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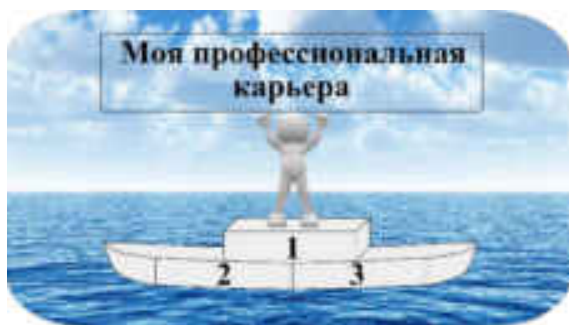


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**Международный научно-образовательный электронный журнал
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Abstract

The growing demand for sustainable construction materials has intensified research into renewable and environmentally friendly resources. Agricultural residues, particularly cotton stalks, represent a significant yet underutilized biomass resource with considerable potential for composite material production. This study investigates innovative methods for converting cotton stalks into green composite materials suitable for structural and non-structural construction applications. Mechanical processing, chemical treatment, and binder optimization techniques are analyzed to enhance material performance. The results demonstrate that cotton stalk-based composites exhibit favorable mechanical strength, low thermal conductivity, and reduced environmental impact compared to conventional materials. The findings highlight the viability of cotton biomass as a sustainable alternative in the construction industry.

1. Introduction

The construction industry is one of the largest consumers of raw materials and a major contributor to environmental degradation. Traditional materials such as concrete, steel, and synthetic polymers are associated with high energy consumption and carbon emissions. Consequently, there is a growing interest in the development of **bio-based composite materials** derived from renewable resources.

Cotton production generates substantial quantities of agricultural waste, particularly cotton stalks, which are often burned or discarded, contributing to

environmental pollution. However, cotton stalks possess a lignocellulosic structure that makes them suitable for reinforcement in composite materials. Their utilization aligns with circular economy principles and promotes resource efficiency.

This study aims to explore innovative methods for processing cotton stalks into high-performance green composites for construction applications.

2. Literature Review

Previous studies have demonstrated the feasibility of using lignocellulosic fibers in composite materials. Natural fibers such as hemp, flax, and jute have been widely investigated due to their biodegradability and low density.

Cotton stalks, composed primarily of cellulose ($\approx 40\text{--}50\%$), hemicellulose, and lignin, exhibit mechanical properties comparable to other natural fibers. Research indicates that chemical treatments such as alkali treatment (NaOH) improve fiber-matrix adhesion, thereby enhancing composite strength.

Recent advancements include:

- bio-based resin systems (e.g., starch, lignin-based binders)
- hybrid composites combining natural and synthetic fibers
- low-temperature processing techniques

However, comprehensive studies focusing specifically on cotton stalk composites for structural applications remain limited.

3. Materials and Methods

3.1 Raw Material Preparation

Cotton stalks were collected, dried, and mechanically processed into particles and fibers. The material was sieved to obtain uniform particle size distribution.

3.2 Chemical Treatment

To improve interfacial bonding, fibers were treated with sodium hydroxide (NaOH) solution:

NaOH treatment $\rightarrow$ removal of lignin and impurities $\rightarrow$ increased surface roughness

This process enhances adhesion between fibers and the matrix.

3.3 Composite Fabrication

Different composite formulations were prepared using:

- bio-based binders (starch, lignin adhesives)
- polymer matrices (epoxy or polyester for comparison)

The mixtures were compressed using a hot press under controlled temperature and pressure conditions.

3.4 Testing Methods

The fabricated composites were evaluated for:

- **Mechanical properties** (compressive strength, flexural strength)
- **Thermal conductivity**
- **Water absorption**
- **Density**

Standard testing procedures (ASTM/ISO) were applied.

4. Results and Discussion

4.1 Mechanical Performance

The treated cotton stalk composites exhibited improved mechanical properties compared to untreated samples. Alkali treatment increased fiber-matrix bonding, resulting in higher strength values.

4.2 Thermal Properties

The composites demonstrated low thermal conductivity, making them suitable for insulation applications in buildings.

4.3 Environmental Impact

Compared to conventional materials:

- reduced carbon footprint
- biodegradability
- utilization of agricultural waste

This confirms their potential as sustainable construction materials.

4.4 Limitations

- moisture sensitivity
 - variability in natural fiber properties
 - need for standardized processing methods
-

5. Conclusion

This study confirms that cotton stalks are a viable raw material for producing green composite materials. The integration of chemical treatment and optimized binder systems significantly enhances performance characteristics. These composites offer a promising alternative for sustainable construction, particularly in regions with high cotton production.

Future research should focus on long-term durability, large-scale production techniques, and hybrid material systems.

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