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Use of Bamboo & Copper Slag for Replacement of Steel & Fine Aggregate

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***Abstract*—Recently considering the issue of global warming, lack of resources & other eco-friendly issues the use of natural materials has become active in the construction industry. Now a days Bamboo has been in wide usage as a vital material for construction due to its low cost, high strength, flexibility, light weight, etc. As well as concrete is widely used construction material and has ability to consume industrial wastes in high volume. As demand for concrete is increasing one of the effective ways to reduce the undesirable environmental impact of concrete is by use of waste and by-product material as replacement for aggregate in concrete.**

The main objective of this study is to encourage the use of waste product i.e. copper slag and also serves as a major of rescue for the massive pollution produced by the steel production. The utilization of bamboo reinforcement & copper slag as replacement of steel reinforcement & river sand is gaining immense importance today mainly an account of improvement in economical aspect combined with ecological benefits. In this study bamboo strips are used as reinforcement in a concrete that is made with supplementary cementitious material & partial replacement of copper slag with fine aggregates. The bamboo reinforced concrete beams are casted with different stirrup material along with copper slag as a replacement to 50% of fine aggregate for M25 Grade of concrete.

In this study there are various tests such as Tensile test, Double shear and Flexural tests are conducted on bamboo reinforced beams along with the compression test on concrete blocks of 150mm x 150mm x 150mm with the various proportions of replacement of copper slag as a fine aggregate. By test results and analysis it is found that Bamboo can be used as an alternative for reinforcement as well as Copper slag can be used as an alternative fine aggregate

Keywords— Bamboo, Copper slag, Tensile test, Double shear test, Flexural test

I. INTRODUCTION

The construction industry is an integral part of the human civilization. The glory of construction is mainly determined by the financial factors. The cost of project is mainly depend on two factors called as labour cost and material cost[2].In future the cost of steel reinforcement will be increasing and also its production will be shorten[5].Now a days there are many projects are working based on 'low cost building'. The main motive behind the low cost building project is any one from middle class people can construct the building[2].By efficient supervision the workforce can be manipulated but alternatives should be introduced in order to tackle the market price of the conventional materials[2]. By various researches, alternatives have been found to be used in concrete for that the waste material which is generated in high amount from treatment plant, production industries, mining etc. can be used can be used[4].But there is no any proper alternative for the steel reinforcement. We know that concrete is weak in tension and strong in compression. For strengthen the concrete reinforcement is provided [2]. But recently considering the issue of global warming the main disadvantage in steel is that its production is one of the most polluting and hazardous and also steel is not economical [8]. To tackle this use of sustainable material must be provided. For that we suggest the eco-friendly Bamboo for replacement of steel reinforcement [2]. Bamboo is renewable resource which has similar characteristics by high strength to weight ratio and its growth is faster [6].Bamboo is perennial grass which is easily available in various shapes according to required dimensions [8].The various forest of bamboo has been found across tropic and sub-tropic zones between latitude of 40degree south where temperature range is from 20 to 30 degree Celsius [6].Different species of bamboo are grow as tall as 35inches within one day. Bamboo shows some similar properties like steel which is used in construction[7].Bamboo has also an several advantage of high yielding[9].As per research the tensile strength specific weight ratio of bamboo is 20times more than that of steel[10].

Similarly now a days there is lack of River sand and also lots of restrictions on river sand mining and its transportation. For that it is necessary to find the alternative for river sand. It is beneficial to find the by-product so that its cost is less and also it can be usable. For that the best option is Copper Slag [3].Copper slag is an industrial product obtained during matte smelting and refining of copper [1,4]. By using copper slag in concrete we can the environmental pollution as well as we reduce the cost of concrete [3]. Copper slag can possesses the physical, chemical and mechanical properties that can be used in concrete as a partial replacement for fine aggregate [1].

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II. MATERIAL AND METHODS

Materials were collected for both Steel Reinforced and Bamboo Reinforced concrete. Materials needed for Reinforcement cement concrete are cement, fine aggregate, coarse aggregate, steel rod, bamboo, copper slag and water.

Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The cement used in this experimental work is "Birla Super Cement."(OPC53).

Table I. Properties of Cement

Sr. No.	PROPERTY	IS CODE 8112
1	Specific Gravity	3.12
2	Consistency	53
3	Initial Setting time	30 minutes
4	Final Setting time	10 hours

Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e. a soil containing more than 85% sand-sized particles (by mass).

Copper Slag

Copper slag is an industrial by-product material produced from the process of manufacturing copper having similar physical, mechanical &chemical properties of Sand can be considered as an alternative to the river sand.

Coarse Aggregate

Aggregates are the most mined materials in the world. Aggregates are component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

Table II. Properties of FA,CA,CS

Sr. No.	Properties	FA	CA	CS
1	Specific Gravity	2.64	2.70	3.68
2	Fineness Modulus	3.24	7.40	3.47

Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

Steel

Steel is a vital component as it provides the required tensile strength to the reinforced concrete. It is preferred to any other tensile material because its physical properties are matched with those of concrete. Fe500 is used conforming to IS 456 – 2000.

Bamboo

Bamboo being an eco-friendly material comes with a surprisingly good tensile capacity. It grows from 30cm to 1m per day in a standard 250 C to 500 C. It is easily available in large quantities in countries like India. After the seasoning process bamboo can be used as a replacement to steel reinforcement.

III. SPECIMEN PREPARATION

The cubes were designed having dimensions 150mm X 150mm X 150mm. The M25 grade concrete was prepared with copper slag as a replacement of fine aggregate in various proportions i.e. 20,30,40,50,60& 70% by hand mixing then casted cubes are then unmolded and was cured for 7days and 28days.

The beams were designed having dimensions 750mm in length,150mm in breadth,150mm in depth and cover of 20mm.The reinforcement was provided according to the provisions adopted in Is SP34:Handbook on Concrete Reinforcement and Detailing. Bars of 12mm,10mm and stirrups of 8mm at a spacing of 150mm are used in each 2 beam. The larger diameter 12mm bars are placed in the bottom row to resist the deflection effects.

The M25 grade concrete was prepared with 50% replacement of copper slag by hand mixing and with the help of the trowel, the beam is casted. Casted beam is then unmolded and was cured for 7days and 28days.

Fig. 1. Beam specimen Used for casting

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Fig. 2. Cube & Beam after Casting

TESTING OF MATERIAL

Slump cone test-

It is used to measure the uniformity as well as consistency of fresh concrete. There are various mix proportions due to different replacement content of copper slag in concrete.

Compressive Strength test-

A compression test on standard size cubes of conventional concrete with partial replacement of copper slag mix of M25 grade of concrete with 20% -70% is done after 7days and 28 days curing.

Seasoning of Timber-

It is the process of drying timber to remove the bound moisture contained in wood. This is done by keeping wood samples in sunlight. With the help of this we can remove moisture from Bamboo samples which is used as reinforcement in beam.

TESTING OF SPECIMEN

Due to replacement of various proportions of copper slag as a fine aggregate we have comparative of all percentage replacement of copper slag by Compressive strength of each sample. Also we replace the bamboo as a steel reinforcement we have to compare those both two materials with the help of Tensile strength, Double shear and Flexural strength.

Compressive Strength Test

A compression test is performed on standard cubes of concrete with copper slag as partial replacement of fine aggregate as 20% to 70% with 10% intervals of size 150mm x 150mm x 150mm after 7 days immersion in water for curing and 28 day cubes are in possess of curing.

Tensile Test

The tensile test of Bamboo is carried out to find the limit of Proportionality, Young's modulus of elasticity and elongation in the steel rod as the test is used for the bamboo for reinforcement.

Double Shear Test

The double shear test is performed on bamboo to find the shear strength in bamboo in the jointed area to resist the failure (12mm).

Flexural Strength Test

All the beams are tested into Flexural Strength by the Universal testing machine. The beams where supported by Simply Supported over a span of 700mm the load were applied by 1/5th of its span. The load is applied continued until the deflection became excessive and readings were noted at first crack point and the ultimate load. While testing it was noted that Bamboo reinforced beams produced initial cracks without any cracking noise and their crack widths were small when compared to the steel reinforced beams.

RESULTS AND ANALYSIS

Compressive Strength Test

With M25 grade of concrete the replacement of 30% and 50% gives high performance concrete

Table III. Compressive Strength Results

Sr. No.	% Replacement of Copper slag	Compressive Strength Mpa After 28 days
1	20%	32.58
2	30%	39.59
3	40%	36.90
4	50%	41.25
5	60%	32.88
6	70%	30.85

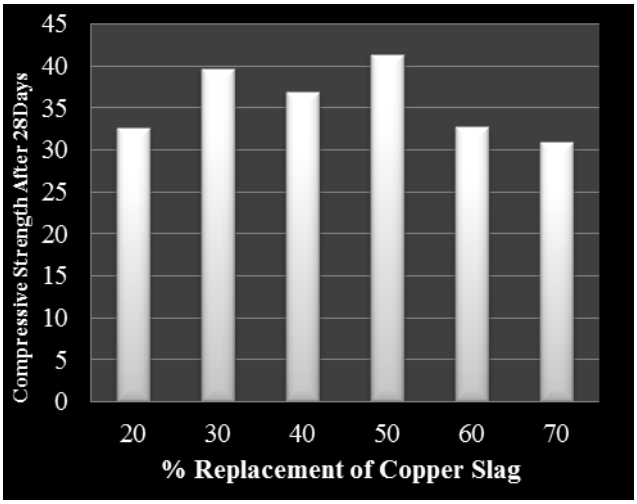

Fig. 3. Compressive Strength Vs. %Replacement

Tensile Test

Table IV. Tensile Strength of Specimen

Specimen Type	Breaking Load in KN	Tensile Stress in N/mm^2
Steel Reinforcement	55.4	505
Bamboo Reinforcement	34.7	290

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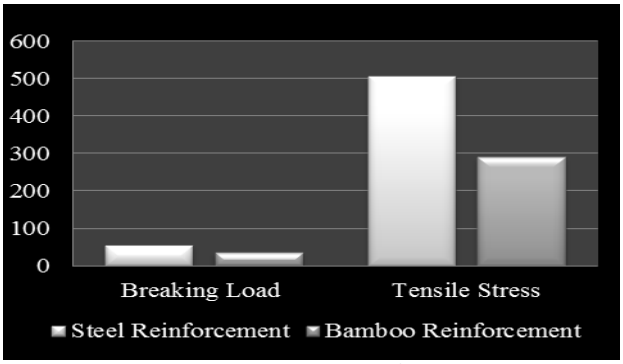

Fig. 4. Tensile Strength of Specimen

Double Shear Test

Table V. Shear Strength of Specimen

Sr. No.	Specimen Type	Breaking Load in KN
1	Steel Reinforcement	86
2	Bamboo Reinforcement	25.50

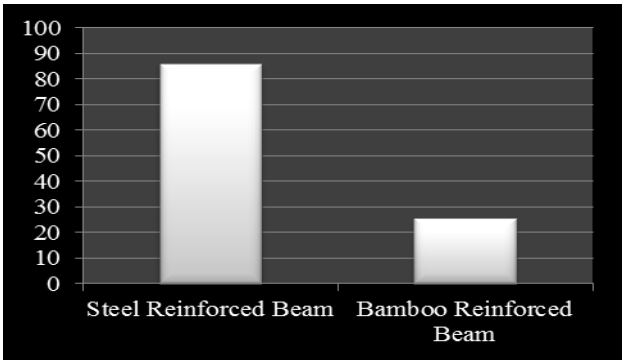

Fig. 5. Shear Strength of Specimen

Flexural Strength

Table VI. Flexural Strength after 7days

Specimen Type	Identifi-cation Mark	Breaking Load in KN	Average in KN
Steel Reinforcement	SR1.A SR2.A SR3.A	70 68 72	70
Bamboo Reinforcement	BR1.A BR2.A BR3.A	57 58 59	58

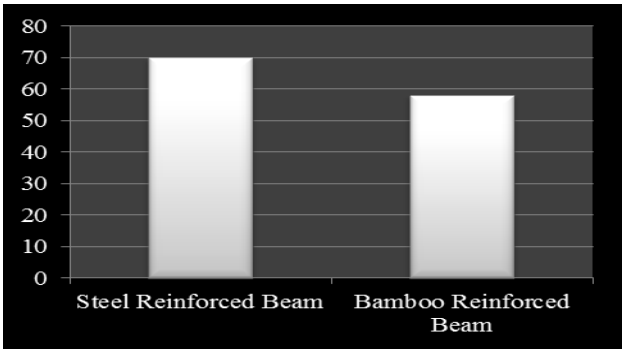

Fig. 6. Comparison of Flexural Strength after 7days

Flexural Strength

Table VII. Flexural Strength after 28days

Specimen Type	Identifi-cation Mark	Breaking Load in KN	Average in KN
Steel Reinforcement	SR1.B SR2.B SR3.B	106 108 110	108
Bamboo Reinforcement	BR1.B BR2.B BR3.B	89 87 88	88

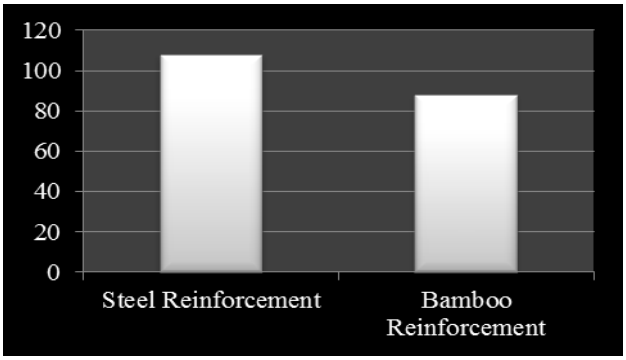

Fig. 7. Comparison of Flexural Strength after 28days

CONCLUSION

1. The mix design of M25 grade of concrete gives HPC concrete when replacement of copper slag is 50%.
2. In this case we observed that Copper slag behaves like river sand.
3. When we use bamboo as a replacement of steel, bamboo gain almost same flexural strength compared to steel reinforced concrete.
4. This can be used in the members where load intensity is less such as Roof slab of parking area, Public toilets, Sunshades, Watchman cabin, etc.

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