Green Construction Materials Partially Replacement of Steel With Bamboo and Aggregates with Coconut Shell and Glass Fibers

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ABSTRACT:

The cost, double shear, flexural strength, and tensile strength of bamboo underpinning and widely used brand underpinning are compared in this work. Lately The main issue we want to focus on is global warming. Although brand underpinning is typically employed in building, we are aware that the brand's products pose a serious threat to the environment. The middle class is not qualified to utilize brand underpinning due to the extremely high cost of the brand. The cost of design is the primary determinant of construction sedulity. The primary determinants of design cost are similar to labor and material costs. As a solid waste, coconut shell is one of the primary causes of pollution since it is burned for fire, which contaminates the air. The use of coconut shell as coarse aggregate in concrete promoted environmentally friendly and sustainable building materials. In order to maximize their usable portions and decrease their sins, composites are created by mixing two or more natural or manufactured items. The materials used in construction, including as sand, asphalt, and complexion, will become increasingly unavailable. First of all, it is a naturally occurring, non-renewable substance that will be valuable. While building is increasing, the natural abundance is declining. Therefore, we can employ bamboo as an underpinning instead of the equivalent material to lower the design expense. Because of its low cost, great strength, seismic resistance, light weight, etc., bamboo is a useful building material. By substituting this, we may accomplish our primary goal of efficient building and promote the use of natural goods, which lessens the negative effects of pollution on the environment. We can employ bamboo as underpinning in various structural rudiments where weight intensity is less comparable, such as roof domes for security cabins, restrooms, bus parking, etc., and accomplish our ideal by carrying out the various experiments and analyzing the results. As a solid waste, coconut shell is one of the primary causes of pollution since it is burned for fire, which contaminates the air. The use of coconut shell as coarse aggregate in concrete promoted environmentally friendly and sustainable building materials. In order to maximize their usable portions and decrease their sins, composites are created by mixing two or more natural or manufactured items. The materials used in construction, including as sand, asphalt, and complexion, will become increasingly unavailable. First of all, it is a naturally occurring, non-renewable substance that will be valuable. While building is increasing, the natural abundance is declining.

Keywords: Bamboo Reinforced concrete; Bamboo Corrosion; Flexural Strength; Tensile Strength; Light Weight; Cement; Coarse Aggregate; Coconut Shell; Glass Fiber

1.Introduction

Construction diligence is an essential component of mortal civilization. We are aware that financial considerations such as labor and material costs have a significant impact on the cost of any construction design (1, 6). As is well known, concrete is a widely utilized building material with a number of benefits, including fire resistance, low cost, and vacuity. However, its tensile strength is minimal. We provide sword underpinning in order to obtain tensile strength (2). Sword corroborated concrete is utilized for constructions that support cargo (10). The primary drawback of the sword is its product, since global warming is currently the biggest problem (3). In the future, the product will be shortened and the cost of sword underpinning will increase (4). Since anyone from a middle-class household can build the structure, we know that many systems are working on the idea of a "low cost structure" (1). We can use environmentally beneficial bamboo as a basis for that (1). The treated bamboo species will be successfully utilised for colourful structural and non-structural operations in the construction, and it exhibits a very good eventuality for the product of varied element corridor (7). According to research, bamboo is a renewable resource with similar qualities, such as high strength relative to weight. Bamboo grows quickly (8). According to contractors' demands, bamboo is an imperishable grass with vibrant shapes and sizes (3). The world's tropical and subtropical regions, with latitudes of 40 degrees south, are home to the vibrant timber of bamboo species. Temperatures between 20 and 30 degrees Celsius are ideal for the bamboo timber civilisation (8). The many bamboo species grow up to 35 inches in altitude in a single day. Similar pieces, such as sword underpinning used in construction, are displayed by this bamboo (9). One of the primary benefits of bamboo underpinning is its high yielding property (7). Bamboo comes in a variety of mechanical and physical forms depending on the species and soil type (5). Instead of using sword underpinning, bamboo is being repurposed as underpinning by standard bar sizes for improved development. 10. The tensile strength of that brand's foundation ranges from 50 to 75, making bamboo genuinely good under strain

(5). According to the study, the mild brand's modulus of pliantness is about one-third (6). The primary determinant of bamboo's lifespan is its humidity content, which is influenced by the bamboo's height, location, and seasoning duration (5), which we wish to determine. We must employ sustainable materials to address this environmental problem. For It's glass fibre. Fibreglass is the common term for glass-based fiber-corroborated polymers (Fig. 1). This confirmed fibre is currently the most commercially feasible. It is significantly less expensive than carbon fibre. "For further than 40 times, glass fibre corroborated concrete(GFRC) has made a significant donation to the economics, technology, and aesthetics of the construction sector encyclopedically" (1). Compared to material, it is stronger and more flexible. It can withstand electromagnetic radiation and is alsonon-conductive. Additionally, it is inert under a variety of chemical circumstances (2). It may be shaped into intricate forms. Aeroplanes, yachts, the automobile industry, heated tanks, big swimming pools, orthopaedic and casting surfboards, etc. Epoxy resin is used to make fibreglass, FRP, and GRP. Casting, spinning, winding, and other processes are used to create colourful artificial and aeronautical objects made of resin, resin, and glass hair or fibreglass. Fibreglass Also referred to as fibreglass, "GFRC pieces are stripped the following day, usually between 16 and 24 hours after casting." (glass-corroborated part). Because it is composed of ultra-fine glass fibre, it is extremely robust, featherlight, and long-lasting. The raw coffers are substantially less expensive and the products are typically far less brittle, even though the capacity and stiffness rates are marginally lower than those of carbon fibre. "GFRC is a type of concrete that contains fine beach, cement, polymer(constantly acrylic polymer), water, colourful combinations, and alkali-resistant glass filaments" . When compared to material, it has superior bulk capacity and weight characteristics, and moulding may be used to create it fluidly. The most well-known and traditional high-performance fibre is glass. Glass has been used to create fibre since the 1930s. GFRC is widely used and reasonably priced. The main purpose of glass fibre corroborated cementitious mixtures is to create thin distance factors with a paste or mortar matrix and a 5 fibre content ("3). The use of glass fibre in the High Performance Concrete (HPC) class has increased recently due to its exceptionally high mechanical performance, continuity, plasticity, and aesthetics ("2). Glass fibre is a sort of corroborated plastic, and glass fibre is corroborated plastic. This is probably the reason glass fibre is also referred to as fibreglass corroborated plastic or fibreglass corroborated plastic. Typically, fibreglass is woven, randomised, or smoothed into textiles. . "Glass fiber corroborated concrete pastes or mortars are constantly applied in thin wastes that are primarily used for cladding." Depending on their intended use, glass filaments can be made of a variety of glass kinds. Compared to other equipment, fiberglass is strong, lightweight, and less brittle. Fiberglass's ability to be shaped into a variety of complex shapes is what makes it fashionable. The best building material for civil engineering is concrete. Constituents, summations, water, and amalgamations are consumed during the production of concrete. The need for construction equipment has expanded due to construction projects worldwide. The primary building material in civil engineering is summations. It creates the majority of the concrete. The primary components of concrete are amalgamation, water, and summations. Summations make up the majority of all the components. Natural monument deposits are dramatically reduced by the enormous demand for concrete in construction employing standard summations like complexion and determination. This has degraded the landscape and resulted in ecological imbalance. To replace the natural monument, appropriate relief materials must be found. Many natural materials, such as pumice, scoria, and stormy debris, as well as man-made materials, such as clinker, vermiculite, and blast furnace deposit, are utilized in construction plants in developed nations as backups for natural summations. Global structure development has increased demand for construction materials. Summations make up the majority of all the components. The United States produces a total of two billion tons every year. By 2020, the product is expected to reach more than 2.5 billion tons. Additionally, the United Kingdom's primary overall consumption increased from 110 million tonnes in 1960 to around 275 million tonnes by 2006.

2.Methodology

We decide to add 4 nos. of 25 mm range bamboo sticks as main bars. And W/ C portion of 0.50. In this methodology we decide to add the stirrups of 20 mm consistence.

1. First we take the quantum of required water for concreting as per 0.50 W/ C portion also make bamboo underpinning of needed dimension.
2. also add water in 2 to 3 corridor in the concrete blend.
3. also add all water and mix it well.
4. After mixing it and tamp it well till the concrete progeny spread overall in beammold.
5. Prepare all 6 shafts.

Fig: Bamboo Reinforcement

Fig: Oiled Mould

Fig: Casting of BRC

Fig: After Casting of BRC

Material selection & preparation

1.1 Bamboo reinforcement

Bamboo underpinning elect a applicable bamboo species(locally available, mature age, suitable periphery). Studies of show the colorful of species used for underpinning in concrete. Season the bamboo(drying for 3- 4 weeks or more) to reduce the humidity content and loss. Treat the bamboo(anti-termite, waterproofing, chemical preservatives) to ameliorate the continuity, bond with concrete, reduce lump/ loss. To determine the mechanical parcels of the bamboo tensile strength, modulus of pliantness, bond strength with concrete if possible. These are to be demanded to compare with sword underpinning and for blend/ structural design.

1.2 Coarse total relief Crushed coconut shell total(CSA)

Mix design & instance medication Accoutrements were collected for both Steel Reinforced and Bamboo Reinforced concrete. Accoutrements demanded for underpinning cement concrete are fine total, coarse total, sword rod, cement, bamboo and water.

- **Fine Aggregates/Sand**

Beach/Fine total Beach, often referred to as fine total, is a naturally occurring granular substance made up of finely divided mineral and gemstone patches. Its size defines it; it is coarser than ground and finer than clay. Beach can also refer to a soil type or textural class, such as a soil that has more than 85 beach-sized patches (by mass).

- **Coarse Aggregate**

Coarse Aggregate summations are the most booby-trapped accoutrements in the world. summations are element of compound accoutrements similar as concrete and asphalt concrete; the aggregate serves as underpinning to add Page 1 of 2 strength to the overall compound material

Table -1: Properties of FA & CA

Sr.No.	Property	Fine Aggregate	Coarse Aggregate
1	Specific Gravity	2.64	2.70
2	Fineness Modulus	3.24	7.40

- **Steel**

Steel is essential because it gives the reinforced concrete the necessary tensile strength. Fe500 is utilized in accordance with IS 456-2000 and is chosen over all other tensile materials because its physical characteristics are similar to those of concrete.

- **Cement**

Cement is a binder—a compound that binds other materials together by setting and solidifying. "Birla Super Cement" is the cement utilized in this experiment. (OPC53).

Table -2: Properties of Cement

Sr.No.	Property	IS CODE 8112
1	Specific Gravity	3.12
2	Consistency	53
3	Initial Setting Time	30 min
4	Final Setting Time	10 hrs

- **Bamboo**

As an environmentally benign material, bamboo has an unexpectedly high tensile strength. In a typical temperature range of 250 to 500 degrees Celsius, it grows between 30 and 1 meter every day. In nations like India, it is readily available in big amounts. Bamboo can be used in place of steel reinforcement after the seasoning process.

The following are some particular characteristics of bamboo:

- Specific Gravity: 0.575 To 0.655
- Average Weight: 0.625 Kg/m
- Rupture Modulus: 610 To 1600 Kg/Cm2
- Elasticity Modulus: 1.5 To 2.0 X105 Kg/Cm2
- Ultimate Compressive Stress: 794 To 864 Kg/Cm2
- Safe Working Stress In Compression: 105 Kg/Cm2
- Safe Working Stress In Tension: 160 To 350 Kg/Cm2
- Safe Working Stress In Shear: 115 To 180 Kg/Cm2
- Bond Stress: 5.6 kg/cm2

Water

Due to its active participation in the chemical reaction with cement, water is a crucial component of concrete. The amount and quality of water must be carefully considered since it aids in the formation of the cement gel that provides strength.

Typical Range of Water–Cement Ratios

- For high-strength concrete: 0.35 – 0.45
- For medium-strength concrete: 0.45 – 0.55
- For normal construction work: 0.50 – 0.60

2 Casting & curing

A Mix fresh concrete as per design. Record fresh properties: slump test/workability, fresh density. Cast specimens, ensure proper compaction (vibration) especially important when fibres & CSA are present (prevent voids) Cover curing: For example, 28 days of water curing in standard conditions (23 ± 2 °C) or as per local code. Optionally test at 7 days, 14days , 28 days. Mark specimens clearly with mix ID, curing age, and reinforcement type.

Fig: Mixing of Materials

Fig: Casting of BRC

3.TESTING PROCEDURE:

Due to the substitution of bamboo for steel, we have compared the tensile, double shear, and flexural strength tests of those two materials.

a)Compressive Strength Specimens

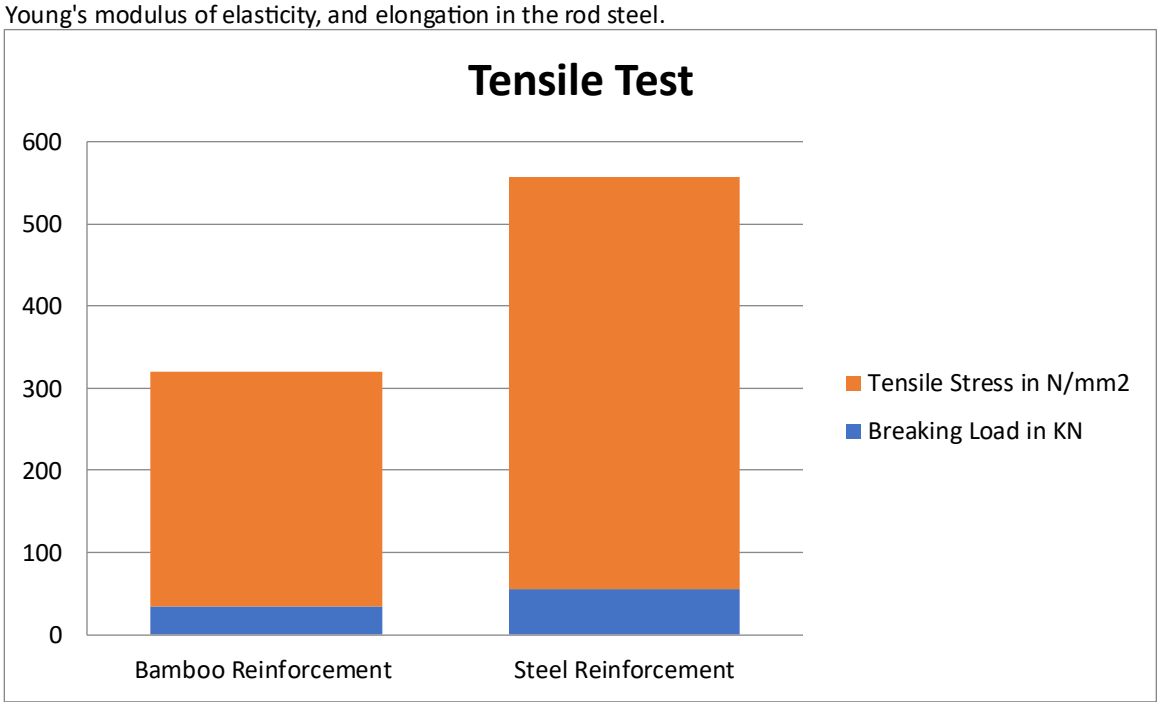
Shape: Cube

Dimensions: 150 mm × 150 mm × 150 mm

Material Composition: Cement, fine aggregate, coarse aggregate (partially replaced with coconut shell and glass fibres), water, and bamboo reinforcement (if required for specific tests)

b)Tensile Test

When bamboo is used for reinforcement, a tensile test is performed to determine the limit of proportionality, yield strength, Young's modulus of elasticity, and elongation in the rod steel.



c) Flexural Strength

The universal testing equipment, which has a 1000KN capability, tests each beam for flexural strength. Simply Supported provided 700mm of support for the beams.

4. Result and data analysis

- **Compressive Strength Test**

Material	% of partially Replacement of aggregate	Compressive Strength (N/MM^2)
Glass fiber	5	10.67
Coconut Shell	5	9.33

Material	% of partially Replacement of aggregate	Compressive Strength (N/MM^2)
Glass fiber	10	9.77
Coconut Shell	10	8

- **Combination of both material (glass fiber & coconut shell)**

Material	10% of partially Replacement of aggregate	Compressive Strength (N/MM^2)
Coconut Shell	40	13.77
Glass fiber	60	13.77

Fig:- Coconut Shell vs Glass Fibre

➢ **Split Tensile Strength Test**

Mix ID	7 Day (MPa)	14 Day (MPa)	28 Day (MPa)
M0	2.25	2.45	3.65
M1	2.86	2.87	3.22
M2	2.29	2.48	3.01
M3	2.16	2.48	2.89

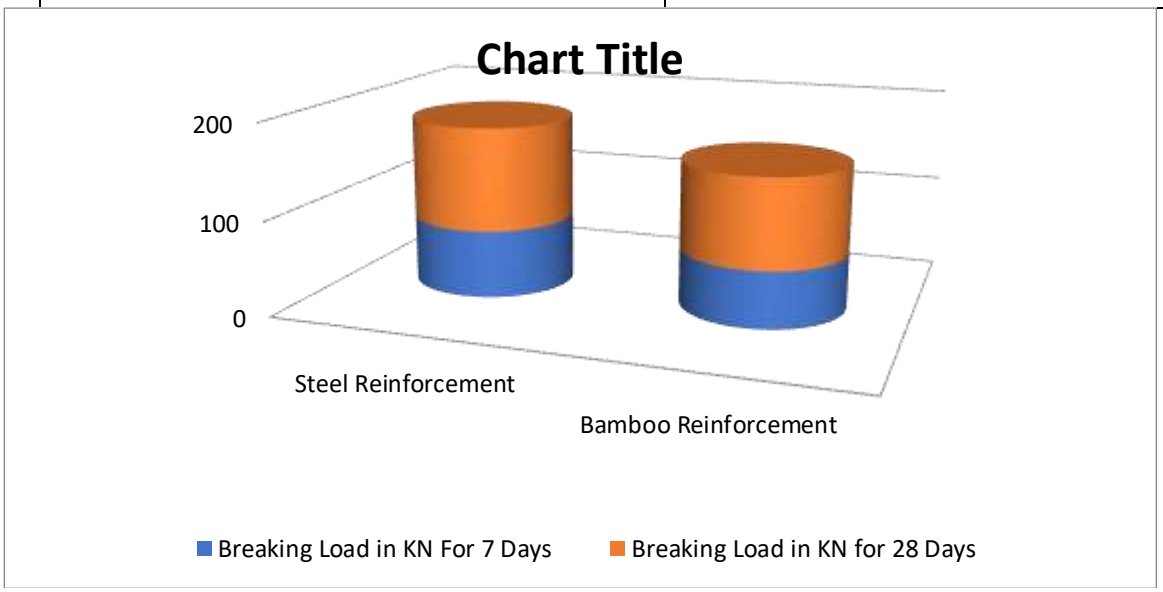
➢ **Flexural Strength**

- **Flexural Strength for 7 day**

Type	Breaking load in (KN)
Steel Reinforcement	72
Bamboo Reinforcement	60

- **Flexural Strength for 28 days**

Type	Breaking load in (KN)
Steel Reinforcement	110
Bamboo Reinforcement	94



5. Conclusions:

The experimental investigation on sustainable construction materials using bamboo, coconut shell, and glass fiber demonstrates that eco-friendly alternatives can partially replace conventional materials without significantly compromising structural performance.

- **Compressive Strength**: Concrete containing up to 20% replacement of coarse aggregates with coconut shell achieved an average 28-day compressive strength of 31 MPa, which is within acceptable limits for M25-grade concrete. Beyond this percentage, the reduction in strength became more pronounced.
- **Flexural and Tensile Strength:** The inclusion of glass fiber (1% by weight of cement) improved tensile and flexural properties by reducing crack propagation and enhancing post-cracking behavior. The hybrid reinforcement of bamboo and steel maintained adequate flexural performance compared to conventional reinforcement.
- **Density and Workability:** Replacement of natural aggregates with coconut shell reduced the concrete's density by approximately 10%, producing a lightweight concrete suitable for low- to medium-load applications. Minor reductions in workability were mitigated with the use of a superplasticizer.
- **Bamboo Reinforcement:** Properly treated bamboo (boric acid–borax solution and bitumen coating) showed satisfactory bond and tensile characteristics. When used to replace up to 50% of steel reinforcement, it provided a cost-effective and renewable reinforcement option for small-scale and low-rise structures.
- **Sustainability Impact:** The combination of bamboo, coconut shell, and glass fiber reduced the consumption of non-renewable materials such as steel and natural aggregates, leading to a lower carbon footprint, cost savings, and promotion of sustainable construction practices.

References

[1] R. Pandi, B.V. "An Experimental Study on Replacement of Steel with Bamboo as Reinforcement" IRJET; Volume: 05 Issue: 04; 2018.

[2] M. M. Rahman, M. H. Rashid "Performance Evaluation of Bamboo Reinforced Concrete Beam" International Journal of Engineering & Technology IJET-IJENS ; Vol: 11 No: 04; 2011.

[3] 1prem Kumar.V, 2vasugi.V "Study On Mechanical Strength Of Bamboo Reinforced Concrete Beams" International Journal Of Advances In Science Engineering And Technology; Volume- 2, Issue-3;2014

[4] Adom-Asamoah Mark1, Afrifa Owusu Russell2 "A comparative study of Bamboo reinforced concrete beams using different stirrup materials for rural construction" International Journal Of Civil And Structural Engineering; Volume 2, No 1; 2011.

[5] Abhijeet Deya, Dr.(Mrs) Nayanmoni Chetiab "Experimental study of bamboo reinforced concrete beams having various functional properties" Science Direct; Proceedings 5 (2018) 436–444; 2016.

[6] I.K. Khan "Performance Of Bamboo Reinforced Concrete Beam" International Journal of Science, Environment ; Vol. 3, No 3, 836 – 840; 2014. **[1]** Damodhara Reddy1, I. V. Ramana Reddy2 & S. Aruna Jyothy3, Associate Professor, Department of Civil Engineering, Sri Venkateswara College of Engineering and Technology, Chittoor, Andhra Pradesh, India, Professor, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India, Assistant Professor, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India. (Jan, 2014)

[7] Maninder Kaur, Manpreet Kaur,(2012), "A review on utilization of coconut shell as coarse aggregate in mass concrete", International Journal of Applied Engineering Research, Vol. 7, No.11, pp 05-08

[8] 3.Damre Shraddha1, Firake Hitali1, Dode Pradeep1, and Shrikant Varpe2,*1Datta Meghe College of Engineering, Department of Civil Engineering, Mumbai University 2 Ambuja Cements Ltd, Mumbai

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