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Sustainable Bio Block & Engineering Bomboo

Miss. Diksa Arjun Dumane, Dr. (Mrs). P.M. Alandkar, Prof. A.B.Khemalapur

PG Student, Department of ME Construction & Management, Rasiklal M. Dhariwal Sinhgad School of Engineering,
Warje, Pune, India

Department of Civil Engineering, Rasiklal M. Dhariwal Sinhgad School of Engineering, Warje, Pune, India

PG Assistant Professor, Department of Civil Engineering, Rasiklal M. Dhariwal Sinhgad School of Engineering, Warje,
Pune, India

ABSTRACT: The creation and assessment of sustainable building materials using engineered bamboo and bio-based blocks is the main goal of this research. The aim of the project is to produce economical, energy-efficient, and environmentally friendly materials to take the place of conventional construction supplies like steel reinforcement and burned clay bricks. The process involves choosing sustainable raw materials, creating bio block mixtures, processing bamboo for reinforcing, and conducting mechanical and durability testing experiments. The results show that bio blocks with treated bamboo reinforcement and natural binders can significantly reduce carbon emissions without sacrificing structural performance. In line with green building principles and the Sustainable Development Goals (SDGs) of the United Nations, this effort advances sustainable construction techniques.

KEYWORDS: Text Bamboo, Universal testing machine (UTM), Additive manufacturing, Bamboo-PLA composites, Mechanical properties, Thermal characterization, Recyclability

I. INTRODUCTION

Bio-based replacements like engineered bamboo and sustainable bio blocks have shown potential as sustainable building materials. By reducing dependency on conventional, carbon-intensive materials like concrete and steel, these materials provide an eco-friendly alternative to modern construction techniques.

Sustainable bio blocks are typically made from agricultural residues, natural fibers, and bio-binders. They are designed to minimize environmental impact through reduced embodied energy, lower carbon emissions, and enhanced recyclability. Their production often utilizes local, renewable resources, promoting circular economy principles and supporting rural livelihoods.

Engineered bamboo, on the other hand, harnesses the fast-growing nature of bamboo to produce strong, versatile, and durable construction components. Through processing and lamination, bamboo can be transformed into beams, panels, and flooring materials that rival or surpass traditional timber in strength and resilience. Moreover, bamboo's rapid growth cycle and high carbon sequestration capacity make it a key material in achieving low-carbon and regenerative design goals. The aim of this project is to design, develop, and evaluate eco-friendly and sustainable construction materials by combining bio-based blocks and engineering bamboo as structural components. The project seeks to create an environmentally responsible alternative to conventional building materials such as fired clay bricks, cement concrete, and steel reinforcement. To manufacture Sustainable bio bricks from natural waste materials and assess their suitability for construction applications.

II. DATA ACQUISITION AND EXPERIMENTAL SETUP

The methodology involves a structured experimental approach combining material selection, sample preparation, testing, and performance evaluation to assess the feasibility of sustainable bio blocks and engineering bamboo for construction purposes. Sustainable bio blocks and engineered bamboo are produced using methodologies that involve mechanical processing, chemical or thermal treatments, adhesive application, and high-pressure compression to create durable, standardized building materials with enhanced properties compared to natural bamboo. These products offer

environmental benefits, such as rapid renewability, high carbon sequestration potential, and a lower carbon footprint than traditional materials like steel and concrete.

Harvesting and Pre-processing

Harvesting: Mature bamboo culms (typically 3–5 years old) are harvested. Selective cutting of mature stems allows the root system to remain intact, ensuring annual regeneration and a sustainable supply.

Sizing and Splitting: Culms are cross-cut into manageable lengths, and then mechanically split into strips or crushed into fiber bundles, depending on the desired end product (laminated bamboo uses strips, while scriber uses fiber bundles).

Knot and Skin Removal: External knots and the waxy outer and inner skins (which are hydrophobic and hinder adhesive penetration) are mechanically removed to ensure a uniform surface for bonding.

Treatment and Drying

Treatment: To enhance durability and resistance to pests (insects and fungi) and moisture, the bamboo is treated.

Natural methods: Traditional techniques include water leaching, smoke treatment, or heat treatment.

Chemical methods: Modern industrial processes often use eco-friendly chemicals like boron-based preservatives or an alkaline solution (e.g., sodium hydroxide) to partially remove lignin and hemicellulose, improving permeability and mechanical strength.

Drying: Treated bamboo elements are dried to a specific moisture content (typically below 10-12%) to prevent warping, cracking, and blistering during the hot-pressing stage.

Adhesive Application and Compression

Adhesive Application: The dried strips or fiber bundles are coated or dipped in structural-grade adhesives, such as phenol formaldehyde (PF) resin (most common due to water resistance) or non-formaldehyde alternatives like polyurethane or soy-based adhesives.

Compression Curing (Hot Pressing): The assembled material is compressed in a hydraulic press under high pressure (around 1.96 MPa for LBL, up to 70-80 MPa for scriber) and temperature (120–150 °C for thermosetting adhesives) to form dense, standardized panels or blocks. This process bonds the material and increases its density and mechanical performance.

Post-processing and Quality Control

Conditioning: The hot-pressed panels are conditioned (e.g., at specific temperature and humidity) for several days to stabilize.

Finishing: The blocks or panels are cut, trimmed, sanded, and machined to meet final product specifications (e.g., beams, columns, flooring panels).

Testing: Products undergo quality tests for mechanical properties (tensile, flexural, compressive, shear strength), dimensional stability, and durability according to relevant stand

Material collection:

Assembly: The adhesive-coated bamboo elements are assembled into layers or mats. For laminated bamboo, strips are oriented in parallel or orthogonal directions, while for scriber, randomly oriented fiber bundles are aligned longitudinally.

The following eco-friendly materials are collected

Black Soil, 2. Wheat bran, 3. Cement, 4. Dry all natural fibers properly, 5. Remove impurities and dust, 6. Cut fibers into small pieces, 7. Sieve the soil to obtain a uniform particle size.

Mix Design

Prepare different bio-brick samples by varying the percentage of fires, 2. Black Soil (60-70%) 3. Wheat bran (5-15%), 4. Cement (10-15%), 5. Coconut Coir (2-8%), 6. Sugarcane bagasse (5-10%), 7. Cow Dung (10-20%), 8. Water (Required quantity for proper mixing)

Raw Materials Used Images:



Wheat Bran



Coconut Coir



Sugarcane Bagasse



Cow Dug



Black Soil



Mix Raw Material

III. RESULTS

Compressive Strength Test (Dry Bio Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	36.2	17.6
B2	57.6	21.2
B3	109.95	36.1
Compressive Strength Test (Weight Bio Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	36.2	17.6
B2	57.6	21.2
B3	109.95	36.1

Compressive Strength Test (Dry Red Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	30.01	5.53
B2	26.11	6.05
B3	20.19	6.32

Compressive Strength Test (Weight Red Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	35.45	8
B2	45.02	8.4
B3	31.09	9.5

Compressive Strength Test (Dry Cemet Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	880	9.47
B2	834	9.74
B3	800	9.21

Compressive Strength Test (Weight Cemet Brick Test)		
Sample No	Load(KN)	DSP(Mpa)
B1	942	10.22
B2	921	10.42
B3	918	10.05

IV. CONCLUSION AND FUTURE WORK

Sustainable construction materials have gained global attention due to the environmental impact of conventional building materials such as cement and fired clay bricks. These traditional materials consume high energy, emit significant CO₂, and deplete natural resources. Bio-based blocks and engineering bamboo are innovative, eco-friendly alternatives that utilize renewable natural materials and agricultural or industrial waste to create strong, durable, and sustainable construction components.

Sustainable Bio Block:

- Made from a mix of soil, lime, fly ash, rice husk ash, or natural fibers (like coir or hemp).
- Often produced through low-energy processes such as sun-drying or mechanical compaction.
- Designed to be biodegradable, recyclable, and carbon-neutral.

Engineering Bamboo:

- Bamboo is a fast-growing grass that reaches maturity in 3–5 years, compared to 20–50 years for timber.
- It has high tensile strength (up to 370 MPa) and compressive strength comparable to concrete.
- Used as reinforcement, structural frames, or composite materials with resins or polymers.

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BIOGRAPHY

Diksha Arjun Dumane

PG Student, ME Construction & Management
RMD School of Engineering Warje, Pune, India

Dr.(Mrs). P.M. Alandkar

HOD Civil Engineering Department
RMD School of Engineering Warje, Pune, India



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