fibres, and the maximum size of the aggregate. Balling should not be allowed to occur as it has a detrimental effect on the strength. Certain mixing methods can be employed to minimize the balling effect. Normally, the progressive addition of fibres at the end of the mixing process, after the other ingredients have been mixed, reduces the balling effect. Also, the use of high-range water-reducing admixtures is found to substantially increase workability without adversely affecting strength. Depending upon the amount of fibres and the method of mixing (dry batch or wet batch), unit weight may be reduced to 1500 kg/m3 (compared to normal concrete which are 2300 to 2500 kg/m3. The workability of the dry-compacted mix is normally poor.

Table 3.3.1 - Technical Properties of Fibre

Factors	Variables
'ibres type	onut, sisal, sugarcane bagasse, bamboo, jute, wood, vegetables (akwara, hant grass, water reed, plantain and musamba)
res geometry	th, diameter, cross, section, rings and hook ends
'ibres form	o-filament, stands, crimped and single-knotted
bres surface	othness, presence of coatings
rix properties	ent type, aggregate type and grading, additive types
proportioning	r content, workability aids, defoaming agents, fibres content
xing method	e of mixer, sequence of adding constituents, method of adding fibres, duration speed of mixing
cing methods	ventional vibration, vacuum dewatering for sprayed-up member, vacuum-s dewatering for slurry-dewatering member, extrusion and guniting
ting technique	ting pressure
ring method	ventional, special methods

Hardened Concrete

One of the important properties of the hardened composite is its strength. Since the unreinforced cement mortar matrix possesses adequate strength for many applications, but is brittle, it is customary to study the influence of fibres on the increased ductility that can be achieved. Apart from strength, other aspects such as deformation under load (stiffness), durability, cracking characteristics, energy absorption, water tightness, and thermal properties should also be evaluated. The most important contribution of the fibres can be rationally evaluated by determining the fracture toughness of the composite.

Properties of the hardened processed natural fibres reinforced concrete

The performance of PNFRCs in both the short and long term depends on the methods used for their curing and their mix proportions. The mix proportions used for commercial products are not readily available.

In the case of slurry-dewatered wood fibres reinforced cement, it has been reported that the density of the composite decreases and its water absorption capacity increases with increasing fibres content. The overall density of the composite reflects the changing proportions of the constituent fibres and the matrix. The void volume of the composite also increases, but in a non-linear fashion, as the fibres content increases. The amount of water absorbed by wood fibres reinforced cement depends on the density of the composite.

Studies on processed natural fibres reinforced cement have shown that increase in moisture content tends to decrease the flexural strength and increase the flexural toughness of the composites. Based on direct comparisons of the flexural strength and toughness values, respectively, of slurry-dewatered Kraft pulp reinforced cement with different fibres contents tested in wet or oven-dried conditions, or in an environment of 50 percent R.H. Increase in moisture content seems to weaken the bonding of matrix to fibres, thus encouraging fibres pull-out rather than rupture at cracks. The weakened bond reduces flexural strength, while the frictional energy consumed during pull-out tends to increase the fracture toughness of the composite.

Further details on the performance of air-cured composites are given in the references. Autoclave-cured composites are dealt with in detail in the references. The long-term performance of both autoclaved-cured and air cured processed natural fibres cements are also available from the literature list.

3.4Construction

Placing and Finishing of unprocessed natural fibres reinforced Concrete

The placing and finishing of the unprocessed natural fibres reinforced concrete is dependent on the method of mixing used (wet mix or dry-compacted mix). Placing of the wet mix may be achieved by using conventional equipment. Internal or external vibrators should be used. Other properties such as workability can be measured by the slump test or the K-slump tester as recommended Penetration Test. Air content in the mix can be measured in a standard way.

3.5Materials and Methods

Banana fibres are obtained from Krushi Tantraniketan Vidhyalay, Nimbhora, Dist- Jalgaonin Maharashtra Pin- 425506, and India. Banana fibres are extracted from the stems of banana plant. Longitudinal slices are prepared from stems and fed to fibres extracting machine (Figure 1). The fibres extracting machine, also known as a mechanical decorticator, consists of a pair of feed rollers and a beater. The slices were fed to the beater between the squeezing roller and the scrapper roller, (Figure 3-1) following which the pulp gets separated and fibres are extracted and air dried in shade.

Figure 3.5.2 - Fibre Extraction machine (Krushi Tantraniketan Vidhyalay, Nimbhora)

3.6Testingof Fibres

Conditioning

Specimens were conditioned, at 65% RH and 21ºC for a day to ensure environmental equilibrium, prior to testing.

Fibres linear density

Fibres diameter is evaluate from optical observations under microscope as the average of five diameter measurements taken at different locations along the fibres with a range of standard deviation from 0.05 to 0.1. Based on the diameters of the fibres, the whole fibres samples are divided into four broad categories. The diameter of the fibres is then measured at 100 different places along the length of four fibres. 100 fibres were also taken at random from the sample and their diameter is measure at 10 different places. The Tex of the fibres is calculated assuming the density of banana fibres to be 1.4g/cc, determined using a density gradient column prepared from xylene (0.865 g/cm^3) and carbon tetrachloride (1.595 g/cm^3) by Kumar et.al. Figure 2, which is the cross section of fractured banana fibres, shows the circular nature of the fibres, along with the presence of some protruding fibrils. Thus for a circular cross section of the fibres, the Tex of the fibres, defined as the weight in grams of 1000m of the fibres, would be related to the volume as

Tex = Volume (cc) x 1.4 x 1000 …..(1)

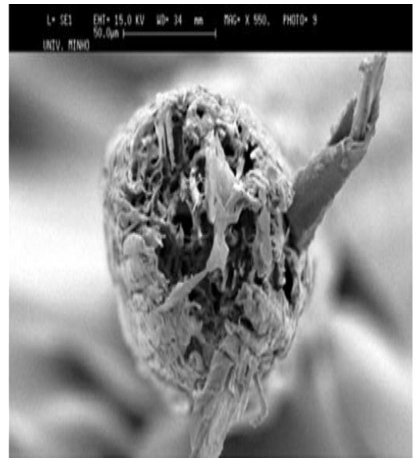

Figure 3.6.1- SEM of Banana Fibre Showing Circular C/S(8)

Single fibres tensile test

Fibres were carefully manually separated from the bundles. Fibres ends are glued onto a paper frame according to the preparation procedure described in ASTM D3822-07 Standard. A Hounsfield tester is used to test the fibres. A load cell of 100 Newton was used for fibres testing. Due to variability of natural fibres, 20 samples are tested and the average value reported along with the variability of the data. The strain rate is varied to study its effect on properties. Pneumatic grips are used to clamp the fibres with a pressure of 0.4MPa. When mounting specimens onto the tester, special care is taken to prevent fibres misalignment. The distance between the grips are fixed to 100mm and the upper end of the fibres is clamped first and the fibres is allowed to self-align, under the weight of lower paper tab, followed by clamping of the lower end. The tenacity values are calculated based on the maximum load and the Tex of the fibres, the calculation of which has already been discussed. Modulus values are not reported as the tester had no strain gauge attachment.

SEM

A scanning electron microscope (SEM), Model Leica Cambridge S-360 was used to study the fracture surface of the tensile and impact specimens. The specimens were coated with a thin gold–palladium layer using Sputter Coater to avoid electrical charge accumulation during examination.

3.7Results and Discussion about fibres testing

Hundred fibres are chosen at random from the collection of banana fibres. There is a wide range of variation of diameter starting from 0.08mm to 0.32 mm. Based on a class interval of 0.029 mm, which is decided based on the presence of at least 10 fibres in a class, the fibres are divided into classes.. Diameter distribution of fibres measured along 100 different points along the length for four different fibres also follow a normal distribution (Figure 3-4) except for Fibres 1, which had a bimodal distribution. However majority of the fibres follow a normal distribution, 25% of the fibres fall in the 0.17 to 0.19 mm group and 66% of the fibres clusteraround the diameter of 0.14 to 0.23 mm.

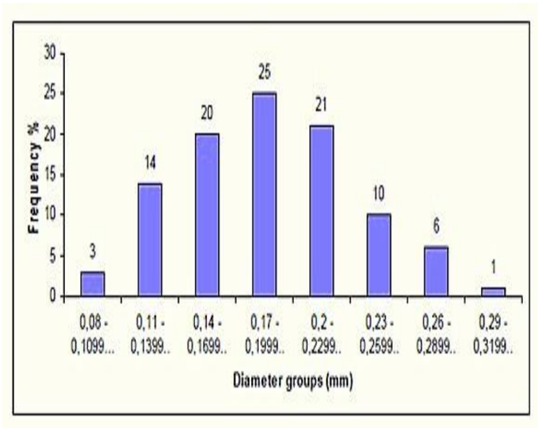

Figure 3.7.1- Frequency Distribution of Banana Fibre Based on Diameter (6)

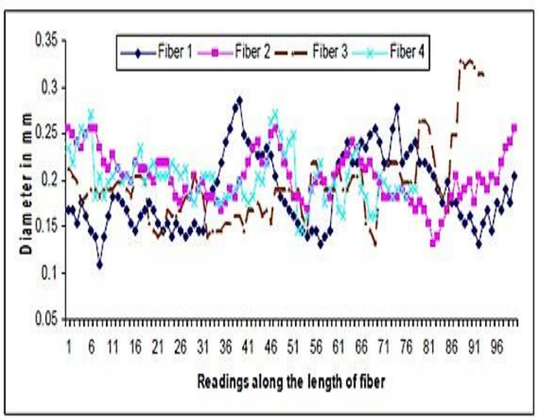

Figure 3.7.2- Variation of Fibre Diameter along Length (6)

(Figure3.7.2) shows the diameter variation along the fibres length. It is important that the variation do not show any trend whatsoever for the different fibres tested. It is equally interesting to note the diameter distribution of fibres measured along 100 different points along the length for four different fibres also follow a normal distribution.

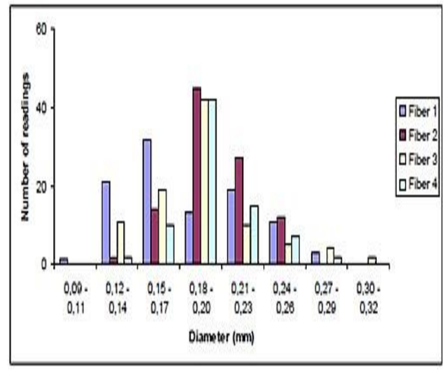

Figure 3.7.3 - Frequency Distribution of Diameter along Length of Four Individual Fibers (6)

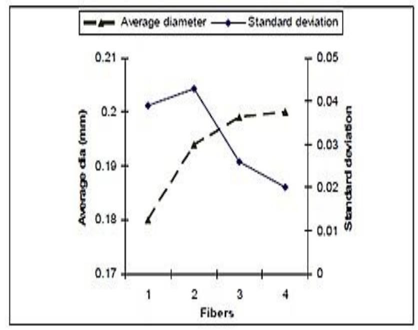

Figure 3.7.4 - Average Diameter vs Standard Deviation (6)

Figure 3-7 establishes that the standard deviation has decreased with an increase of diameter of the fibres meaning that courser fibres are more regular in nature. The majority of the fibres, as evident from Figure 3 come in the diameter range of 0.17 to 0.19 mm. Hence such fibres are chosen for tensile testing. Results of tensile testing revealed that strain rates played an important role in the nature of the stress strain curves, the strength of the fibres and the nature of failure. The tenacity, as observed from Table III increased when the strain rate is increased to 0.5 min^{-1} but ultimately decreased with an increment in speed.

Table 3.7.1-Results of the Tex Test.

Sl No	Strain rate (min^{-1})	Tenacity (MPa)	Extension (%)
1.	0.1	167.2 (26.8)	3.0 (17.2)
2.	0.5	203.4 (18.6)	2.7 (17.8)
3.	1	168.6 (30.1)	2.3 (27.8)
4.	10	146.2 (26.2)	1.2 (28.2)

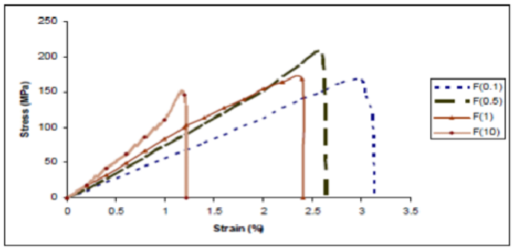

Figure 3.7.5- Strain Stress Curve (6)

Figure 3.8.5 comprises the representative stress strain curves for banana fibres. There is some initial compliance of the system. The averaged curves show the tendency of a dominantly brittle fracture for the fibres except at the lowest strain rate of 0.1 min-1. Some of the fibres showed evidence for strain hardening. This phenomenon can be interpreted as a progressive reorientation of micro fibrils which occur for some of the fibres. Similar observations have been made by Hornsby et.al. in their research with wheat and straw fibres. The modulus values were not calculated because of non availability of a strain gauge. It is apparent from the stress strain curves that higher strain rates resulted in higher apparent modulus values.

At higher strain rates of 1 min-1 a fall of tensile strength is observed (curve F (1) in Figure 3-8) which may be a result of the presence of imperfections in the fibres causing immediate failure. It has to be noted that at higher speeds, the imperfections play a major role in tenacity or breaking strength, being dependent on imperfections, deteriorates. SEM micrographs (Figure 3-11) show a majorly brittle fracture, with some element of ductility still present in the fractured surface. With still higher strain rates 10 min-1 a further fall of tensile strength is observed (curve F (10) in Figure 3.7.5). SEM micrographs (Figure 3.7.5) show a substantial brittle fracture. The lower elongation of 1.2% is a result of the brittle failure of the specimen.

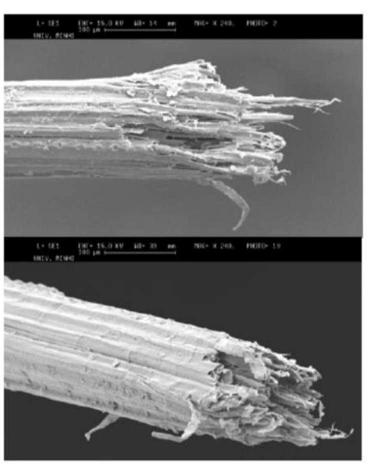

Figure 3.7.6- Fracture (Strain Rate of 0.1 per min-1). (8)

a) Side view b) Angular view

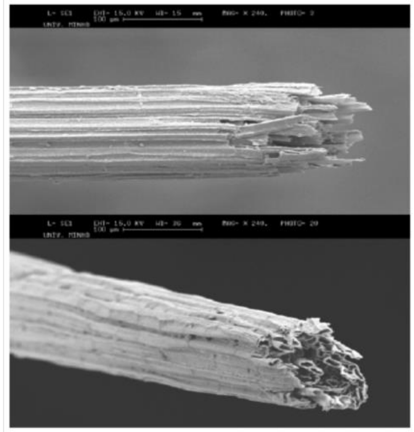

Figure 3.7.7- Fracture (Strain Rate of 0.5 per min -1). (8)

a) Side view b) Angular view

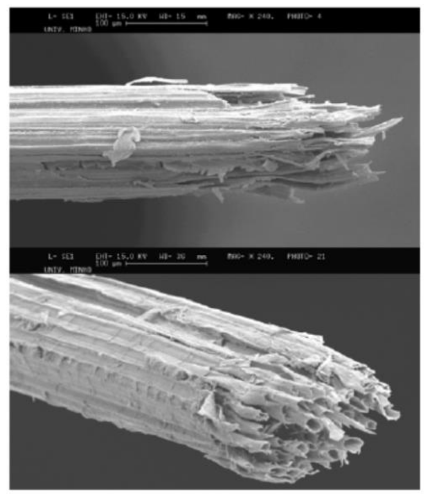

Figure 3.7.8 -Untreated fracture (strain rate of 1 per min -1). (8)

a) Side view b) Angular view

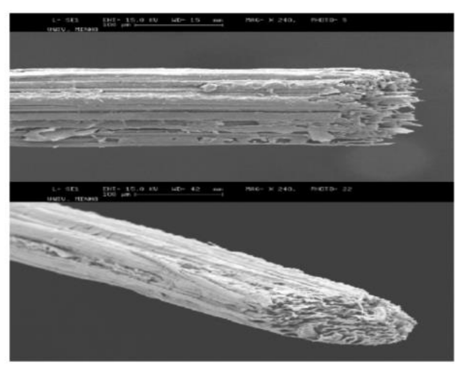

Figure 3.7.9-Untreated fracture (strain rate of 10 per min -1). (8)

a) Side view b) Angular view

IV. TEST RESULT ANALYSIS

4.1 Compressive testing

Testing of the cubes (M20) is carried out as per the IS 516:1959. The results of the test are as follows:

Table 4.1.1-Results for Compressive Strength

Result for compressive testing of fibres composite concrete cubes										
Grade of concrete used : M20										
	be wt	/c	re fraction	re weight	xing	sticizer	ays strength	days strength (F_{act})	F_{act}/F_{ck}	mark
Unit	Kg		%	Grams	W	Y/N	N/mm²	N/mm²		
Sr.No.	We have assumed that nominal mix of M20 gives minimum characteristic strength of 20 N/mm²									
1	3.1	5	0	0	W	Y	13.40	20	1	ntrol
2	3.1	5	0.1	8.1	W	Y	20.06	28.3	1.41	ood
3	3.1	5	0.1	8.1	W	Y	20.78	29.4	1.47	ood
4	3.1	5	0.1	8.1	W	Y	24.49	28.9	1.45	ood
5	3.1	5	0.2	16.2	W	Y	15.26	30.25	1.51	ood
6	3.1	5	0.2	16.2	W	Y	15.70	33.56	1.67	ood
7	3.1	5	0.2	16.2	W	Y	15.26	32.05	1.60	ood
8	3.1	5	0.3	24.3	W	Y	18.31	28.64	1.43	ood
9	3.1	5	0.3	24.3	W	Y	23.98	31.56	1.57	ood
10	3.1	5	0.3	24.3	W	Y	19.62	28.85	1.44	ood

Results and inference:

From the above mention test, it is inferred from that up to 0.2 % of fibre composite concrete; there is no need of the addition of the plasticizer. For 0.3 % and 1 % of fibre composite concrete plasticizer is required as per the specification. In case of the 1% fibre composite concrete the compressive strength of the specimen is compromised else it was efficient. So it can be inferred that as the percentage of the fibre is increased the compressive strength is compromised.

Conclusion:

The compressive strength is not compromised because of the addition of the fibres up to certain limit.

4.2 Flexural test

1) Testing of the cubes (M20) is carried out as per the IS 516. The results of the test are as follows:

Table 4.2.1- Results for Flexural Test

	/c	Fibre action	ibre eight	ixing	asticizer	ead eight	ealking load	al load aken
nit		%	rams	)/W	Y/N	Kg	Kg	Kg
no								
1	.5	0.1	7.80	W	Y	7.80	256.00	06.00
2	.5	0.1	7.80	W	Y	7.80	036.00	86.00
3	.5	0.2	5.60	W	Y	7.80	110.00	60.00
4	.5	0.2	5.60	W	Y	7.80	490.00	40.00
5	.5	0.3	3.40	W	Y	7.80	47.00	97.00
6	.5	0.3	3.40	W	Y	7.80	50.00	00.00

2)Testing of the beam (M20) is carried out as per the IS 516. The results of the test are as follows:

Table 4.2.2- Maximum Bending Moment for Flexural

	/c	ibre ction	bre ight	xing	al load aken	Load tribution 2 Points	Imax	nding resses	odulus of upture
nit		%	rams	/W	N	kN	Nm	/sq.m	/sq.cm
no									
1	55	0.1	5.6	W	398.6	5.19	3986	48.64	8.84
2	55	0.1	5.6	W	72.66	4.83	67266	19.584	7.52
3	55	0.2	7.8	W	330.86	5.91	83086	03.264	1.44
2	55	0.2	7.8	W	126.4	7.06	1264	11.36	25.6
5	55	0.3	3.4	W	56.57	2.92	85657	41.168	0.61
5	55	0.3	.4	W	867	3.43	6867	220.8	2.44

Results and inference:

The breaking load for the beam samples goes on decreasing with the increase in the fibre fraction.This shows that the flexural strength is affected by the percentage increase in the fibre. Also, the moment of inertia being constant, the reduction in the maximum bending moment with increase in fibre fraction reduces the bending stress in the beam.

Conclusion

Flexural members being fundamental structural member, strength reduction in any form is not desired. Thus, it is advisable to avoid the use of fibres in high percentages. (Not more than 0.2% with plasticizers).

4.3 Flexural test on tiles

Specimen used was conforming to IS 1237:1980 and IS 456:2000. Size was as per the standards is 300mmX300mX25mm.

Table 4.3.1 Results for FibreComposite Concrete Tiles

Results and inference:

	/C	Fibre nction	ibre eight	lix	lasticizer	reaking load	tal ad ken	otal load aken	odulus Of upture
nit		%	rams	/W	Y/N	Kg	g	N	N/mm²
no									
1	55	0	0	W	Y	185.00	55	20.00	3.648
2	55	0.3	6.2	W	Y	230.00	00	62.00	4.708
3	55	0.4	1.6	W	Y	242.00	12	79.72	4.991
4	55	0.5	27	W	Y	168.00	38	53.78	3.249

It is possible to achieve good finish and satisfactory strength using banana fibre in concrete tiles. It also reduces the shrinkage cracks and also helps to increase the abrasion value of the tiles.

Conclusion:

Thus, it can be concluded that the major percentage of the fibre (about 0.4 %) can be used as an additive in concrete tiles without compromising on the strength and finish of the product.

4.4 Plaster of composite cement mortar

On the fourth day, it was observed that the cracks were minimum in the patch of 0.3% fibre which further reduced in the patch 0.5% fibre. On the other hand, the control specimen shows considerable cracks of varying widths and lengths.

Figure 4.4.1- 0.5 % Plaster Patch withoutCracks

Figure 4.4.2- At 0.3% Plaster Patch With Cracks

However, on the 14th day from plastering, it was observed that the patch of 0.3% fibres showed minor cracks on the edges of the plaster which is not included in the area of observation.

Figure 4.4.3 Control Specimen after 14 Days at 0.5%

The control specimen had further deteriorated to a great extent the patch containing 0.5% fibres showed no changes.

Results and inference:

From the above mention observations, it is inferred that the increase in fibre content up to 0.5% shows good results as no were found even after 14 days.

Conclusion:

The holding property of the plaster increases as the fibres helps in interlocking of the mortar ingredients. It also gives a pleasant texture on the plaster surface. It also plays a vital role of crack arrestors.

V. RESULT DISCUSSION

5.1 Compressive testing

From the above calculation, it's said that the compressive strength of concrete is higher at 0.2 % of fibre and it should be decrease with increasing the percentage of fibre. The compressive strength of the concrete not significantly compromised due to addition of the fibres.

The percentage increase is inversely proportional to the compressive strength.

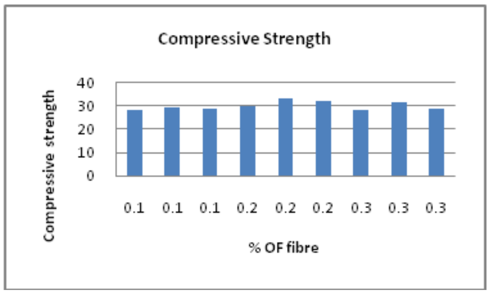

Figure 5.1.1 – Compressive Strength Variation with FibrePercentage

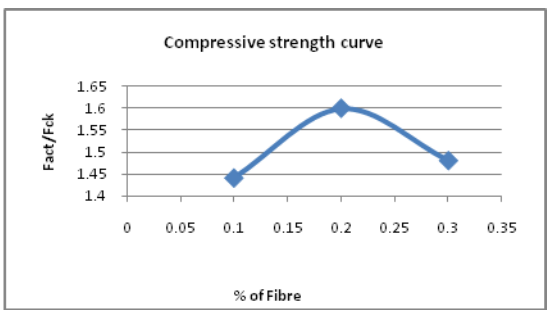

Figure 5.1.2 - Compressive Strength Variation curve on % of Fibre

5.2 Flexural test

From the above flexural test result it can be said that the percentage of fibre is increasethan 2% then, decrease the bending moment.At the 0.2% of fibre the flexural strength of the concrete is also increase as compared to other percentage. Thus, it is advisable to avoid the use of fibres in high percentages. (Not more than 0.2% in concrete).

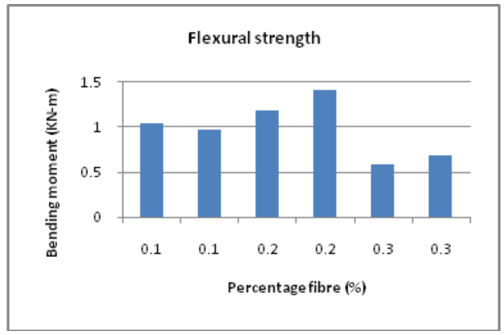

Figure 5.2.1- Graph of Percentage Fibre Vs Bending moment

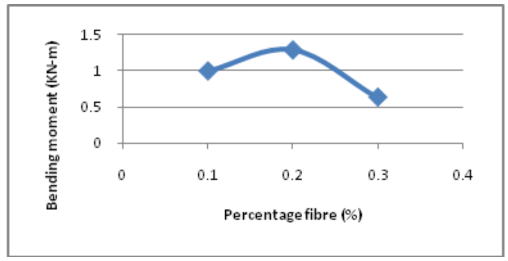

Figure 5.2.2 - Flexural Test Result Variation curve with % of Fibre

5.3 Transverse test for fibre composite concrete tiles

Possible to achieve good finishing and satisfactory strength using the fibres and at the same time add reduced shrinkage cracks, increased abrasion value due to the fibres holding the slurry and reduced crack propagation .Major percentage of the fibres (about 0.4%) can be used to suffice as an additive to concrete pavers**.**

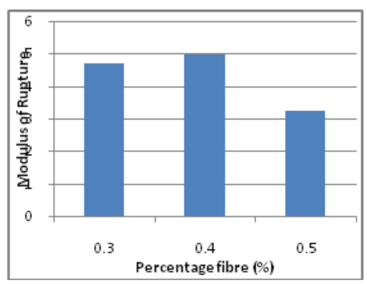

Figure 5.3.1- Graph of Percentage Fibre Vs Modulus of Rupture

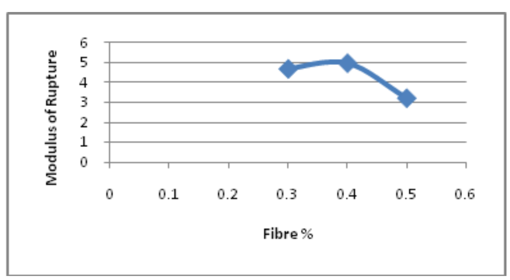

Figure 5.3.2 - Transverse Test for Fibre Composite Concrete TilesVariation with % of Fibre

VI. CONCLUSION

From the project, we conclude that the banana fibre is effective to improve the strength of concrete at certain percentage. And the percentage of banana fibre is increase with increase the honey combing. The objective of the project is optimum utilization of the banana stem fibres as a composite in building materials.Analytical conclusions pertaining to the testing carried out under the scope of the project give us major understanding of how the concrete behaves due to addition of fibres.

From the above project report we are conclude as below:

1. In the compressive test, for 0.2% of fibre the compressive strength should be achieved maximum. So it is beneficial to use this percentage of banana fibre in the concrete.
2. At the 0.2% of fibre the flexural strength of the concrete is also increase as compared to other percentage. Thus, it is advisable to avoid the use of fibres in high percentages. (Not more than 0.2% in concrete).
3. The major percentage of the fibre (about 0.4 %) can be used as an additive in concrete tiles without compromising on the strength and finish of the product.Possible to achieve good finishing and satisfactory strength using the fibres and at the same time add reduced shrinkage cracks, increased abrasion value due to the fibres holding the slurry and reduced crack propagation .
4. For the plastering result we conclude that, 0.5 % of fibreare useful to reduced shrinkage cracks. And more than 0.5% fibre are affected on plastering.
5. The strength of concrete is not compromised because of the addition of the fibres up to certain limit.
6. It thus would be a major subject to study to understand the behavior of the fibre in a mix design and then prescribe standards for the use of the fibres.

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