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EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF FIBER REINFORCED CONCRETE

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Abstract:

Fibre reinforced concrete is getting highly popular in the field of construction technology. Plain concrete is known to have low tensile strength and little resistance to cracking. Bamboo fibres are used in concrete as a natural fibre to produce Bamboo Fibre Reinforced Concrete. Bamboo fibres and waste foundry sand is being used as a partial replacement for river sand. In our project we have used 0.5% and 1% of bamboo fibre as a partial reinforcement and 25% and 50% of foundry sand is being used as a partial replacement for river sand respectively (fine aggregate). The mechanical properties such as compression, flexure and tension are then derived for 7, 14 and 28 days of curing. The test results are tabulated and the strengths are compared with that of conventional concrete prepared under the same conditions.

Key Words: Fibre Reinforced Concrete, Plain Concrete, Bamboo Fibre, Foundry Sand & Mechanical Properties.

1. Introduction:

The recent energy crisis provoked by indiscriminate industrial growth has caused increasing concerns about managing the energy resources still available and about environmental degradation. There is an intense on-going search for non-polluting materials and manufacturing processes, which require less energy. Attention of researchers and industries has turned to materials such as organic fibres including bamboo, soil, wastes from industry, mining and agriculture for engineering applications. In a global effort to find a substitute for the health hazardous asbestos cement new cements using all types of wastes are being developed and used for the production of composites, reinforced with fibres. On the other hand, the goals of reutilizing industrial by products such as waste foundry sand (WFS) include reducing the use of natural resources and reducing the negative environmental and ecological impacts of industrial waste. Moreover, the reutilization of industrial waste can achieve the objective of sourcing green construction materials to reduce energy consumption and waste generation. The main chemical components of these WFSs are silicon dioxide, aluminum oxide, and ferric oxide. These components are can improve the compactness and strength of the concrete. When WFS is reused as a construction material, it is typically employed as a raw material in cement or an aggregate in concrete.

2. Related Work:

Bindhu M. et. Al., (2016) did a review on bamboo fiber reinforced concrete. Bamboo has high strength to weight ratio, due to the longitudinal alignment of fibers and have better modulus of elasticity when compared to other natural fibers. Bamboo fiber used in Fiber Reinforced Concrete showed increased strength. It is also a comparatively cost effective method. Harish Sakaray et. al., (2012) did an investigation on properties of bamboo as reinforcing material in concrete. The test results showed that the compressive strength of bamboo is nearly same as the tensile strength of bamboo and this behavior is similar to steel. From the test conditions, bamboo can potentially be used as substitute for steel reinforcement and due to its eco-friendly nature it can be utilized in green building concept. Huan-Lin Luo et. Al., (2014) did an experimental study on the replacement of waste foundry sand for clay in tile manufacture. From the experimentation the bending strengths were found to increase up to 15%. Liu Yu et. al., (2011) did a study on the mechanical properties of the bamboo fiber reinforced cement composite materials.. It is concluded that making bamboo fiber reinforced cement composite is viable and the rupture strength of cement composite would be improved by adding bamboo fibers and the pretreatment of bamboo fibers would enhance the mechanical properties of the cement composite. Mahzuz et. al., (2011) did a performance evaluation of bamboo with mortar and concrete. The uses of bamboo as an alternative for construction products are increasing rapidly.. The most important advantage of bamboo housing technology is its low cost that does not sacrifice quality, durability or space. Hence bamboo can be effectively used for low cost housing. Masakazu Terai et. al., (2012) did a basic study on mechanical properties of bamboo fiber reinforced concrete. The Bamboo fiber reinforced concrete showed significant increase in strength from 28 to 56 days. Also increased volume of fibers showed increase in tensile strength. In the case of flexural strength, the composite with 2% fiber showed a 200% increase in flexural toughness over the conventional concrete. Shakeel Ahmad et. Al., (2014) did a study on the mechanical properties of bamboo fiber reinforced concrete. This study shows that, when compared with an un-reinforced concrete beam those reinforced with bamboo showed an increase in ultimate load of 400%. It is concluded that Bamboo fiber reinforced concrete is a potential low cost alternative for light construction. Smit M. Kacha et. Al., (2014) did a review on the use of waste foundry sand in concrete. From the review it was concluded that concrete with foundry sand percentage up to 30-40% replacement of fine aggregate showed 20% increase in compression and tension tests. Yogesh Aggarwal et. Al., (2014) did a study on properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates. The concrete thus formed showed comparable properties and greater resistance to aggressive agents.

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3. Methodology:

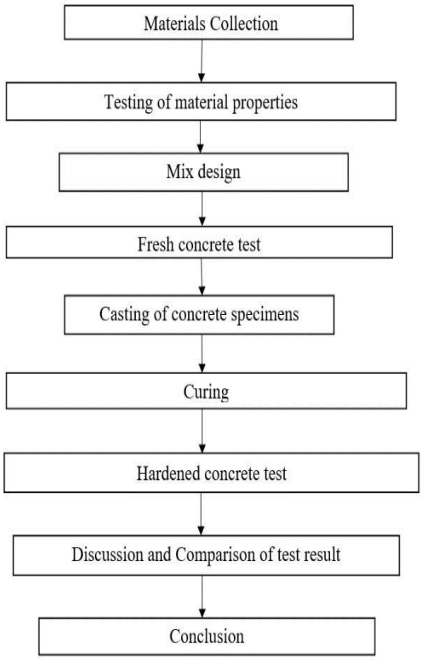

Figure 1: Flow chart of Methodology

4. Materials Used:

- ✓ Cement
- ✓ Fine aggregate
- ✓ Coarse aggregate
- ✓ Bamboo fiber
- ✓ Foundry sand and
- ✓ Water.

Cement: Cement is a binding material in concrete, which binds another material to form a compact mass. The PPC Grade -43 (used in this project) is known for its rich quality and high durability.

Fine Aggregate: Fine aggregate is free from salt, silt, clay and organic impurities. The most suitable fine to coarse ratio to be used for any particular mix. The Aggregate size lies from 150 micron to 4.75 mm.

Coarse Aggregate: For reinforced concrete only crushed rock aggregate of size 12.5 mm are generally considered as satisfactory. The grading of coarse aggregate is very important for getting good quality concrete. It further increase in economy, high strength, lower shrinkage and greater durability.

Bamboo Fiber: Bamboo fiber is a cellulose fiber extracted from natural bamboo. Bamboo had been used in construction even from early times. It can be used in Technical and Non-Technical ways. Because of its high strength to weight ratio, traditionally it has been used in varied living facility and tools.

Foundry Sand: Foundry sand consists of primarily of clean, uniform sized, high-quality silica sand or lake sand that is bonded to from molds for ferrous and nonferrous metal casting. Although these sands are clean prior to use, after casting they may contain ferrous industries account for approximately 95% of foundry sand used for casting. The automotive industry and its parts suppliers are the major generator of foundry sand.

Water: Water is an important ingredient of concrete. As general guidance, if the water is fit for drinking and it is fit for making concrete. Water containing a small sum of salt is not suitable for concrete. pH is between 6 and 8 the water is accepted to be suitable.

5. Experimental Investigation:

Specimen Details: The standard size of concrete cube is 150mm X 150mm X 150mm and concrete beam of size 500mm X 150mm X 150mm and cylinder specimen of 150mm diameter and 300mm height were cast to determine the compressive strength and flexural strength and split tensile test of the concrete at 7days, 14 days and 28 days.

6. Test On Concrete:

- ✓ Compressive strength test.
- ✓ Splitting tensile strength test.
- ✓ Flexural strength test.

Compressive Strength Test: Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock. Record the maximum load applied to the specimen. Also note the type of failure and appearance cracks.

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Splitting Tensile Strength Test: The load is applied to the specimen without shock and increases it continuously at a rate to produce a split tensile stress. Record the maximum load applied to the specimen. Note the appearance of concrete and any unusually feature in the type of failure.

Flexural Strength Test: The specimen is placed in the machine in such manner that load is applied to the upper most surface as cast in the mould. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers. The load is applied without shock and increasing continuously at a rate of the specimen. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded.

7. Results:

Compression Strength Test: The compressive strength of concrete is the most common performance measure used by the engineer in designing buildings and other structures. The compressive strength is measured by breaking concrete specimens in a compression-testing machine.

Table 1: Compressive Strength for 7 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	22.5 x 10³	Conventional Concrete	16.89
2		25% of foundry sand and 0.5% of bamboo fiber	20
3		50% of foundry sand and 1% of bamboo fiber	27.3

Table 2: Compressive Strength for 14 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	22.5 x 10³	Conventional Concrete	21.09
2		25% of foundry sand and 0.5% of bamboo fiber	28.2
3		50% of foundry sand and 1% of bamboo fiber	36.2

Table 3: Compressive Strength for 28 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	22.5 x 10^3	Conventional Concrete	32.89
2		25% of foundry sand and 0.5% of bamboo fiber	33.75
3		50% of foundry sand and 1% of bamboo fiber	41.1

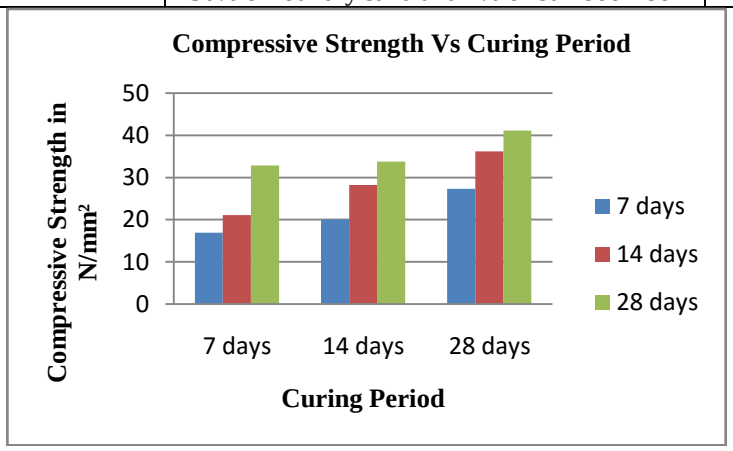

Figure 2: Compressive Strength Vs Curing Period

Splitting Tensile Strength Test: The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

Table 4: Splitting Tensile Strength for 7 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	70.68 x 10³	Conventional Concrete	1.27
2		25% of foundry sand and 0.5% of bamboo fiber	2.12
3		50% of foundry sand and 1% of bamboo fiber	3.8

Table 5: Splitting Tensile Strength for 14 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	70.68 x 10³	Conventional Concrete	2.14
2		25% of foundry sand and 0.5% of bamboo fiber	2.6
3		50% of foundry sand and 1% of bamboo fiber	4.2

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Table 6: Splitting Tensile Strength for 28 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	70.68 x 10³	Conventional Concrete	2.68
2		25% of foundry sand and 0.5% of bamboo fiber	3.1
3		50% of foundry sand and 1% of bamboo fiber	4.80

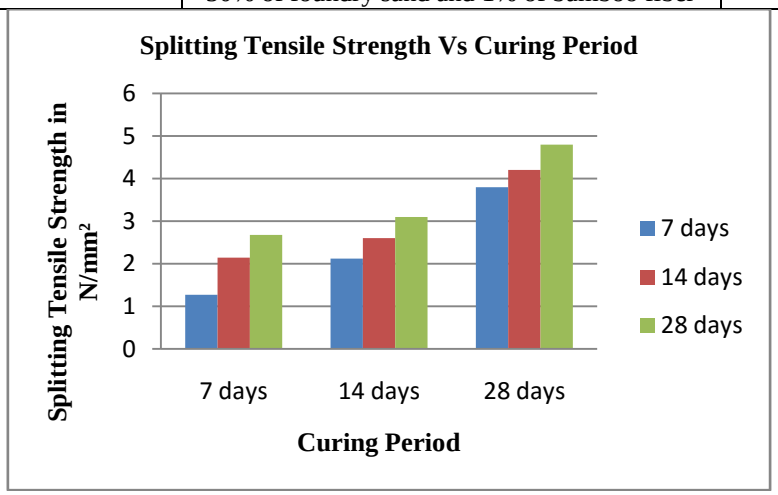

Figure 3: Splitting Tensile Strength Vs Curing Period

Flexural Strength Test: Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending.

Table 7: Flexural Strength for 7 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	10.5 x 10³	Conventional Concrete	3.03
2		25% of foundry sand and 0.5% of bamboo fiber	4.3
3		50% of foundry sand and 1% of bamboo fiber	5.9

Table 8: Flexural Strength for 14 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	10.5 x 10³	Conventional Concrete	4.1
2		25% of foundry sand and 0.5% of bamboo fiber	5.7
3		50% of foundry sand and 1% of bamboo fiber	6.35

Table 9: Flexural Strength for 28 days

S.No	Area of the Specimen (mm²)	Combination	Average Flexural Strength in N/mm²
1	10.5 x 10³	Conventional Concrete	4.6
2		25% of foundry sand and 0.5% of bamboo fiber	6.81
3		50% of foundry sand and 1% of bamboo fiber	7.25

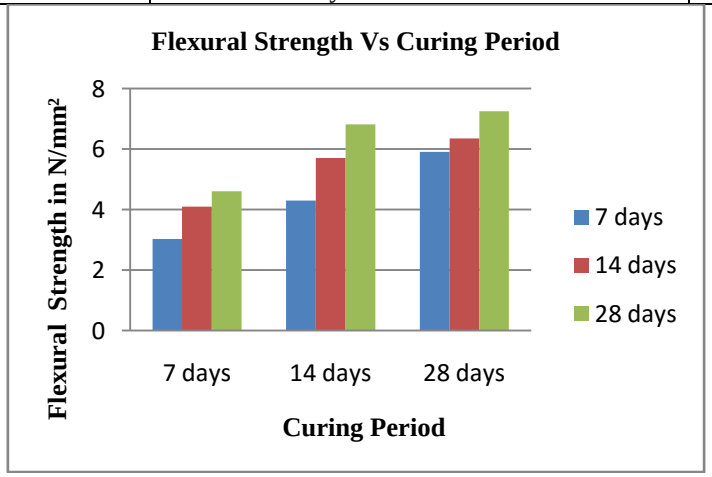

Figure 4: Flexural Strength Vs Curing Period

8. Conclusion:

In this study, fibre reinforced concrete was developed to determine its mechanical properties. The following are the conclusions obtained from the experimental results:

- ✓ The compressive strength of the bamboo fibre reinforced concrete C1 is 15.55%, 25.21% and 2.54% more than that of conventional concrete at the end of 7days, 14days and 28days curing period respectively. Similarly Bamboo Reinforced Concrete C2 is 38.13%, 41.74% and 19.9% more than that of conventional concrete at the end of 7days, 14days and 28days curing period.
- ✓ The split tensile strength of the bamboo fibre reinforced concrete C1 is 40.09%, 17.69% and 13.54% more than that of conventional concrete at the end of 7days, 14days and 28days curing period respectively. Similarly Bamboo Reinforced Concrete C2 is 66.57%, 49.07% and 44.16% more than that of conventional concrete at the end of 7days, 14days and 28days curing period.
- ✓ The flexural strength of the bamboo fibre reinforced concrete concrete C1 is 29.53%, 28.07% and 32.45% more than that of conventional concrete at the end of 7days, 14days and 28days curing period respectively. Similarly Bamboo Reinforced Concrete C2 is 48.64%, 35.43% and 36.55% more than that of conventional concrete at the end of 7days, 14days and 28days curing period.

The compression, tensile and spilt tension strength of the fiber reinforced concrete is studied. By this study the behavior of bamboo fibre and foundry sand in concrete is noted and we compare the result with conventional concrete, So that we obtain the best combination of bamboo fibre and foundry sand is 0.5% of bamboo fibre and 25% of foundry sand. This combination gives us best compression, tensile and spilt tension strength then compare to conventional concrete.

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