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EFFECT OF BAMBOO FIBRE ON THE PROPERTIES OF PAVEMENT QUALITY CONCRETE: A REVIEW

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Abstract- As for as flexible pavements are concerned concrete pavements are more durable, while requiring less maintenance and having longer life. This paper discusses about the benefits of rigid pavements utilizing bamboo fibre. The study aims to investigate the feasibility of using bamboo as a fibre in pavement quality concrete with different water/powder ratios by adding bamboo fibre. This research presents the detailed amount of fibres used in the pavement quality concrete on trial basis.
Since the strength and stiffness of natural fibre concrete reduces with time, adequate precautions should be taken when using natural fibre. To prevent the decay of fibres, the partial replacement of cement with mineral admixture is being recommended. Also using mineral admixtures makes concrete less permeable and less the permeability more durable the concrete is. Bamboo with high percentage of sugars(4.92%) having retarding effect on the setting and strength development of cement matrix should be kept in concentration and to overcome that, addition of chemical admixtures is necessary to counteract the adverse effect.

Key words: pavement, durable, fibre, admixtures, permeability, strength.

1. INTRODUCTION

Problems encountered with the commonly used construction material like steel are rise in cost; degradation of the non-renewable material, the pollution of the environment due to industrial process etc. are common in the globe. However, with sustainability as a key issue in the last decades the environmental load of building materials has also become a more important criterion. The building industry, directly or indirectly causing a considerable part of the annual environmental damage, can take up the responsibility to contribute to sustainable development by finding more environmentally benign ways of construction and building. One of the directions for solutions is to look for new material applications: recycling and reuse, sustainable production of products, or use of renewable resources. Attention has to be given to materials such as vegetable fibres including bamboo, jute, and glass, wastes from industry, mining and agricultural products for engineering applications to control environmental degradation and to minimize cost.
On the basis of these expedient characteristics of bamboo, studies have been made over the bamboo as a structural material and reinforcement in concrete.
Concrete is a widely used construction material for its various advantages such as low cost, availability, fire resistance etc. But it cannot be used alone everywhere because of its low tensile strength. So, generally steel is used to reinforce the concrete. Though steel has a high tensile strength to complement the low tensile strength of concrete, use of steel should be limited since it is very costly and also so much energy consuming in manufacturing process. Thus a suitable substitute of this with a low cost, environmental friendly and also a less energy consuming one, is a global concern; especially for developing country. Addressing all these problems, bamboo is one of the suitable replacements of reinforcing bar in concrete for low cost constructions. Bamboo is natural, cheap, widely available and most importantly strong in both tension and compression.

1.1 Selection criteria of bamboo for use as a reinforcement in concrete structures as per Priyadarshee et al. (2014)

1. At least three years old plant should be used showing a pronounced brown colour.
2. The longest large diameter culms available should be selected.
3. Whole culms of green, unseasoned bamboo should not be used.
4. Bamboo cut in spring or early summer should be avoided since they are generally weaker due to increased fibre moisture content.

1.2 *Properties of bamboo*

1.2.1 Physical structure of bamboo

Bamboo is usually contrasted with wood items because of its comparative compound structure. The physical structure is the angle that separates bamboo from wood. Wood has anisotropic properties and contains grains arranged a similar way all through the entire structure. On the outside edge of every hub, branches frame making diverse sorts of grass looking leaf structures. Bamboo contains parallel filaments that are strengthened along the pivotal bearing of the Culm.

1.2.2 Shrinkage and swelling

Bamboo, similar to wood, changes its measurement when it loses or gains dampness. Bamboo is a hygroscopic material, along these lines the dampness content changes with the adjustments in the relative moistness and temperature of the encompassing condition.

1.2.3 Elasticity

The gigantic versatility of bamboo makes it to a decent building material for tremor imperiled territories. Another preferred standpoint of bamboo is its low weight. It tends to be transported and worked effectively, accordingly rendering utilization of cranes and other huge machines superfluous.

1.2.4 Fire resistance

The imperviousness to fire of bamboo is great due to its high substance of silicate corrosive. Topped off with water, it can stand a temperature of 400° C while the water cooks inside.

1.3 Factors affecting properties of natural fibre reinforced concrete

Table1

Factors affecting properties of natural fibre reinforced concrete. ***Ref. Sethunarayanan et al. (2007).***

Factors	Variables
Fibre type	Coconut, sisal, sugarcane, biogases, bamboo, jute, wood and vegetables, canes, skin from trunk.
fibre geometry	Length, diameter, cross section, rings, and hooked ends.
fibre form	Mono-filament, strands, crimped, and single-knotted.
fibre surface	Smoothness, presence of coatings.
Matrix properties	Cement type, aggregate type and grading, additive type.
Mix design	Water content, workability aids, defaming agents, fibre content.
Mixing method	Type of mixer, sequence of adding constituents, method of adding fibres, duration and speed of mixing.
Placing method	Conventional vibration, vacuum dewatering, sprayed-up concrete member, extrusion, and guniting.
Casting technique	Casting pressure.
Curing method	Conventional, special method.

2. BASIC REQUIREMENTS

i. The pavement concrete should be a class M40 concrete and above with a minimum 28 days compressive strength of 40 N/mm^2, whatever the grade is.
ii. The slump value should be in the range of 25+/-10mm while using fibres (IRC: SP: 46).
iii. Ordinary Portland cement OPC of grade 43 and 53 can be used as per IS-8112 and IS-12269.
iv. Portland pozzolana cement PPC shall not exceed 20% conforming to IS-3812 Part I.

2.1 Tests on fresh concrete

i. Workability test (slump cone) as per IS: 1199-1959.

2.2 Tests on hardened concrete

i. Compressive strength test.
ii. Modulus of elasticity.
iii. Flexural strength test.
iv. Flexural toughness test.
v. Young's modulus E.

3. EFFECT OF FIBRES ON THE MECHANICAL PROPERTIES OF CONCRETE

As we know that the fibres help to transfer loads at internal micro cracks and we call that fibre reinforced concrete. Using fibres in concrete leads to early accomplishment of compressive, tensile and flexural strengths of concrete which had been practically investigated by **Vignesh *et al.* (2016).** However the research conducted by **Sudin *et al.(2004)*** using fibres in concrete workability decreases to a greater amount which demands a use of chemical admixtures and since bamboo with high amount of sugar (4.92%) having retarding effects on setting and strength developments can only be counteracted by the addition of chemical admixtures**.**

4. REPLACING COARSE AGGREGATES BY BAMBOO PIECES

In a study conducted by **Pandey *et al.* (2016) i**t is seen that while replacing coarse aggregates in concrete by bamboo pieces flexural strength gets decreased by almost about 50% and keeps decreasing with slow rate. This shows that the concrete where coarse aggregates have been replaced by bamboo pieces are weak in taking bending moment which recommends it not to be used in upper floors. However on increasing the percentage of bamboo earlier accomplishment of compressive strength was seen**.**

5. EFFECT OF RECYCLED CONCRETE AGGREGATES

Since the concrete that is used in pavements demands higher strength because of the high volume of traffic, the aggregates play an important role in the strength development. Using recycled concrete aggregates RCA in concrete reduces the 91 days compressive strength by 7% and 12% and 56 days modulus of elasticity by 22% and 14%. Also the 56 days split tensile strength and flexural strength of the RCA mixtures remains similar to that of reference concrete. With the help of experimental work conducted by **Sadati *et al.* (2016)** it is seen that using recycled concrete aggregates in concrete decreases mechanical properties of concrete, so their use should be avoided in pavements**.**

6. USING FIBRES OF DIFFERENT ASPECT RATIOS

The investigation on the fibres of different aspect ratios plays an important role in checking the mechanical properties of concrete. According to the study conducted by **Sane *et al.* (2016),** it is seen that in most of the cases higher the aspect ratio higher is the strength.

Table2 Factors affecting properties of natural fibre reinforced concrete.
Ref. Sethunarayanan et al. (2007)

Different Aspect Ratio of fibres	For SFRC with 0.5% fibres		For SFRC with 1.0% fibres		For SFRC with 1.5% fibres		For SFRC with 2.0% fibres	
	Compressive Strength (Mpa)							
		Avg.		Avg.		Avg.		Avg.
46.667	40.55 35.32 45.78	40.55	45.34 38.80 40.98	41.71	41.42 45.78 39.24	42.15	37.06 39.24 30.52	35.61
40.909	43.60 37.93 48.40	43.31	39.24 41.86 43.60	41.57	38.80 37.06 32.70	36.19	34.01 32.70 38.37	35.03

7. SUGAR CONTENT ANALYSIS

On the basis of experimental studies it has been seen that the freshly felled bamboos contains the major content of sugars with fructose, glucose and smaller amounts of sucrose. The average sugar content is about 4.92% of dry weight of wood as per the study conducted by **Sudin *et al.* (2004).**

8. MATERIALS

The materials to be used in pavement quality concrete as per IRC and IS codes are listed below

8.1 Portland cement* as per *IRC: 44-2008

i. Ordinary Portland cement OPC of grade 43 and 53 can be used as per IS-8112 and IS-12269.
ii. Portland pozzalona cement PPC shall not exceed 20% conforming to IS-3812 Part I.

8.2 Aggregates

8.2.1 Properties of coarse aggregates (IS: 2386 PART IV)

i. Specific gravity = 2.73
ii. Crushing value < 45% for non wearing surfaces and < 30% for wearing surfaces.
iii. Abrasion value shall not exceed 30%.
iv. Impact value shall not exceed 30%.

8.2.2 Properties of fine aggregates (IS: 12269-1987)

i. Specific gravity = 2.61.
ii. Water absorption < 1.5%.
iii. Fine modulus should be 2.2 – 2.6 (zone II).

9. CONCLUSION

i. With the help of research papers the test results are showing that on increasing the percentage of bamboo fibre earlier accomplishment of compressive strength are seen, but after 50 days of curing there is not much increase in the strength.
ii. Using bamboo pieces as coarse aggregates decreases the flexural strength by about 50% which shows concrete where coarse aggregates are replaced by bamboo pieces are weak in taking bending. So the use in upper floors should be avoided.
iii. With the help of experimental work, it is seen that using recycled concrete aggregates in concrete decreases mechanical properties of concrete. So they should be avoided in pavements.
iv. Using fibres in concrete decreases workability, so the use of chemical admixture is recommended.
v. To prevent the decaying of fibre use of mineral admixture is necessary.
vi. Higher the aspect ratio of fibre higher is the strength for most of the cases.

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