

Manufacturing of Cement Light Weight Door Frame with Design Using Coir Fiber, Natural Fiber and Glass Fiber

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DOI: 10.5281/zenodo.20646685

ABSTRACT

Sustainability is a wide accepted concept in modern construction scenario. Even though the construction industry is revolutionizing in a significant manner in terms of both equipment and materials used, the cost of construction has skyrocketed along with the deteriorative impact on environment. This resulted in the adoption of a more balanced approach with the environment as its nerve centre to create a better world to live in. This has led to the adoption of a natural fibre like Coconut for the strength enhancement in concrete.

This experiment describes the behavioral study of coconut fiber in door panel. The addition of coconut fibre in concrete improves various engineering properties of concrete. Coconut fibre is treated as natural fiber before using in concrete. Addition of coconut fiber improves the compressive strength, flexural strength and split tensile strength of concrete. Also this experiment presents the work that has been done in developing a rubber mould for producing wooden panel frame shaped samples. Wood-rubber composites have been successfully manufactured through the rubber mixing and vulcanization molding process. All work starting from the design and selection of material to be used for the mold right up to its actual production and the characteristic of samples are presented.

Keywords: Decorative Door Frames, Vulcanization Molding

1. INTRODUCTION

A lightweight door panel frame can be designed using a combination of coir fiber, glass fiber, and other natural fibers, creating a hybrid composite. This approach offers a lighter alternative to traditional materials while maintaining or even improving strength and durability. The use of natural fibers like coir also contributes to sustainability by utilizing renewable resources. These materials offer a promising alternative to traditional ones, providing benefits like reduced weight, improved sustainability, and enhanced mechanical properties. By combining natural fibers with glass fibers, the strength, stiffness, and durability of the composite material can be improved. This innovative approach can lead to applications in various industries, including automotive, construction, and furniture, promoting Ecofriendly.

The use of composite materials like coir fiber and glass fiber allows for a lighter door panel frame compared to traditional materials. This weight reduction can lead to fuel savings in vehicles or easier handling in other applications. Additionally, these materials promote sustainability by being eco-friendly, renewable, and biodegradable, reducing environmental impact and supporting a more sustainable future.

1.1 LITERATURE SURVEY

1. Coir fiber (natural & renewable resource)

Applications & Advantages:

N. Vanakijpaibul et al. (2008) highlighted that coir fiber is suitable for indoor panel frames due to its lightweight, sustainable, and mechanical properties. It offers high tensile and flexural strength, making it an eco-friendly alternative to synthetic materials.

Enhancements & Future Work:

The addition of glass fibers and surface treatments can further improve the mechanical properties of coir composites. Future research should focus on optimizing coir fiber content and investigating different matrix materials.

2. GLASS FIBER COMPOSITES

Structural Potential: According to Pratiksha H. Wagh, glass fiber composites are ideal for door panel frames because of their high strength-to-weight ratio, durability, and impact resistance.

Properties:The mechanical properties (stiffness, impact) are heavily influenced by fiber orientation and content. They are widely used in automotive, construction, and aerospace industries.

3. COIR FIBER AND AGRICULTURE WASTE IN CONCRETE

Structural Optimization: Domke P. V investigated the use of coconut fibers and rice husk ash (RHA) in fiber-reinforced concrete (FRC), identifying them as crucial materials for enhancing high-performance construction.

Optimal Fiber Content: Anthony Liu et al. (2012) studied the mechanical properties of coconut fiber reinforced concrete, concluding that a 5% fiber content (by mass of cement) with a 5 cm fiber length yielded the best improvements in concrete properties.

Rice Husk Ash (RHA) Impact: Makarand Suresh Kulkarni and S.N. Tande (2014) found that adding RHA makes concrete more cohesive, improves workability, and reduces bulk density. The optimal mix (M0 + 20% RHA) significantly increased tensile, flexural, and compressive strength compared to normal concrete.

Coconut Coir Cement Boards:

Cheul Shin U. et al. (2007) highlighted that coconut coir-based cement boards are lightweight with low thermal conductivity, making them excellent insulating materials for energy conservation in building applications.

4. PROPOSED FRAMEWORK STRUCTURE

CORE MATERIAL:

Cement (OPC 53 Grade) blended with fine sand, lightweight aggregates (e.g., vermiculite, pumice, or fly ash-based particles), and water.

5. REINFORCEMENT (HYBRID SYSTEM):

Coir Fiber (Primary Natural Fiber):

Provides high toughness, crack bridging, and impact resistance. Optimum concentration is generally 0.5%–1.5% by weight of cement, with lengths of 12mm–30mm.

Glass Fiber (Secondary Reinforcement):

Improves flexural strength, ductility, and early strength. Typically used in 1%–2% by weight.

Design Method:

Sandwich panel or hollow core design to reduce weight while maintaining structural integrity.

Surface Treatment:

Alkali treatment (NaOH) for natural fibers to enhance bonding with the cement matrix and reduce water absorption.

6. PROPOSED METHODOLOGY (RESEARCH FLOW)

Material Selection & Pre-treatment:

Cleaning and alkali treatment of coir fibers to remove lignin/hemicellulose.

Mix Design:

Optimizing ratios of cement, sand, lightweight aggregates, water, and hybrid fibers (Coir:Glass) to achieve a unit weight of 1600kg/m³

Experimental testing:

Workability:

Slump test (expected: 50-75 mm).

Mechanical Strength:

28-day compression, flexural (bending), and split tensile tests.

Physical Properties:

Water absorption, density, and shrinkage tests.

Modeling & Optimization:

Utilizing Response Surface Methodology (RSM) to predict optimum fiber volume fraction (FVF) and fiber length (FL).

7. KEY FINDINGS & ADVANTAGES

Strength Enhancement:

Hybridization of glass and coir fiber increases flexural and compressive strength compared to unreinforced cement.

Lightweight Property:

Cellular lightweight concrete (CLC) with fiber can reduce weight by up to 32%-75% compared to conventional concrete.

Sustainability: Reduces reliance on steel reinforcement and uses eco-friendly agricultural waste (coir).

Performance: Improved resistance to cracks, impact, and fire. PROPOSED DESIGN FEATURES

Shape: Pre-cast, molded C-section or box-section for high rigidity.

Applications: Suitable for bathroom, balcony, and interior door frames due to water and termite resistance.

Hardware Compatibility: Engineered to allow for direct screwing or insertion of hinges and locks. This framework leverages coir's high ductility and glass fiber's high tensile strength to create a sustainable, durable, and lightweight alternative to traditional door frames.

8. RESULTS AND PERFORMANCE DISCUSSION

Density and weight:

The use of foam and natural fibers significantly reduces the self-weight of the door frame compared to conventional reinforced concrete or timber.

Strength properties:

Compressive Strength: While pure lightweight concrete is weaker, the addition of glass fiber (1%–2%) and treated coir fiber (0.5%–1.5%) enhances compressive strength.

Flexural/tensile strength:

Coir and natural fibers drastically improve flexural strength (sometimes up to 2.5 times compared to unreinforced mortar) and ductility, allowing the door frame to withstand higher bending stresses without sudden rupture.

Durability and cracking:

Fibers act as arresters for micro-cracks.

Natural fiber composites, when treated, show good resistance to environmental degradation.

Glass fibers prevent crack propagation, increasing the energy consumption ability to resist damage.

WORKABILITY:

Increased fiber content can reduce workability (slump value).

9. KEY FINDINGS IN DISCUSSION

OPTIMUM FIBER CONTENT:

Studies indicate that for natural fibers, the optimal addition rate is generally between 1% and 3%. Exceeding 5% usually leads to agglomeration (clumping) and a reduction in strength.

Fiber treatment necessity:

Untreated coir fibers can suffer from premature mineralization and degradation in the high-alkaline cement environment. Alkali treatment (NaOH) improves bonding and durability.

Hybridization (coir + glass):

Combining coir (flexibility/tenacity) with glass (tensile strength) creates a synergistic effect, offering both strength and impact resistance.

Environmental benefit:

The use of waste materials like coir fiber reduces the carbon footprint and creates sustainable building products.

10. CONCLUSION

Cement-based lightweight door frames reinforced with a combination of coir and glass fiber provide a superior alternative to conventional materials. They offer high tensile and impact resistance, superior aesthetic design potential, lighter weight, and better resistance to termites, rust, and water. A composite with 1-2% glass fiber and 0.5-1% treated coir fiber is recommended for optimal strength, durability, and cost-effectiveness.

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