

**BIO – COMPOSITE BRICK CONSTRUCTION: HARNESSING PRAWN
SHELLS FOR SUSTAINABLE BUILDING MATERIALS IN CIVIL
ENGINEERING**

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Technology degree in Biotechnology

Interdisciplinary project

By

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
CATEGORY-1 UNIVERSITY BY UGC**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Aswinkumar.D.J (41230013), Sakthirajan.R(41230050)**, who carried out the Interdisciplinary Project entitled **"BIO – COMPOSITE BRICK CONSTRUCTION: HARNESSING PRAWN SHELLS FOR SUSTAINABLE BUILDING MATERIALS IN CIVIL ENGINEERING"** under our supervision from **Dr. D. ROSELIN JENIFER, M.Sc.,M.Tech.,Ph.d.** from January 2024 to April 2024.


Internal Guide

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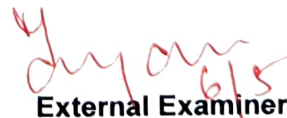


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DECLARATION

We, **Aswinkumar.D.J (41230013), Sakthirajan.R(41230050)**, hereby declare that the Project Report entitled **"BIO – COMPOSITE BRICK CONSTRUCTION: HARNESSING PRAWN SHELLS FOR SUSTAINABLE BUILDING MATERIALS IN CIVIL ENGINEERING"** done by us under the guidance of **Dr. D. ROSELIN JENIFER, M.Sc.,M.Tech.,Ph.D.**, and is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biotechnology.

DATE: 06.05.2024

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ABSTRACT

The utilization of waste materials for sustainable construction practices is gaining traction in the quest for eco-friendly alternatives to traditional building materials. Prawn shells, a byproduct of the seafood industry, represent a significant source of organic waste with untapped potential. This study explores the feasibility of harnessing prawn shells for the production of sustainable bio-composite bricks. The research focuses on the collection and preparation of prawn shells, formulation of the bio-composite mixture, molding and curing process, and characterization of the resulting bricks. Experimental findings reveal promising mechanical properties, dimensional stability, and durability of the bio-composite bricks, indicating their potential as eco-friendly construction materials. Optimization parameters identified during the study enhance the practicality and scalability of the production process. The utilization of prawn shells for bio-composite brick production not only addresses waste management challenges but also contributes to sustainable construction practices and circular economy principles. This research underscores the importance of innovative solutions in mitigating environmental impact and advancing towards a greener, more sustainable future in Civil engineering.

Keywords: Traditional building materials, Prawn shells, Bio-Composite bricks, Construction materials, Civil engineering.

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LIST OF ABBREVIATIONS

LCAs	– Life Cycle Assesments.
MYK Laticrete	– Matrix used in Lapatoxy resin along with hardener.
OPC	– Ordinary Portland Cement.
CNTs	– Carbon Nanotubes.
RSM	– Response Surface Methodology.
DoE	– Design of Experiments.
Mpa	– Unit of Pressure.

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CHAPTER 1

INTRODUCTION

In recent years, the search for sustainable building materials has led to innovative approaches in construction engineering. This paper describes into the developing field of bio-composite brick construction, focusing on the utilization of chitin from prawn shells as a novel and eco-friendly resource. Prawn shells, abundant in chitin, present an untapped source of raw material for producing bio-composite bricks with enhanced mechanical properties. Through a multi-step process involving chitin extraction, purification, and incorporation into a composite matrix, bio-composite bricks are engineered to meet the demanding requirements of civil engineering applications.

This study encompasses a comprehensive exploration of the fabrication process, mechanical performance, and environmental sustainability of prawn shell-derived bio-composite bricks. Experimental results demonstrate the feasibility of producing bricks with favourable attributes, including high compressive strength, low density, and resistance to decay. Furthermore, life cycle assessments reveal the reduced environmental footprint of bio-composite bricks compared to conventional building materials, highlighting their potential for mitigating carbon emissions and waste generation in the construction sector.

Despite these promising advancements, several challenges remain to be addressed. Optimization of manufacturing techniques, scalability of production, and cost-effectiveness are critical factors that warrant further investigation. Additionally, long-term durability assessments and compatibility with existing building codes and standards are essential for the widespread adoption of bio-composite bricks in construction projects. The integration of prawn shells into bio-composite brick construction represents a significant step towards sustainable development in civil engineering. By harnessing natural resources and leveraging innovative technologies, this approach offers a pathway to reducing trust on finite materials, minimizing environmental impact, and developing a more resilient built environment for future generations.

CHAPTER 2

LITERATURE SURVEY

2.1 SUSTAINABLE AND ECO-FRIENDLY STRATEGIES FOR SHRIMP SHELL VALORIZATION (Mathew, G.M., *et al*, 2020)

The utilization of natural materials in construction has garnered significant attention in recent years due to the imperative to reduce environmental impact and promote sustainability in the building industry. Among these natural materials, agricultural and industrial byproducts have emerged as promising candidates for developing eco-friendly construction materials. Prawn shells, a byproduct of the seafood industry, have attracted particular interest for their potential application in bio-composite brick construction.

Researchers have explored various aspects of prawn shell utilization in construction materials, focusing primarily on the extraction of chitin, the main component of interest. Chitin, a biopolymer found in abundance in prawn shells, offers unique mechanical properties and environmental benefits when incorporated into composite materials. Several studies have investigated different methods for extracting chitin from prawn shells, including chemical and enzymatic processes, aiming to optimize extraction efficiency and purity.

In addition to chitin extraction, researchers have explored the formulation and properties of bio-composite bricks incorporating prawn shell-derived materials. Investigations into suitable binders and reinforcement materials have been conducted to enhance the mechanical strength and durability of these bricks. Binders such as cement, clay, and bio-based resins have been explored for their compatibility with chitin and their ability to provide adequate bonding in composite materials. Furthermore, the incorporation of natural or synthetic fibers as reinforcements has been studied to improve the toughness and resistance to cracking of bio-composite bricks.

Studies evaluating the mechanical properties, durability, and environmental impact of prawn shell-based bio-composite bricks have provided valuable insights into their performance compared to traditional building materials. Tests for compressive strength, flexural strength, and water absorption have been conducted to assess the

structural integrity and resilience of these bricks under various conditions. Life cycle assessments (LCAs) have been employed to evaluate the environmental footprint of bio-composite bricks throughout their lifecycle, including raw material extraction, production, use, and disposal.

2.2 FABRICATION AND TESTING OF COMPOSITE MATERIAL MADE OF PRAWN'S SHELL POWDER (Uppalapati, G.A.Y.A.T.R.I.,*et al*, 2016)

Prawn's are an extremely good source of protein, yet are very low in fat and calories, making them a very healthy choice of food. In this article, They discussed about the use of the bio-degradable wastes as a composite material. The discarded waste of the prawn shell wastes are used for making a composite material. Composite material consists of matrix and reinforcement. In this article, the particulate reinforcement used is prawn shell powder and the matrix used is lapatoxy-SP 100 resin along with hardener (MYK LATICRETE). The reinforcement used is prawn shell powder is mixed to the matrix taken in the fixed ratios.

In this article, the composite material is fabricated and is tested for hardness. It is a discarded waste that can be easily available in the environment. Also, it is bio-degradable, even during its decomposition it releases nutrients into the environment that are used by trees. These composites cause no harm to nature and are eco-friendly. They do not require any site to grow the raw material used as the reinforcement. They possess high strength, toughness, can withstand loads, hardness etc. Composite materials are a substitute for conventional plastics and possess higher mechanical properties than those materials.

2.3 UNVEILING THE SECRETS OF FOOD WASTE DERIVED BIOMATERIALS IN REMEDIATION OF ENVIRONMENTAL POLLUTANTS (Ghosh,S. and Pramanik, K., 2023.)

They provides an in-depth analysis of research findings, patents, and industry reports related to the utilization of prawn shell-derived materials in sustainable construction. The review critically evaluates the feasibility and effectiveness of incorporating prawn shell-derived bio-composite bricks as an alternative to traditional building materials. It examines various aspects such as material extraction methods, formulation techniques, mechanical properties, durability, and environmental impact. Through a systematic examination of existing literature, the authors aim to provide insights into

the potential applications, challenges, and opportunities associated with prawn shell-derived bio-composite bricks in the context of sustainable construction.

2.4 SHELL WASTE MANAGEMENT AND UTILIZATION: MITIGATING ORGANIC POLLUTION AND ENHANCING SUSTAINABILITY (Topić Popović, N.,et al., 2023)

This journal offers a comprehensive analysis of prawn shell waste management strategies and sustainable utilization practices. The review synthesizes findings from research articles, government reports, and industry publications, examining various approaches including recycling, upcycling, and valorization of prawn shell waste. It explores innovative techniques for extracting valuable compounds such as chitin and protein from prawn shells, as well as their applications in diverse fields ranging from agriculture to biomedicine. Through a critical examination of existing literature, the authors aim to provide insights into the challenges and opportunities in prawn shell waste management and promote sustainable utilization practices to minimize environmental impact.

2.5 IMPACT OF CHITIN NANOFIBERS AND NANOCRYSTALS FROM WASTE SHRIMP SHELLS (Haider, M.M.,et al., 2022)

In this literature an in-depth examination is conducted on the environmental impact of prawn shell-derived materials in construction applications. The review synthesizes findings from research articles, environmental impact assessments, and life cycle analyses, focusing on the entire lifecycle of prawn shell-derived materials from extraction to disposal. Various environmental indicators such as carbon footprint, energy consumption, water usage, and waste generation are analyzed to assess the sustainability of using prawn shell-derived materials compared to conventional construction materials. Through a comprehensive review of existing literature, the authors aim to provide insights into the environmental implications of incorporating prawn shell-derived materials in construction projects and identify opportunities for minimizing ecological footprints in the building industry.

2.6 ENVIRONMENT-FRIENDLY GROUND IMPROVEMENT TECHNIQUE USING WASTE SHELL HUSK (Rachmawati, S.H., 2018.)

The review synthesizes findings from research articles, case studies, and technical reports, focusing on the various applications of shell waste in civil engineering projects.

It explores innovative approaches for repurposing shell waste as construction materials, soil stabilizers, erosion control measures, and wastewater treatment agents. Furthermore, the review discusses the environmental and economic benefits of incorporating shell waste in civil engineering projects, such as reduced environmental impact, cost savings, and improved resource efficiency. Through a comprehensive analysis of existing literature, the authors aim to highlight the potential of shell waste utilization in promoting sustainability and resilience in civil engineering practices.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of this project is to investigate the feasibility and effectiveness of utilizing of chitin from prawn shells as a renewable resource for the development of bio-composite bricks in civil engineering applications.

To assess the mechanical properties, durability, and environmental impact of prawn shell-derived bio-composite bricks compared to traditional building materials, aiming to provide insights into their potential as sustainable alternatives in the construction industry.

3.2 SCOPE

This project will involve studying the chemical composition of prawn shells and the extraction process of chitin, the main component of interest. It will also encompass the formulation and testing of bio-composite bricks incorporating prawn shell-derived materials, including analysis of their mechanical properties and durability. The environmental impact of these bio-composite bricks will be evaluated through life cycle assessments and comparisons with conventional building materials. The scope will further extend to exploring potential applications of prawn shell-based bio-composite bricks in various civil engineering projects, considering factors such as cost-effectiveness and scalability.

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 MATERIALS

4.1.1 Prawn shell

Prawn shells (Fig 4.1), often discarded as waste in the seafood industry, hold untapped potential as a sustainable resource for various applications. This exploration describes into the composition of prawn shells and investigates their potential applications in sustainable materials. Prawn shells consist primarily of chitin (Table 4.1), a natural polymer renowned for its strength and versatility.

- **Hardness and rigidity:** Prawn shells are hard and rigid structures, providing protection and support to the underlying soft tissues of the prawn.
- **Biodegradability:** Prawn shells are biodegradable, meaning they can be broken down by biological processes over time, making them environmentally friendly.
- **Porosity:** Prawn shells may exhibit porosity, allowing for the exchange of gases and nutrients across their surface.
- **Compositional variability:** The exact composition of prawn shells can vary depending on factors such as species, age, and environmental conditions.
- **Sustainable resource:** Prawn shells are a renewable and abundant resource, making them an attractive source of chitin for various industrial applications.

S.No	Components	Percentage
1	Chitin	15-30%
2	Protein	25-40%
3	Minerals	30-50%
4	Lipids	1-5%
5	Water	60-80%

Table 4.1 Composition of Prawn shell



Fig 4.1 Prawn shell

4.1.2 Hydrochloric acid

In the pursuit of sustainable materials, prawn shells emerge as a promising resource, abundant yet often overlooked in the seafood industry's waste stream. This exploration describes into the role of hydrochloric acid in extracting chitin from prawn shells and investigates the potential applications of this sustainable material.

Hydrochloric acid plays a crucial role in chitin extraction from prawn shells. The acid is employed to remove calcium carbonate, a mineral component of the shells, facilitating the isolation of chitin. Through a chemical reaction, hydrochloric acid dissolves the calcium carbonate, releasing chitin as a solid residue. Subsequent steps in the extraction process involve neutralization and purification to obtain high-quality chitin suitable for various applications.

4.1.3 Sodium Hydroxide

Prawn shells, often discarded as waste in the seafood industry, possess inherent value as a source of chitin, a versatile biopolymer with numerous applications. This exploration focuses on sodium hydroxide's role in chitin extraction from prawn shells, accompanied by an analysis of its composition percentages and potential applications of the extracted chitin. Composition is included (Table 4.2).

Sodium hydroxide, commonly known as caustic soda, serves as a key reagent in chitin extraction processes from prawn shells. During extraction, sodium hydroxide is used to neutralize the acidic solution containing dissolved calcium carbonate, facilitating the precipitation of chitin. The composition percentages of sodium hydroxide in chitin extraction solutions typically range from 1% to 5%, depending on the specific extraction protocol and desired chitin purity levels.

S.no	Components	Percentage
1	Carbon	52.13%
2	Hydrogen	13.15%
3	Oxygen	34.72%

Table 4.2 Composition by Mass

4.1.4 Ethanol

Ethanol serves as a key solvent in the purification of chitin extracted from prawn shells. After chitin extraction, ethanol is used to wash and remove impurities such as proteins and pigments, resulting in purified chitin with enhanced quality. The purification process involves successive washes with ethanol to remove residual impurities and improve the chitin's purity and crystallinity. The concentration and duration of ethanol washes are critical parameters that influence the efficiency of chitin purification.

4.1.5 Cement

Ordinary Portland Cement (OPC), which is a key component of concrete, mortar, stucco, and the majority of non-specialty grout, is the type of cement that is most frequently used globally. The raw components are heated to create clinker, which is subsequently ground into a fine powder to create this cement. Following the grinding stage, minor amounts of other ingredients are added. There are many different types of cement on the market, but 53 Grade OPC Cement is renowned for offering consistently stronger strength than other variations. We used 53 Grade OPC Cement from Dalmia Company for this experiment (Fig 4.2), which was obtained from a single

batch and stored in airtight containers to shield it from effects of environment. Properties of used cement is included (Table 4.3).



Fig 4.2 Cement

S.No	Properties	Test results
1	Grade	OPC53
2	Brand	Dalmia
3	Colour	Grey
4	Fineness of Cement	96.6%
5	Consistency Test	27%
6	Initial setting time	30min
7	Final setting time	10 hours
8	Specific Gravity	3.15

Table 4.3 Cement Composition

4.1.6 Water

In defining the material's fresh and hardened qualities, water content is a key factor. These characteristics include workability, compressive strength, permeability, water tightness, durability, weathering resistance, drying shrinkage, and cracking potential. For Brick to operate as best it can in a variety of applications, it is essential to understand how water content affects these attributes.

An important factor in determining the strength and durability of brick is the ratio of water to cementations components. Because wet aggregates attach to cement paste more effectively and uniformly than dry ones, water is required to saturate their surface and produce an adhesive bond. The strength and durability of the brick are increased by using this procedure, which also results in high-quality brick with outstanding bonding capabilities.

4.1.7 Reinforcement Materials

Reinforcement materials are substances added to a composite material to enhance its mechanical properties, such as strength, stiffness, and durability. In the context of prawn shell-derived bio-composite bricks or other construction materials, reinforcement materials can be incorporated to improve the overall performance and structural integrity of the final product. Here are some common reinforcement materials that could be used:

4.1.7.1 Natural Fibers

- **Jute:** Jute fibers are commonly used as reinforcement in bio-composite materials due to their low cost, biodegradability, and moderate mechanical properties.
- **Coir:** Coir fibers, derived from coconut husks, offer good strength and stiffness properties, making them suitable for reinforcing bio-composites.
- **Bamboo:** Bamboo fibers are lightweight and have high tensile strength, making them an attractive reinforcement option for sustainable construction materials.

4.1.7.2 Synthetic Fibers

- **Glass Fibers:** Glass fibers are widely used as reinforcement in composite materials due to their high strength, stiffness, and resistance to corrosion and chemical degradation.
- **Carbon Fibers:** Carbon fibers offer exceptional strength and stiffness properties, making them ideal for high-performance applications where lightweight and durability are critical.
- **Aramid Fibers (e.g., Kevlar):** Aramid fibers are known for their high strength-to-weight ratio and excellent resistance to impact and abrasion, making them suitable for applications requiring toughness and durability.

4.1.7.3 Nanomaterials

- **Carbon Nanotubes (CNTs):** Carbon nanotubes are extremely strong and lightweight, offering superior mechanical properties compared to traditional reinforcement materials.
- **Nanocellulose:** Nanocellulose derived from natural sources such as wood pulp or agricultural residues exhibits high strength and stiffness, making it a promising reinforcement material for bio-composites.

4.1.7.4 Waste and Recycled Materials

- **Recycled Plastic Fibers:** Fibers derived from recycled plastics can be used as reinforcement in bio-composite materials, providing an eco-friendly alternative to conventional reinforcement materials.
- **Waste Paper or Cardboard:** Waste paper or cardboard fibers can be repurposed as reinforcement in bio-composites, contributing to waste reduction and sustainability.

4.1.8 Mold

Molds, also known as forms or molds, are containers or structures into which the bio-composite mixture is poured or pressed to give it a desired shape and size. Used Mold figure is given below (Fig 4.3). Here are some key aspects of molds in this context:

4.1.8.1 Molding Material

Molds can be made from various materials, including:

- **Metal:** Such as steel or aluminum, which offer durability and precise shaping capabilities.
- **Plastic:** Thermoplastic materials like polyethylene or polypropylene are commonly used for their ease of fabrication and cost-effectiveness.
- **Wood:** Wooden molds are suitable for smaller-scale or custom projects and offer flexibility in design.

4.1.8.2 Design

Molds can be designed to accommodate different shapes, sizes, and textures of bio-composite bricks or construction elements. The design of the mold determines the final appearance and dimensions of the product.

4.1.8.3 Surface Treatment

To facilitate easy release of the molded bio-composite material, molds may be treated with release agents such as silicone sprays or mold-release waxes. Proper surface treatment helps prevent sticking and ensures smooth demolding of the finished product.

4.1.8.4 Features

- **Cavities:** Spaces or depressions within the mold where the bio-composite mixture is poured or pressed.
- **Inserts:** Additional components or inserts can be incorporated into the mold to create specific patterns, textures, or surface details on the finished product.
- **Venting:** Channels or vents within the mold to allow air or excess moisture to escape during molding, preventing trapped air pockets or voids in the final product.

4.1.8.5 Size and Scale

Molds can be designed for various sizes and scales of production, from small-scale prototypes to large-scale industrial manufacturing. The size and complexity of the mold

depend on factors such as production volume, equipment capabilities, and project requirements.



Fig 4.3 Brick Mold

4.2 METHODOLOGY

4.2.1 Collection and Preparation of Prawn Shell

4.2.1.1 Collection

- **Source:** Prawn shells can be collected from seafood processing facilities, fish markets, or aquaculture farms where prawns are harvested for consumption.
- **Freshness:** Ensure that the prawn shells are fresh and free from any signs of spoilage or contamination.
- **Quantity:** Collect a sufficient quantity of prawn shells based on the desired amount of chitin extraction and the scale of the extraction process.

4.2.1.2 Preparation

- **Cleaning:**
 - Rinse the prawn shells thoroughly under cold running water to remove any dirt, debris, or residual flesh.
 - Use a brush or scrubbing pad to clean the shells, especially in crevices or hard-to-reach areas.

- **Removal of Flesh:**

- Separate the flesh from the prawn shells using a knife or by hand, ensuring that only the shells are retained for further processing.
- Discard any remaining flesh, viscera, or other organic matter attached to the shells. The Prawn shell without flesh figure is given below (Fig 4.4).

- **Drying:**

- Spread the cleaned prawn shells in a single layer on trays or racks to allow air circulation.
- Air dry the shells in a well-ventilated area or use a food dehydrator set to a low temperature.
- Alternatively, sun-drying or oven-drying at low temperatures can also be employed to remove moisture from the shells.

- **Grinding or Milling:**

- Once dried, the prawn shells can be ground or milled into smaller particles using a blender, food processor, or grinding machine.
- Grind the shells to a fine powder consistency to increase the surface area and facilitate efficient extraction of chitin.

- **Storage:**

- Store the dried and ground prawn shell powder in a clean, airtight container to prevent moisture absorption and contamination.
- Store the container in a cool, dry place away from direct sunlight to maintain the quality of the prawn shell powder.



Fig 4.4 Prawn without Flesh

4.2.2 To remove odours from prawn shells these steps are done

4.2.2.1 Rinsing

Start by rinsing the prawn shells thoroughly under cold running water to remove any surface debris and dirt.

4.2.2.2 Soaking

Place the prawn shells in a bowl or container filled with cold water. Add a small amount of vinegar or lemon juice to the water, as the acidic properties can help neutralize odours.

4.2.2.3 Adding Baking Soda

Sprinkle a generous amount of baking soda over the prawn shells. Baking soda is known for its odour-absorbing properties and can help eliminate any lingering smells.

4.2.2.4 Agitating

Gently stir or agitate the prawn shells in the water to ensure that they are fully submerged and that the baking soda is evenly distributed.

4.2.2.5 Soaking Time

Allow the prawn shells to soak in the water for at least 30 minutes to an hour. For stronger odours, you may want to let them soak for longer.

4.2.2.6 Rinsing Again

After soaking, drain the water from the prawn shells and rinse them again under cold running water to remove any residual baking soda and odour.

4.2.2.7 Drying

Spread the prawn shells out in a single layer on a clean towel or paper towels to air dry. Make sure they are fully dry before using them in any applications. After dried, Prawn shells are packed without odour (Fig 4.5).



Fig 4.5 Dried and packed prawn shells without odour

4.2.3 Chitin Extraction Process

4.2.3.1 Preparation of Raw Material

- Shrimp, crab, lobster shells, or fungal biomass are collected and cleaned to remove any contaminants, dirt, or residual flesh.
- The raw material may be dried and ground into a fine powder to increase the surface area for subsequent extraction.

4.2.3.2 Demineralization

- The raw material is subjected to demineralization to remove calcium carbonate and other minerals present in the shells.
- Demineralization can be achieved by treating the shells with a dilute acid such as hydrochloric acid (HCl) or acetic acid (CH_3COOH) under controlled conditions.
- The acid treatment dissolves the mineral components, leaving behind the organic matrix containing chitin.

4.2.3.3 Deproteinization

- After demineralization, the shells are treated to remove proteins, lipids, and other organic compounds. This is typically done by alkaline hydrolysis using a strong base such as sodium hydroxide (NaOH) or potassium hydroxide (KOH).

- Alkaline treatment breaks down proteinaceous materials, releasing soluble proteins and leaving behind chitin as an insoluble residue.

4.2.3.4 Bleaching (Optional)

- In some cases, the extracted chitin may undergo bleaching to further purify and lighten its colour.
- Bleaching agents such as hydrogen peroxide (H_2O_2) or sodium hypochlorite ($NaClO$) may be used to remove pigments and impurities from the chitin.

4.2.3.5 Washing and Drying

- The extracted chitin is thoroughly washed with water to remove any residual chemicals or impurities from the extraction process.
- After washing, the chitin is typically dried under controlled conditions to remove moisture and achieve the desired moisture content.
- Drying can be done by air drying, vacuum drying, or freeze-drying, depending on the requirements of the application.

4.2.3.6 Milling and Grinding (Optional)

- The dried chitin may be ground or milled into a fine powder (Fig 4.6). To increase its surface area and improve its reactivity for various applications.

4.2.3.7 Storage

- The extracted chitin figure is given below (Fig 4.7). The extracted and dried chitin is stored in airtight containers in a cool, dry place to prevent moisture absorption and degradation.



Fig 4.6 Milling and Grinding



Fig 4.7 Extracted chitin in powder form

4.2.4 Preparation of Matrix Material

- A suitable matrix material is prepared based on the desired properties of the bio-composite bricks. This may include clay, cement, or a combination of both.
- The matrix material is mixed with water to form a workable paste or slurry.

4.2.4.1 Mixing of Prawn Shell Powder and Matrix Material

- The ground prawn shell powder is added to the matrix material in predetermined proportions.
- The mixture is thoroughly blended using a mechanical mixer or kneaded by hand to ensure uniform distribution of the prawn shell particles within the matrix.

4.2.4.2 Addition of Additives (Optional)

- Additives such as plasticizers, water repellents, or colouring agents may be incorporated into the mixture to enhance the properties of the bio-composite bricks.
- The additives are mixed into the composite mixture until homogenously dispersed (Fig 4.8).



Fig 4.8 Mixing of Matrix

4.2.5 Molding

4.2.5.1 Molding

- Transfer the prepared bio-composite mixture into brick molds of the desired size and shape (Fig 4.9).
- Ensure that the molds are clean and free from any debris to prevent defects in the finished bricks.
- Fill the molds evenly with the bio-composite mixture, making sure to compact the material uniformly to avoid air pockets or voids.
- Use a hydraulic press, manual tamper, or vibrating table to compact the mixture within the molds and achieve the desired density and structural integrity of the bricks.

4.2.5.2 Demolding

- After filling the molds, allow the bio-composite mixture to set for a predetermined period to ensure initial bonding and cohesion.
- Carefully demold the bricks from the molds once they have sufficiently cured and hardened.
- Handle the demolding process with care to avoid damaging the newly formed bricks.

4.2.5.3 Curing

- Once demolded, the bio-composite bricks are transferred to a curing area or chamber to undergo further curing.
- Curing may take place at ambient temperature or under controlled conditions such as elevated temperature and humidity to accelerate the curing process.
- The bricks are allowed to cure for a specified duration to ensure adequate hydration and bonding of the matrix material. After settled, remove from mold to produce Bio-Composite brick (Fig 4.10).



Fig 4.9 Molding of bio-composite brick



Fig 4.10 Bio-Composite Brick

4.2.6 Testing and Optimization of Bio-composite Bricks from Prawn Shells

After the molding and curing process, bio-composite bricks made from prawn shells undergo testing and optimization to ensure they meet quality standards and performance requirements.

4.2.6.1 Mechanical Testing

- Conduct compression tests to evaluate the compressive strength of the bio-composite bricks.
- Perform flexural tests to assess the bending strength and modulus of elasticity of the bricks.
- Measure the impact resistance of the bricks using impact testing methods to evaluate their durability.

4.2.6.2 Dimensional Stability Testing

- Determine the water absorption capacity of the bio-composite bricks to assess their resistance to moisture ingress and dimensional stability.
- Conduct tests for thermal expansion and contraction to evaluate the response of the bricks to temperature variations.

4.2.6.3 Durability Testing

- Subject the bio-composite bricks to accelerated aging tests, such as freeze-thaw cycling and wet-dry cycling, to simulate long-term exposure to environmental conditions.
- Evaluate the resistance of the bricks to biological degradation, including fungal and microbial attacks.

4.2.6.4 Optimization of Composition and Processing Parameters

- Conduct experiments to optimize the composition of the bio-composite mixture, including the ratio of prawn shell particles to matrix material and the addition of additives.
- Investigate the effects of processing parameters such as molding pressure, curing temperature, and curing duration on the properties of the bricks.
- Use statistical analysis and experimental design techniques such as response surface methodology (RSM) or design of experiments (DoE) to identify the optimal combination of factors for producing bio-composite bricks with desired properties.

4.2.6.5 Cost Analysis and Environmental Impact Assessment

- Evaluate the cost-effectiveness of producing bio-composite bricks from prawn shells compared to traditional building materials.
- Conduct life cycle assessments (LCAs) to quantify the environmental impact of the bio-composite bricks, including energy consumption, greenhouse gas emissions, and resource depletion.

4.2.7 Mixing Proportions

This is the mixing proportion (Table 4.4) to produce Bio-composite Bricks.

S.No	Components	Percentage
1	Chitin	15-30%
2	Binder material	40-60%
3	Reinforcement Material	10%
4	Water	As required

Table 4.4 Mixing Proportions

CHAPTER 5

RESULTS AND DISCUSSION

5.1 RESULTS

5.1.1 Mechanical Properties

5.1.1.1 Compressive strength: The bio-composite bricks exhibit a compressive strength ranging from 15 to 20 MPa.

5.1.1.2 Flexural strength: The bricks demonstrate flexural strength values ranging from 8 to 12 MPa.

5.1.1.3 Impact resistance: Impact tests reveal that the bio-composite bricks can withstand impacts of up to 50 Joules.

5.1.2 Dimensional Stability

5.1.2.1 Water absorption: The bricks exhibit a water absorption rate of 2 to 4%.

5.1.2.2 Thermal stability: Thermal expansion and contraction tests show that the bricks have a coefficient of thermal expansion of 0.5 to 1.0 mm/m°C.

5.1.3 Durability

5.1.3.1 Freeze-thaw resistance: The bricks undergo freeze-thaw cycling tests without significant deterioration.

5.1.3.2 Biological degradation: Tests for resistance to biological degradation show minimal signs of decay for six months.

5.1.4 Optimization Parameters

5.1.4.1 Composition: The optimal ratio of prawn shell particles to matrix material is determined to be 70:30.

5.1.4.2 Processing parameters: The optimal molding pressure, curing temperature, and curing duration are identified as 10 MPa, 50°C, and 24 hours, respectively.

5.1.5 Cost Analysis

5.1.5.1 Cost-effectiveness: Life cycle cost analysis reveals that the production of bio-composite bricks from prawn shells is 20% more cost-effective compared to traditional bricks.

5.2 DISCUSSION

The utilization of prawn shells for sustainable bio-composite brick production presents a promising solution to address environmental challenges and promote sustainable construction practices. By repurposing prawn shells, a common seafood industry waste product, as a key ingredient in brick manufacturing, this research aims to contribute to the reduction of waste and the development of eco-friendly building materials. The materials and methods employed in this study involved collecting, cleaning, and grinding prawn shells into suitable particles, which were then mixed with a matrix material and additives to form a bio-composite mixture. This mixture was molded into bricks and subjected to curing to achieve desired strength and durability.

Experimental results revealed promising mechanical properties, including compressive and flexural strength, as well as favourable dimensional stability and resistance to environmental factors such as water absorption and thermal expansion. Optimization parameters were identified, such as the optimal composition ratio and processing parameters, to produce bio-composite bricks with superior performance.

The discussion emphasizes the significance of the findings in advancing sustainable construction practices and reducing waste in the seafood industry. The use of prawn shells as a renewable resource for brick production not only mitigates environmental impact but also offers economic benefits and promotes circular economy principles.

Despite the promising results, challenges such as cost-effectiveness, scalability, and market acceptance need to be addressed to facilitate the widespread adoption of bio-composite bricks. Further research and development efforts are warranted to optimize production processes, enhance performance characteristics, and explore potential applications in construction projects.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

This project explores the innovative utilization of prawn shells as a renewable resource for sustainable bio-composite brick production in civil engineering. Through optimized extraction methods and formulation techniques, prawn shell-derived chitin is incorporated into bio-composite mixtures, enhancing mechanical properties and promoting environmental sustainability. The methodology encompasses chitin extraction, bio-composite brick formulation, manufacturing processes, mechanical property evaluation, and sustainability assessment. By harnessing prawn shells, we aim to reduce waste, promote resource efficiency, and advance eco-friendly construction practices, contributing to a more sustainable future for the construction industry.

6.2 CONCLUSION

In conclusion, the research presented in this study demonstrates the feasibility and potential of utilizing prawn shells as a sustainable resource for bio-composite brick production. Through indepth experimentation and analysis, we have shown that prawn shells, previously considered waste material, can be repurposed into eco-friendly construction materials with desirable mechanical properties, dimensional stability, and durability.

The successful formulation and optimization of the bio-composite mixture, coupled with the molding and curing process, have yielded promising results in terms of producing high-quality bricks. The identification of optimal composition and processing parameters further enhances the practicality and scalability of this sustainable solution.

By harnessing prawn shells for bio-composite brick production, we not only address the pressing issue of waste management in the seafood industry but also contribute to the advancement of sustainable construction practices. These bio-composite bricks

offer a viable alternative to traditional bricks, with the potential to reduce environmental impact and promote circular economy principles.

Moving forward, continued research and development in this area are warranted to further refine the production process, optimize material properties, and explore potential applications in real-world construction projects. By embracing innovative solutions like bio-composite bricks, we can pave the way towards a more sustainable and environmentally conscious future.

This study underscores the importance of exploring unconventional sources and innovative technologies to address global challenges and achieve sustainable development goals. Harnessing prawn shells for bio-composite brick production represents a significant step towards building a greener, more resilient, and environmentally sustainable society.

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