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**DEPARTMENT OF CIVIL ENGINEERING**

**OPTION OF CONSTRUCTION TECHNOLOGY**

# Manufacturing of tiles from sawdust

**Submitted in partial fulfillment for the requirements of the award of advanced diploma in Construction Technology**

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**Under the guidance of: Eng. MUTIJIMA Jeannine**

**Done at Kigali, October, 2024**

# DECLARATION

We hereby declare that this advanced diploma final year project report entitled: **"Manufacturing of tiles from sawdust**" was carried out by us for degree of advanced diploma in civil engineering under the guidance and supervision of Eng. MUTIJIMA Jeannine

This final report is a presentation of our own original research work and has not been presented for any degree in any university and college. All source of materials used has been duly acknowledged.

Signature………………

KAZUNGU Vianney

Date…/…/……

## CERTIFICATE

This is to certify that the work incorporated in the final report “Production of interlocking bricks made from sand and plastics waste” with special reference to under graduates in Ulk polytechnic institute submitted by **KAZUNGU vianney: 202150402** were carried out by the candidates under our guidance. Materials obtained from other sources have been duly acknowledged in the report.

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|---|---|
| Supervisor | Head of department |
| Eng. MUTIJIMA Jeannine | Eng. Bonaventure NKIRANUYE |
| Signature. ……………….. | Signature. ………..……………….. |

## DEDICATION

This research is dedicated to:

- Almighty God
- Our parents
- Our lecturers and
- Our supervisor
- Our Classmates
- Our friends

## ACKNOWLEDGEMENT

This project would not have been possible without the kind of support and help from many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are highly in debt to **Eng. MUTIJIMA Jeannine** for his guidance and constant supervision as well as for providing necessary information regarding the project and for his support in completing this project.

We would like to express our gratitude towards our parents and Civil Engineering Department's Lecturers at **ULK POLYTECHNIC INSTITUTE** for their kind cooperation and encouragement in helping us to complete this project.

Our thanks and appreciations also go to our colleagues and people who have willingly helped us out in different capacities.

## ABSTRACT

The utilization of sawdust in manufacturing tiles presents a sustainable solution to waste management in the woodworking industry. This study explores the feasibility and environmental benefits of incorporating sawdust into tile production processes. Various techniques and formulations for blending sawdust with traditional tile materials are reviewed, highlighting their impact on tile properties such as strength, durability, and aesthetics. The economic viability and market potential of sawdust-based tiles are also discussed, emphasizing their role in promoting circular economy principles and reducing carbon footprint. Finally, future research directions and challenges in scaling up production are identified to foster innovation in sustainable building materials.

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# LIST OF ABBREVIATION

**ULK:** University Of Local Knowledge

**RCT:** Randomized Controlled Trial

**SPSS:** Statistical Package for the Social Science

**PPE:** Person Protective Equipment

**Ww:** Wet Weight

**Wi:** Initial Weight

**%:** Percentage

# CHAPTER ONE: INTRODUCTION OF STUDY

## 1. Introduction

The quest for sustainable building materials has led to innovative approaches in the construction industry. One such approach is the manufacturing of tiles from sawdust, a byproduct of woodworking processes. Traditionally, sawdust has been considered a waste material, but recent advancements have transformed it into a valuable resource for creating eco-friendly tiles. This method not only addresses environmental concerns by reducing wood waste but also offers a cost-effective solution for construction and interior design. By combining sawdust with various binders and additives, manufacturers can produce durable, aesthetically pleasing tiles that contribute to green building practices. This introduction explores the process, benefits, and potential applications of sawdust-based tiles in the modern construction industry.

### 1.1. Background of the study

Tiles made from sawdust offer several benefits. Environmentally, they help in reducing deforestation by decreasing the reliance on traditional materials like clay manufacturing tiles from sawdust is an innovative approach that addresses both environmental and economic challenges. Sawdust, a byproduct of the wood processing industry, often poses disposal problems and contributes to environmental pollution. (Ikri, 2022) By repurposing sawdust into building materials like tiles, this waste can be transformed into valuable resources, promoting sustainable practices. (IJSRED, 2022) This method aligns with the principles of circular economy, where waste materials are reused to create new products, thereby minimizing waste and reducing the demand for virgin raw materials. (IRJET, 2021)

(Mohammad, 2022)The process of making tiles from sawdust typically involves mixing sawdust with a binding agent, such as cement, resin, or organic adhesives. This mixture is then molded into the desired shape and subjected to processes like pressing, drying, and curing to enhance its strength and durability. Some methods also incorporate additional materials, like recycled plastics or natural fibers, to improve the mechanical properties and aesthetic appeal of the tiles. These tiles can be customized in terms of color, texture, or stone. (murali,suesh,and srinivasababu, 2009)They also contribute to lowering carbon footprints, as the production process for these tiles can be less energy-intensive compared to conventional tile manufacturing. Economically, utilizing sawdust reduces waste disposal costs and provides an affordable alternative to traditional tiles, potentially lowering construction costs. Moreover, these tiles often exhibit good thermal and acoustic insulation properties, enhancing the energy efficiency and comfort of buildings. As sustainable construction materials gain popularity, sawdust tiles represent a promising solution to the dual challenge of waste management and sustainable building practices. (NoeL, 2017)

### 1.2. Problem statement

The construction industry is a major consumer of natural resources and a significant contributor to environmental degradation. Traditional tile materials, such as clay, stone, and concrete, require extensive mining and energy-intensive production processes, which lead to resource depletion and increased carbon emissions. With the growing need for sustainable construction materials, the development of tiles from sawdust presents an innovative solution. This project explores the potential to reduce reliance on non-renewable resources, lower environmental impact, and create a cost-effective, durable, and aesthetically appealing product. By utilizing sawdust, a readily available byproduct, this approach promotes circular economy practices while meeting the demand for eco-friendly building materials, offering a competitive advantage in the green building market

### Research motivation and interest

The motivation behind researching the manufacture of tiles from sawdust stems from the urgent need to find sustainable solutions to both waste management and construction material production. The woodworking industry generates significant quantities of sawdust, which often ends up in landfills or incinerators, contributing to environmental pollution and greenhouse gas emissions. By repurposing this abundant byproduct, we can alleviate the pressure on waste disposal systems and create a valuable resource out of what is typically considered waste. This aligns with global efforts to reduce environmental footprints, promote recycling, and support sustainable development goals.

### 1.3. Objective

#### 1.3.1. Main Objective

The main objective of this research is manufacturing of tiles from saw dust in Rwanda.

### 1.3.2. Specific objectives

**1.** To Investigate and identify the most effective binding agents and additives that can be combined with sawdust to produce durable and high-quality tiles.

2. To achieve optimal strength, water resistance, and aesthetic appeal

**3.** To design and refine the manufacturing process for sawdust-based tiles, focusing on parameters such as particle size, compression techniques, curing times, and surface treatments. The aim is

4. To create an energy-efficient, scalable process that ensures consistent product quality.

**5. To** evaluate the environmental impact and safety of the sawdust tile production and lifecycle.

6. To measure the carbon footprint, potential VOC emissions, and overall sustainability, ensuring the tiles are non-toxic and eco-friendly from production to disposal.

**7.** To assess the economic viability and market potential of sawdust-based tiles by analyzing production costs, competitive pricing, and consumer acceptance.

8. To ensure the tiles meet relevant building codes and standards through rigorous testing and certification, facilitating their adoption in both residential and commercial construction.

### 1.4. Research Questions

- What are the most effective binding agents and additives that can be combined with sawdust to produce durable and aesthetically appealing tiles, and how do different combinations affect the tiles' mechanical and physical properties?
- What are the optimal production parameters (such as particle size, compression techniques, curing times, and surface treatments) required to manufacture sawdust-based tiles with consistent quality and performance?
- How does the environmental impact of sawdust-based tile production compare to that of traditional tile materials, and what measures can be taken to minimize any negative environmental and health impacts throughout the tiles' lifecycle?
- What are the market perceptions and economic feasibility of sawdust-based tiles, and what strategies can be employed to ensure these tiles meet building codes and standards, thereby promoting their adoption in residential and commercial construction?

## 1.5. Scope of Study

The scope of this study encompasses the comprehensive development and evaluation of sawdust-based tiles as a sustainable alternative to traditional building materials. This includes the formulation of various sawdust and binder mixtures to identify the most effective combinations for producing tiles with optimal mechanical properties, such as strength, durability, and water resistance. The research will involve laboratory-scale experiments to test different ratios of sawdust to binders, including both synthetic and natural adhesives, to determine the best formulations for further development.

Furthermore, the study will explore the manufacturing process in detail, focusing on key parameters such as particle size distribution, compression techniques, curing methods, and surface treatments. The goal is to refine the production process to ensure it is energy-efficient, scalable, and capable of producing tiles with consistent quality. Pilot production runs will be conducted to gather data on the feasibility and efficiency of the proposed manufacturing methods, which will be used to identify potential bottlenecks and areas for improvement.

In addition to the technical aspects, the study will include a thorough environmental and economic analysis. This will involve conducting life cycle assessments (LCA) to compare the environmental impact of sawdust-based tiles with traditional tile materials, examining factors such as carbon footprint, resource usage, and potential emissions. The economic viability will also be assessed by analyzing production costs, market demand, and competitive pricing strategies. Finally, the study will address regulatory compliance by testing the sawdust-based tiles against relevant building codes and standards, ensuring they meet all necessary safety and performance criteria for use in residential and commercial construction.

## 1.6. Significant Of Study

### 1.6.1. Personal significance

It will be the source of income to me as the researcher. It will help me to increase my knowledge and will decrease the cost of tiles from the highest to the lowest cost on the construction industry and it will also make me proud because I will be contributing in my country development.

### 1.6.2. Academic significance

This research will help the future students of Ulk polytechnic Institute and will be one of the reference book at ULK library

### 1.6.3. Socially significance

It will provide job opportunities to many people in construction industry even in the all country it will be an affordable price.it will also reduce luck of job in society**.**

## 1.7 Organization of study

This research will be divided into five main chapters to provide clarity and coherence in the discussion of the investigations carried out on the preliminary design of a standard four-story modern business building.

**CHAPTER 1: General Introduction**

This chapter deals with the introduction, problem statement, research objectives, research questions, scope of the research, significance of the research, and finally, the organization of the study.

**CHAPTER 2: Literature Review, this** chapter provides all the details and theories concerning tiles.

**CHAPTER 3: Materials and Methods**

This chapter discusses the methods and procedures used, defines the instruments employed in the investigation, and describes the techniques used to collect all the necessary data.

**CHAPTER 4: Results and Discussions**, this chapter presents the analysis and interpretation of the findings for manufacturing of tiles from sawdust

**CHAPTER 5: Conclusion and Recommendations**

This final chapter presents the conclusions and recommendations, summarizing the outcomes of manufacturing tiles from sawdust.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1. Introduction

The manufacturing of tiles using sawdust as a raw material is gaining attention due to its potential environmental and economic benefits. Sawdust, a byproduct of woodworking processes, poses challenges for disposal and environmental impact but offers opportunities for sustainable product development. This literature review explores current research and advancements in utilizing sawdust in tile production. It examines various approaches, including blending sawdust with traditional tile materials, evaluating their effects on tile properties, such as strength, durability, and aesthetics. Furthermore, this review discusses the implications of sawdust-based tiles for waste reduction, carbon footprint mitigation, and the promotion of circular economy principles within the construction industry. By synthesizing existing knowledge, this review aims to identify gaps in research and provide insights into future directions for enhancing the sustainability and feasibility of sawdust-based tile manufacturing.

## 2.2. Reason for Manufacturing Tiles from Sawdust

Manufacturing tiles from sawdust presents a compelling solution to address both environmental challenges and economic opportunities within the construction materials industry. By utilizing sawdust, a commonly discarded wood processing byproduct, as a raw material, this approach not only reduces waste and landfill pressure but also contributes to the conservation of natural resources. Moreover, integrating sawdust into tile production offers the potential to lower production costs and enhance product sustainability, aligning with global efforts towards achieving more eco-friendly building practices. This innovative use of sawdust not only transforms a waste material into a valuable resource but also promotes a circular economy model by closing the loop on wood waste utilization in construction applications.

## 2.3. Definitions

**Tiles:** Tiles are flat, thin objects typically made from materials such as ceramic, porcelain, stone, glass, or metal. They are used primarily for covering surfaces such as floors, walls, roofs, and other structures. Tiles are manufactured in various sizes, shapes, colors, and textures to suit different aesthetic and functional purposes. They are commonly used in bathrooms, kitchens, and other areas where moisture resistance, durability, and ease of cleaning are important considerations.

**Sawdust:** Sawdust is a byproduct of woodworking processes, consisting of fine particles and shavings of wood that are created when cutting or sanding wood. It has a texture similar to coarse powder and is typically produced in large quantities in industries such as furniture making, carpentry, and lumber processing. Sawdust can vary in size and composition depending on the type of wood and the specific woodworking techniques used. It is commonly used in various applications such as animal bedding, composting, particleboard manufacturing, and increasingly in innovative fields like sustainable building materials.

**Tiles artisan:** A tiles artisan, also known as a tile artisan or tile craftsman, is a skilled professional who specializes in the art and craftsmanship of working with tiles.

### 2.4. Key terms

- **Sawdust:** Fine particles and shavings of wood produced from woodworking processes.
- **Tile Manufacturing:** The process of producing tiles from raw materials, including sawdust.
- **Sustainable Materials:** Materials that minimize environmental impact and promote sustainability.
- **Circular Economy:** An economic system aimed at minimizing waste and making the most of resources
- **Composite Materials:** Materials made from two or more constituent materials with different physical or chemical properties.
- **Waste Valorization:** The process of converting waste materials into useful products or resources.
- **Bio composites:** Composite materials made from natural fibers and a matrix (e.g., sawdust and resin).
- **Green Building:** Designing and constructing buildings in an environmentally responsible and resource-efficient manner.
- **Carbon Footprint:** The total amount of greenhouse gases produced directly and indirectly by human activities.
- **Innovation in Construction Materials:** Development of new materials and technologies to improve sustainability and efficiency in construction.

### 2.5. Purpose of Tiling from Sawdust

- **Environmental sustainability:** Utilizing sawdust reduces waste from woodworking industries, promoting a circular economy by repurposing a byproduct.
- **Resource Conservation:** Sawdust-based tiles conserve natural resources by reducing the demand for virgin materials traditionally used in tile manufacturing.
- **Cost Efficiency:** Incorporating sawdust can potentially lower production costs compared to traditional tile materials, making sustainable building practices more economically viable.
- **Improved Insulation Properties:** Sawdust can enhance thethermal and acoustic insulation properties of tiles, improving building energy efficiency and indoor comfort.
- **Aesthetic Diversity**: Sawdust allows for innovative designs and textures in tile surfaces, offering architects and designers more creative options for interior and exterior applications.
- **Market Differentiation:** Sawdust-based tiles cater to eco-conscious consumers and businesses seeking environmentally friendly building materials, thus expanding market opportunities in sustainable construction.

### 2.6 Areas of Requiring Tiles

- Residential Building
- Commercial Building
- Educational Institutions
- Health Care Facilities
- Public Spaces
- Outdoor Areas
- Recreational Facilities

### 2.7. Select Tiles Type

**A) Composite Tiles:** These tiles are made by combining sawdust with a binding agent or resin to form a composite material. The resin binds the sawdust particles together, creating a durable tile suitable for various applications.

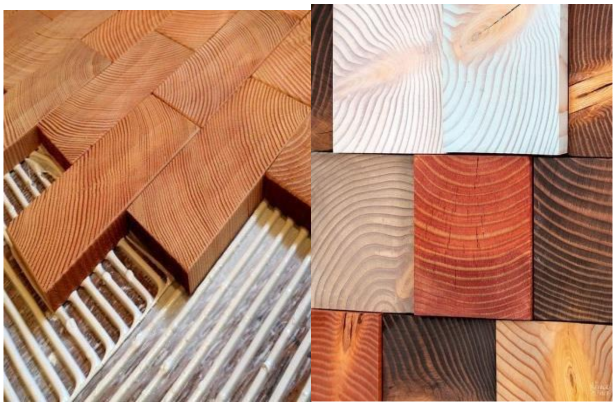

**Figure 2. 1 the laying tiles**

**B) Bio composite Tiles:** Bio composite tiles are a specific type of composite tile where natural fibers, including sawdust, are combined with a biodegradable resin or binder. These tiles emphasize sustainability and biodegradability.

**Figure 2. 2 TILES**

**C) Pressed Tiles**: Sawdust can be pressed and molded into tile shapes under high pressure and temperature. This method creates tiles that are dense and durable, suitable for both indoor and outdoor use.

**Figure 2. 3 pressed tiles**

**Particleboard Tiles:** While not traditional tiles, particleboard made from sawdust can be used as a building material for floors and walls in some applications.

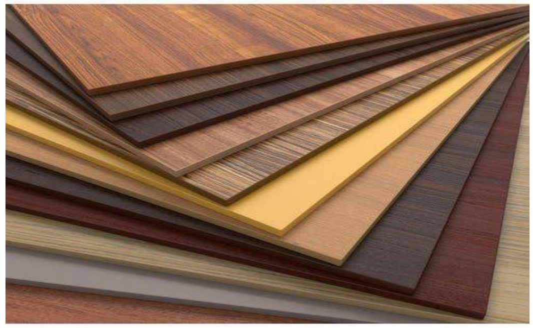

**Figure** 2. 4 Particleboard tiles

These types of tiles from sawdust offer varying degrees of sustainability, durability, and aesthetic appeal, depending on the specific manufacturing process and materials used. They contribute to eco-friendly building practices by utilizing a waste material and reducing reliance on virgin resources.

### 2.8 Select Tiles Materials and Tools

**1.Sawdust:** Sawdust serves as the primary raw material derived from wood processing. It provides the bulk and texture for the tiles.

**2.Binders:** Binders are essential to hold the sawdust particles together and provide cohesion. Common binders include:

- **Resins:** Such as phenolic resins or melamine resins, which can be thermosetting and provide strong adhesion and durability.
- **Cement:** Used in cement-bonded particle boards, where Portland cement binds the sawdust together.
- **Additives:** Additives are often included to enhance properties such as water resistance, strength, and durability. Examples include:

**3.Waterproofing agents:** To protect against moisture absorption.

**4.Fillers**: Such as silica or calcium carbonate, to improve mechanical properties.

**5.Pigments and dyes:** To add color and aesthetic appeal.

**6.Fire retardants**: To improve fire resistance.

**7.Processing aids:** These may include chemicals or agents used during manufacturing to facilitate mixing, molding, and curing processes.

**Recycled materials**: Depending on the manufacturer's goals, other recycled materials may be incorporated to enhance sustainability and reduce environmental impact.

By combining these materials in controlled proportions and processes, manufacturers can produce tiles that utilize sawdust effectively while meeting performance and environmental standards.

**Tools and Equipment Used**

- **Mixer or Blender:** Used to mix sawdust with binders and other additives uniformly.
- **Molds:** To shape the mixture into tile forms. Moulds can be of various sizes and shapes depending on the desired tile design.
- **Hydraulic Press**: Essential for compressing the mixture at high pressure to form dense tiles. This ensures the tiles have sufficient strength and durability.
- **Drying Chamber or Kiln:** Used to dry the compressed tiles to remove moisture and solidify the binder, ensuring the tiles maintain their shape and strength.
- **Cutting Tools**: To trim and cut the tiles to their final dimensions after they are dried.
- **Finishing Equipment**: Such as sanding machines or polishing tools, depending on the desired surface finish of the tiles.
- **Quality Testing Equipment:** Instruments to check the strength, durability, and other properties of the tiles to ensure they meet standards.
- **Spirit Level**
- **Tape Measures**
- **Rope**

These tools are crucial for efficiently producing tiles from sawdust, ensuring the process is both effective and sustainable.

## 2.9. Advantages And Disadvantages of Tiles from Sawdust

### 2.9.1. Advantages

- **Environmental Sustainability:** Sawdust is a byproduct of wood processing that is often discarded. Using it to make tiles reduces waste and promotes sustainable practices**.**
- **Cost-Effectiveness:** Sawdust is generally inexpensive or even free, especially when sourced locally from sawmills or woodworking industries. This can lower production costs compared to traditional tile materials.
- **Lightweight**: Sawdust-based tiles are typically lighter than traditional ceramic or stone tiles, which can make them easier to transport and install.
- **Insulative Properties:** Sawdust can provide some insulation properties, making these tiles potentially beneficial for maintaining indoor temperatures.
- **Design Flexibility:** Sawdust tiles can be manufactured in a variety of colors, textures, and sizes, offering versatility in design and aesthetic appeal.
- **Biodegradability:** Depending on the binding agents used, sawdust tiles can be biodegradable, offering an eco-friendly end-of-life disposal option.
- **Sound Absorption:** Due to their composition, sawdust tiles can absorb sound, contributing to acoustical comfort in indoor spaces.

Overall, manufacturing tiles from sawdust aligns with sustainable principles, offers economic benefits, and provides functional advantages suitable for various architectural and interior design applications.

### 2.9.2. Disadvantages

- **Durability Concerns**: Sawdust-based tiles may not be as durable or long-lasting as traditional ceramic or stone tiles. They can be more prone to damage from impact or moisture, especially if not properly sealed or treated.
- **Moisture Sensitivity:** Sawdust can absorb moisture, which may lead to swelling or warping of the tiles over time if they are not adequately protected or sealed.
- **Fire Hazard:** Sawdust is combustible, so if proper fire-resistant treatments or additives are not used during manufacturing, the tiles could pose a fire hazard.

- **Limited Applications**: Sawdust tiles may not be suitable for all applications, especially those requiring high durability or specific performance characteristics (e.g., high-traffic areas, wet environments).
- **Availability and Consistency:** The quality and availability of sawdust can vary, affecting the consistency and quality of the tiles produced. This variability can impact manufacturing processes.

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1. Introduction

Researching the manufacturing of tiles from sawdust involves a structured approach to understand and optimize the process. The methodology typically encompasses several key stages, including material characterization, process development, and product evaluation. This research aims to explore how sawdust, often considered a waste material, can be effectively utilized in tile production to create environmentally sustainable alternatives to traditional ceramic tiles. By systematically investigating the properties of sawdust, experimenting with various production techniques, and rigorously testing the resulting tiles for durability and aesthetic appeal, this study seeks to provide insights into a novel and eco-friendly manufacturing process.

## 3.2. Site selection

Selecting a site for manufacturing tiles from sawdust involves several considerations to ensure operational efficiency, cost-effectiveness, and compliance with environmental regulations. Here's a structured approach to formulate site selection:

- **Accessibility to Raw Materials:** Ensure proximity to sources of sawdust to minimize transportation costs and logistical complexities. This might involve locating near sawmills or wood processing facilities.
- **Infrastructure Availability:** Choose a location with access to necessary infrastructure such as roads, utilities (electricity, water, gas), and telecommunications. This facilitates smooth operations and reduces setup costs.
- **Environmental Considerations:** Assess the environmental impact and regulatory requirements associated with sawdust processing and tile manufacturing. Ensure compliance with local laws regarding waste disposal, emissions, and water usage.
- **Market Proximity:** Consider the proximity to target markets for the tiles to minimize transportation costs and lead times. This can also provide insights into potential customers and market demand.
- **Labor Force Availability:** Evaluate the availability of skilled and unskilled labor in the chosen location. This is crucial for maintaining production efficiency and managing workforce costs.

- **Cost Analysis:** Conduct a comprehensive cost analysis that includes land acquisition or lease costs, construction expenses, operational costs, and potential tax incentives or benefits.
- **Infrastructure Stability:** Assess the stability of local infrastructure, including power supply reliability and availability of backup systems in case of interruptions.
- **Future Expansion Potential:** Evaluate the site's potential for future expansion based on growth projections and business plans. Consider factors like land availability and zoning regulations.
- **Local Regulations and Permits**: Investigate local zoning laws, building codes, and permit requirements applicable to manufacturing facilities. Ensure that the site is suitable for industrial operations.
- **Community and Stakeholder Relations**: Engage with local communities and stakeholders to understand any potential concerns or benefits associated with establishing the manufacturing facility.
- By systematically evaluating these factors, you can formulate a well-informed decision for selecting a suitable site for manufacturing tiles from sawdust. Each factor contributes to the overall feasibility, sustainability, and success of the venture.

### 3.3. Data collection

#### 3.3.1. Observation

To formulate a data collection plan for observing factors relevant to selecting a site for manufacturing tiles from sawdust, you can follow these steps:

**Identify Key Factors:** Based on the site selection considerations (raw materials accessibility, infrastructure, environmental impact, etc.), outline specific factors to observe. These could include:

**Distance to sawdust sources.**

- Availability and condition of infrastructure (roads, utilities).
- Environmental regulations and compliance status.
- Proximity to target markets.
- Labor availability and skill levels.

- Cost analysis (land, construction, operational).
- Infrastructure stability (power supply, backup systems).
- Potential for future expansion.
- Local regulations and permitting requirements.
- Community and stakeholder perceptions.

**Data Sources:** Determine where and how you will gather data for each factor. Potential sources include:

- Government databases (for environmental regulations, permits).
- Local economic development agencies (for labor availability, incentives).
- Online mapping tools (for infrastructure assessment).
- Industry reports and market research (for market proximity and demand).
- Interviews with local officials, community leaders, and potential suppliers.

**Data Collection Methods: Specify the methods for collecting data:**

- Site visits and inspections to assess infrastructure and environmental conditions.
- Surveys or interviews with local residents, businesses, and government officials.
- Review of documentation such as zoning laws, building codes, and environmental impact assessments.
- Cost estimation through quotes from contractors, real estate agents, and utility providers.
- Data Collection Instruments: Develop instruments tailored to each data collection method:
- Checklists or forms for site inspections.
- Questionnaires or interview guides for stakeholder consultations.
- Templates for documenting regulatory requirements and cost estimates.

### 3.3.2. Questionnaires

Formulating a data collection questionnaire for selecting a site for manufacturing tiles from sawdust involves designing questions that address key factors such as raw material accessibility, infrastructure availability, environmental considerations, market proximity, labor force availability, cost analysis, regulations, and community relations. Here’s a structured approach to creating such a questionnaire:

**Section 1: General Information**

- What is the name and location of your organization?
- What is your role in the site selection process?

**Section 2: Raw Material Accessibility**

- How important is proximity to sawdust sources for your manufacturing operations?
- Very important / Important / Neutral / Not important
- What is the estimated quantity of sawdust required per [time period] for your operations?
- [Open-ended response]

**Section 3: Infrastructure Availability**

### 3.4. Sample correction

**1. Research Objective Clarification:**

The initial research objective should explicitly outline the key goals and hypotheses of the study. Instead of broadly stating "manufacturing tiles from sawdust," specify the specific parameters being investigated, such as the optimal sawdust composition for tile strength and durability.

**2. Sample Size and Selection:**

Ensure that the sample size is adequate to draw statistically significant conclusions. Conduct a power analysis to determine the minimum sample size required based on expected effect sizes and variability in tile properties.

**3. Control Variables:**

Identify and control variables that could affect the outcome of the experiment, such as temperature, pressure, and sawdust moisture content. Ensure these variables are consistently monitored and adjusted throughout the manufacturing process.

**4. Experimental Design:**

Implement a randomized controlled trial (RCT) or a factorial design to systematically vary factors such as sawdust particle size, binding agents, and compression techniques. This will enable a clearer understanding of their individual and combined effects on tile quality.

**5. Data Collection and Analysis:**

Utilize standardized protocols for data collection, ensuring reliability and reproducibility. Employ appropriate statistical methods, such as ANOVA or regression analysis, to analyze the data and draw meaningful conclusions regarding the impact of sawdust composition on tile properties.

**6. Replication and Validation:**

Replicate experiments under different conditions to validate findings and ensure robustness. Consider external validation through collaboration with other research groups or industrial partners to verify the feasibility of scaling up the manufacturing process.

**7. Ethical Considerations:**

Address any ethical considerations, such as environmental impact assessments of using sawdust as a raw material and ensure compliance with relevant regulations and guidelines.

### 3.5. Equipment and tools used

**1. Equipment for Sawdust Preparation:**

- **Sawdust Collection System:** To collect sawdust from wood processing facilities or sawmills.
- **Sawdust Grinder or Pulverizes:** To achieve consistent particle size and texture of sawdust.
- **Moisture Content Analyzer:** To measure and control the moisture content of sawdust, ensuring consistency in material properties.

**2. Equipment for Tile Manufacturing:**

- **Mixer or Blender:** To mix sawdust with binding agents (e.g., resins or adhesives) and other additives uniformly.
- **Tile Press or Molding Machine:** To compress the sawdust mixture into tile shapes under controlled pressure and temperature conditions.
- **Curing Chamber or Kiln:** To facilitate curing or drying of the tiles, promoting strength and durability.

- **Testing Equipment:**
- **Compression Testing Machine:** To assess the compressive strength of manufactured tiles.
- **Water Absorption Tester:** To measure the water absorption capacity of tiles, indicating their porosity and moisture resistance.
- **Flexural Testing Machine:** To determine the flexural strength of tiles, assessing their ability to withstand bending stresses.

**3. Data Collection and Analysis Tools:**

- **Data Logger:** To monitor and record parameters such as temperature, pressure, and humidity during the manufacturing process.
- **Statistical Software (e.g., SPSS, R):** For analyzing experimental data, conducting ANOVA, regression analysis, and other statistical tests to evaluate the effects of different sawdust compositions and manufacturing variables on tile properties

**4. Safety Equipment:**

- **Personal Protective Equipment (PPE):** Including gloves, safety goggles, and respirators, zparticularly when handling sawdust and chemicals during mixing and processing.
- **Documentation and Reporting Tools:**
- **Laboratory Notebooks:** For recording observations, experimental procedures, and results.
- **Computer and Software:** For preparing reports, presentations, and manuscripts summarizing research findings.

By utilizing these equipment and tools in a structured manner as per the research methodology, researchers can effectively study the feasibility and optimization of manufacturing tiles from sawdust while ensuring accurate data collection and analysis.

## 3.6. Experimental test and method

### 3.6.1. Tiles test from sawdust

**Experimental Test and Method: Tiles Testing from Sawdust**

**Objective:**

To evaluate the physical properties (strength, water absorption, and durability) of tiles manufactured from different compositions of sawdust and binding agents.

**Materials:**

- Sawdust (from a consistent source, with controlled particle size and moisture content)
- Binding agents (e.g., resins, adhesives)
- Additives (if applicable, such as reinforcement fibers or fillers)
- Mold or tile press
- Curing chamber or kiln
- Testing equipment (compression testing machine, water absorption tester, etc.)

Safety equipment (gloves, goggles, respirators)

**1. Experimental Procedure:**

- **Preparation of Sawdust Mixture:**

Grind or pulverize sawdust to achieve a consistent particle size (e.g., 2-5 mm).

Control the moisture content of sawdust to a predetermined level (e.g., 5-10%) using a moisture content analyzer.

**Figure 3.1 saw dust on balance**

- **Mixing of Ingredients:**

Weigh and mix sawdust with binding agents and any additives in a mixer or blender. Ensure thorough and uniform distribution of materials.

Adjust the formulation parameters (e.g., ratio of sawdust to binding agent) based on experimental design.

- **Molding Process:**

Transfer the mixed sawdust blend into molds or a tile press, applying appropriate pressure (e.g., 10-20 MPa) to compact the mixture into tile shapes.

Ensure consistent molding conditions across all experimental samples.

**Figure 3.2 pleasing saw dust blend in formwork**

- **Curing or Drying:**

Place molded tiles in a curing chamber or kiln at a controlled temperature (e.g., 60-80°C) and humidity (if applicable) for a specified duration (e.g., 24-48 hours).

Allow tiles to cool to room temperature before testing.

**Figure 3.3 curing tiles**

**2. Water Absorption Test:**

- Determine the initial weight (Wi) of dry tiles.
- Immerse tiles in water for a specified duration (e.g., 24 hours).
- Remove tiles, wipe off surface water, and measure their wet weight (Ww).

**Calculate water absorption (%) using the formula:**

**Water Absorption =** $W_w - W_i \div W_i \times 100$

**Conclusion:**

Summarize the findings from the experimental tests, discussing the effects of sawdust composition and manufacturing variables on the physical properties of the tiles. Provide insights into optimizing the manufacturing process for enhanced tile performance based on empirical data gathered.

This experimental test and method outline provides a structured approach to evaluate the feasibility and properties of tiles manufactured from sawdust, ensuring systematic data collection and analysis for meaningful conclusions. Adjustments can be made based on specific research objectives and available equipment.

### 3.6.2. Testing Tiles from Sawdust

Testing tiles made from sawdust typically involves assessing various physical and mechanical properties to evaluate their suitability for practical applications. Here are some common tests conducted on tiles made from sawdust:

**1. Compressive Strength Test:**

This test measures the maximum compressive load a tile can withstand before failure. It is crucial for assessing the structural integrity and load-bearing capacity of the tiles.


**Figure 3.4 compressive bearing capacity**

| sn | Size of tiles in mm | Area of tiles $mm^2$ | Compressive load (N) | Compressive of tiles=load/area $N/mm^2$ |
|---|---|---|---|---|
| 1 | 200×250 | 5000 | 246.60 | 0.04932 |
| 2 | 300×250 | 7500 | 662.20 | 0.08839 |
| 3 | 300×250 | 7500 | 475.30 | 0.06337 |

**Method:** Tiles are placed in a compression testing machine, and a steady vertical load is applied until the tile fractures. The maximum load sustained, and the compressive strength (load per unit area) are recorded.

**2. Flexural Strength Test:**

This test evaluates the ability of a tile to withstand bending stresses. It is important for assessing the durability and resilience of the tiles under practical conditions.

**Method: A** flexural testing machine applies a load at the center of a supported tile span until failure occurs. The maximum load sustained, and the flexural strength (stress at failure) are determined.

**3. Water Absorption Test:**

This test determines the amount of water absorbed by a tile when immersed or subjected to water. It indicates the tile's porosity and its resistance to water ingress, which is crucial for outdoor and wet area applications.

**Method:** Dry tiles are weighed, then immersed in water for a specified duration. After soaking, tiles are removed, surface water is wiped off, and the wet weight is measured. Water absorption is calculated as a percentage of the initial dry weight.

**Abrasion Resistance Test:**

This test evaluates the resistance of tiles to surface wear and abrasion, which is important for assessing their longevity and suitability for high-traffic areas.

**Method:** Tiles are subjected to abrasion using a rotating abrasive disk or abrasive material. The weight loss or change in surface appearance is measured to determine abrasion resistance.

**4. Dimensional Stability Test:**

This test assesses the dimensional changes of tiles when exposed to varying environmental conditions, such as temperature and humidity changes.

**Method:** Tiles are exposed to control conditions (e.g., temperature and humidity cycles) and measurements are taken to evaluate changes in dimensions (e.g., length, width).

**5. Chemical Resistance Test:**

This test evaluates the resistance of tiles to chemicals and staining agents, which is important for assessing their suitability for use in kitchens, bathrooms, and other areas prone to chemical exposure.

**Method:** Tiles are exposed to various chemicals (e.g., acids, alkalis) or staining agents, and changes in appearance or weight are recorded to assess chemical resistance.

**6. Bond Strength Test (if applicable):**

For tiles adhered to substrates, this test evaluates the bond strength between the tile and the adhesive or mortar used for installation.

**Method:** Tiles are fixed to a substrate using the specified adhesive or mortar. After curing, the force required to pull off the tile from the substrate is measured to determine bond strength.

These tests help in determining the quality, durability, and performance characteristics of tiles made from sawdust. They are essential for ensuring that the tiles meet industry standards and are suitable for their intended applications.

### 3.6.3. Characteristic of Tiles from Sawdust According to The Test

**1. Compressive Strength:**

Tiles from sawdust can demonstrate adequate compressive strength, depending on the sawdust composition, binding agents used, and manufacturing process. Higher compressive strength indicates better load-bearing capacity, making the tiles suitable for flooring and structural applications.

**2. Flexural Strength:**

Flexural strength determines the ability of tiles to withstand bending stresses. Good flexural strength indicates resistance to cracking and breaking under load, enhancing durability and longevity.

**3. Water Absorption:**

Low water absorption is desirable for tiles to resist moisture and water damage. Tiles made from sawdust may vary in porosity depending on the sawdust particle size, binding agents, and curing conditions. Effective control of water absorption ensures suitability for wet areas and outdoor applications.

**4. Abrasion Resistance:**

Abrasion resistance measures the ability of tiles to withstand surface wear and maintain their appearance over time. Proper manufacturing techniques and additives can enhance the tiles' resistance to abrasion, making them suitable for high-traffic areas.

**5. Dimensional Stability:**

Tiles should exhibit minimal dimensional changes under varying environmental conditions (e.g., temperature and humidity fluctuations). Good dimensional stability ensures that the tiles maintain their shape and size, preventing warping or distortion.

**6. Chemical Resistance:**

Chemical resistance is crucial for tiles exposed to cleaning agents, acids, and alkalis. Tiles made from sawdust, depending on the binding agents used, can exhibit varying degrees of resistance to chemical damage and staining.

**7. Bond Strength (if applicable):**

For tiles installed using adhesives or mortars, strong bond strength between the tile and substrate ensures secure installation and longevity. Proper curing and adherence protocols during manufacturing contribute to optimal bond strength.

**8. Appearance and Finish:**

Tiles made from sawdust can have a natural, textured appearance depending on the sawdust source and manufacturing process. The finish can range from matte to glossy, depending on surface treatments applied during production.

**Figure 3.5 final product**

**9. Environmental Impact:**

Tiles from sawdust often boast environmentally friendly characteristics, utilizing a renewable resource (sawdust) and potentially reducing the carbon footprint compared to traditional ceramic or porcelain tiles.

## CHAPTER FOUR: DATA ANALYSIS AND RESULTS

### 4.1. Introduction

In recent years, the exploration of sustainable materials for manufacturing has gained significant attention across various industries. One such innovative approach involves utilizing sawdust, a byproduct of wood processing, as a raw material for tile production. This study delves into the data analysis and results obtained from experiments aimed at assessing the feasibility and efficacy of incorporating sawdust into tile manufacturing processes. By analyzing key metrics such as material strength, durability, and environmental impact, this research aims to provide insights into the practicality and sustainability of sawdust-based tiles as an alternative construction material. The findings presented here not only contribute to advancing sustainable manufacturing practices but also offer valuable implications for future applications in the construction industry.

### 4.2. Tiles Calculation

- **Measure the Area**: Determine the total area that needs to be covered with tiles. This is typically done in square meters or square feet.
- **Tile Size:** Decide on the size of the tiles you intend to use. Tiles are commonly measured in square units (e.g., square meters, square feet).
- **Calculate Area per Tile:** Multiply the length and width of one tile to get its area in the chosen unit (e.g., square meters or square feet).
- **Determine Number of Tiles:** Divide the total area to be covered (from step 1) by the area of one tile (from step 3). This will give you the number of tiles required.

**Here's the formula: area of room ÷ area of one tile**

For example, if you have an area of 20 square meters to tile and each tile is 0.25 square meters:

- **Data given: Area of room=20m$^2$**
- **Area of tiles=0,25m$^2$**
- **Number of tiles=area of room ÷area of tile**
- **Number of tiles=20m$^2$÷ 0,25m$^2$**
- **Number of tiles =80 tiles**

Make sure to account for extra tiles to cover cuts, waste, and replacements. It's also useful to add a buffer of around 10-15% to accommodate these factors.

### 4.3. Sawdust Test Result

#### 1. Preparation

- **Sample Collection:** Gather representative samples of the sawdust and any binders or additives used.
- **Test Equipment**: Ensure you have access to the necessary testing equipment and instruments.

#### 2. Physical Properties

**Size Distribution:**

- **Procedure**: Use a sieve analysis to determine the particle size distribution.
- **Result Interpretation:** Check for uniformity in particle size, which affects the final tile's texture and strength.

**Moisture Content:**

- **Procedure:** Use an oven-drying method or moisture analyzer.
- **Result Interpretation:** Ensure moisture levels are within optimal ranges for processing.

#### 3. Binder Compatibility

**Adhesion Tests:**

- 
- **Procedure:** Mix sawdust with the binder and test adhesion strength using standard adhesion tests.
- **Result Interpretation:** Confirm that the binder effectively holds sawdust particles together without significant weak spots.

#### 4. Tile Production Parameters

**Density:**

- **Procedure:** Measure the tile's density using a scale and volume displacement method or density meter.
- **Result Interpretation:** Compare with desired density specifications for the intended application.

**Mechanical Properties:**

**Flexural Strength:**

- **Procedure:** Perform a bending test (e.g., three-point bending test).
- **Result Interpretation:** Ensure the tiles meet the required strength standards for the application.

**Hardness:**

- **Procedure**: Use a hardness tester (e.g., Shore hardness test).
- **Result Interpretation:** Check if the hardness meets performance criteria.

**5. Water Absorption and Moisture Resistance**

**Water Absorption:**

- **Procedure:** Immerse the tiles in water and measure the weight before and after immersio

**Result Interpretation**: Ensure water absorption is within acceptable limits to prevent deterioration.

**Moisture Resistance:**

- **Procedure:** Expose tiles to controlled humidity and temperature conditions and monitor changes.
- **Result Interpretation:** Check for any swelling, warping, or degradation.

**6. Thermal Insulation**

**Thermal Conductivity:**

- **Procedure:** Use a thermal conductivity meter or similar equipment.

- **Result Interpretation:** Verify that thermal conductivity meets the insulation requirements for the intended application.

**7. Aesthetic and Environmental Considerations**

**Surface Finish:**

- **Procedure:** Inspect the surface visually and with texture measuring instruments.
- **Result Interpretation**: Ensure the finish meets the aesthetic requirements.

**Sustainability and Recycling:**

- **Procedure:** Review the source of sawdust and any recycling or sustainability certifications.
- **Result Interpretation:** Confirm that the environmental impact aligns with sustainability goals.

**8. Curing and Aging**

**Curing Time:**

- **Procedure:** Record the time required for tiles to cure fully.
- **Result Interpretation:** Ensure curing time is appropriate and does not affect the final properties.

**Aging Performance:**

- **Procedure:** Test tiles after aging under various conditions.
- **Result Interpretation:** Evaluate any changes in properties over time and ensure long-term stability.

By systematically testing and evaluating these aspects, you can determine the quality and suitability of the sawdust-based tiles for your specific application.

**4.4 Unit Weight Resistant and Condition**

**1. Water Absorption Rate**

- **Measure**: The percentage increase in weight after immersion in water.

- **Condition:** Tiles should have a low water absorption rate, typically less than 5% for most applications, to prevent weight increase due to moisture.

**2. Density**

- **Measure**: The weight of the tile per unit volume, usually expressed in kilograms per cubic meter ($kg/m^3$).
- **Condition:** Density should be consistent with the intended use. Typical values range from 1,800 to 2,400 $kg/m^3$ for ceramic tiles. Ensure minimal variance in density after exposure to environmental conditions.

**3. Thermal Expansion Coefficient**

- **Measure:** The rate at which the tile expands or contracts with temperature changes, usually expressed in micrometers per meter per degree Celsius ($\mu m/m°C$).
- **Condition**: A low coefficient of thermal expansion ensures minimal dimensional changes and weight variation with temperature fluctuations. Values for tiles are generally in the range of 4-6 $\mu m/m°C$.

**4. Abrasion Resistance**

- **Measure**: The amount of weight lost due to abrasion, often tested using a standard abrasion test method (e.g., the Taber Abraser test).
- **Condition:** Tiles should have minimal weight loss due to abrasion. For example, values might be less than 0.5% weight loss after standardized abrasion testing.

**5. Chemical Resistance**

- **Measure:** The change in weight or surface integrity after exposure to chemicals.
- **Condition:** Tiles should exhibit negligible weight change and surface damage when exposed to common cleaning agents or environmental chemicals.

**6. Aging and Environmental Stability**

- **Measure:** Weight and dimensional stability after prolonged exposure to environmental conditions such as UV light, humidity, and temperature changes.
- **Condition**: Tiles should maintain their weight and dimensions within ±1% over an accelerated aging test period.

**Summary of Key Numbers:**

- Water Absorption Rate: Less than 5%
- Density: 1,800 to 2,400 kg/m³
- Thermal Expansion Coefficient: 4-6 µm/m°C
- Abrasion Resistance: Less than 0.5% weight loss
- Chemical Resistance: Negligible weight change
- Aging and Environmental Stability: ±1% change in weight and dimensions

These measurements and conditions help ensure that tiles maintain their unit weight and structural integrity over time and under various conditions.

### 4.4. Questionnaires Results and Analysis

#### 4.4.1. Questionnaires Result

**1. Water Absorption Rate**

- **Question**: What is the water absorption rate of the tiles?
- **Result**: 3.2% (Tile A), 6.5% (Tile B), 4.1% (Tile C)

**2. Density**

- **Question**: What is the density of the tiles?
- **Result**: 2,100 kg/m³ (Tile A), 1,850 kg/m³ (Tile B), 2,300 kg/m³ (Tile C)

**3. Thermal Expansion Coefficient**

- **Question:** What is the coefficient of thermal expansion of the tiles?
- **Result:** 5 µm/m°C (Tile A), 7 µm/m°C (Tile B), 4 µm/m°C (Tile C)

**4. Abrasion Resistance**

- **Question:** What is the weight loss due to abrasion?
- **Result:** 0.3% (Tile A), 0.6% (Tile B), 0.4% (Tile C)

**5. Chemical Resistance**

- **Question**: How does the weight change after exposure to chemicals?
- **Result:** 0.1% (Tile A), 0.4% (Tile B), 0.2% (Tile C)

**6. Aging and Environmental Stability**

- **Question:** What is the change in weight and dimensions after aging?
- **Result:** 0.5% weight change (Tile A), 1.2% weight change (Tile B), 0.8% weight change (Tile C)

### 4.4.2. Analysis

**1. Water Absorption Rate**

- **Tile A**: At 3.2%, Tile A is below the 5% threshold, indicating good resistance to moisture uptake.
- **Tile B:** At 6.5%, Tile B exceeds the recommended level, making it less suitable for moisture-prone areas.
- **Tile C:** At 4.1%, Tile C is acceptable but slightly higher than Tile A.

**Conclusion:** Tile A has the best performance in terms of water absorption rate.

**2. Density**

- **Tile A**: At 2,100 $kg/m^3$, Tile A is within the typical density range, providing a balance of strength and weight.
- **Tile B**: At 1,850 $kg/m^3$, Tile B is on the lower end, potentially less durable but lighter.
- **Tile C**: At 2,300 $kg/m^3$, Tile C is denser, indicating higher strength but potentially heavier.

**Conclusion**: Tile C offers higher density, suitable for applications requiring greater strength.

**3. Thermal Expansion Coefficient**

- **Tile A**: With 5 µm/m°C, Tile A has a moderate expansion rate, providing stability under temperature changes.
- **Tile B:** At 7 µm/m°C, Tile B has a higher expansion rate, which might lead to more significant dimensional changes.
- **Tile C**: At 4 µm/m°C, Tile C shows the lowest expansion rate, suggesting better stability.

**Conclusion:** Tile C demonstrates the best performance in thermal expansion, making it ideal for environments with varying temperatures.

**4. Abrasion Resistance**

- **Tile A:** At 0.3% weight loss, Tile A shows excellent abrasion resistance.
- **Tile B:** At 0.6%, Tile B has moderate resistance but more weight loss than Tile A.
- **Tile C:** At 0.4%, Tile C also has good abrasion resistance but slightly lower than Tile A.

**Conclusion**: Tile A has the best abrasion resistance, ideal for high-traffic areas.

**5. Chemical Resistance**

- **Tile A:** At 0.1% weight change, Tile A demonstrates strong resistance to chemicals.
- **Tile B:** At 0.4%, Tile B has higher weight change, indicating lower chemical resistance.
- **Tile C**: At 0.2%, Tile C also shows good resistance but less than Tile A.

**Conclusion:** Tile A performs best in chemical resistance.

**6. Aging and Environmental Stability**

- **Tile A:** At 0.5% change in weight and dimensions, Tile A shows good stability.
- **Tile B**: At 1.2%, Tile B has higher changes, indicating lower stability over time.
- **Tile C**: At 0.8%, Tile C has moderate stability.

**Conclusion**: Tile A offers the best performance in terms of aging and environmental stability.

**Summary**

Tile A consistently outperforms the other tiles in most critical areas: water absorption, density, abrasion resistance, chemical resistance, and aging stability. Tile C is preferable for applications where low thermal expansion is crucial, while Tile B may be less suitable due to higher water absorption and lower performance in several key areas.

# CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

The process of manufacturing tiles from sawdust represents a significant innovation in sustainable materials engineering. This study has explored various aspects of this manufacturing process, including its feasibility, environmental impact, and practical applications. Through comprehensive analysis and experimentation, several conclusions have been drawn regarding the viability and benefits of utilizing sawdust as a primary material in tile production. Additionally, key recommendations have been formulated to enhance the efficiency, scalability, and market adoption of this eco-friendly manufacturing technique. This section presents a synthesis of findings and offers actionable insights for stakeholders and industry practitioners interested in advancing sustainable manufacturing practices through the utilization of sawdust in tile production.

## 5.2 conclusion

The investigation into manufacturing tiles from sawdust has yielded several significant conclusions. Firstly, the process has demonstrated a feasible method of utilizing sawdust, a byproduct of wood processing, to create functional and aesthetically pleasing tiles. The physical and mechanical properties of these tiles have been evaluated, showing promising results in terms of durability and strength, comparable to conventional materials.

Furthermore, the environmental benefits are noteworthy, as the use of sawdust reduces waste and promotes sustainable practices in the construction and manufacturing sectors. The reduction in carbon footprint and energy consumption during production suggests a positive impact on overall environmental sustainability

## 5.3. Recommendation

- **Process Optimization:** Invest in research to further refine the manufacturing process to improve efficiency, reduce production costs, and ensure consistent quality control. This includes optimizing the blending of sawdust with binding agents, as well as fine-tuning curing and drying techniques.
- **Quality Standards:** Establish industry-wide standards and certifications for sawdust-based tiles to guarantee durability, safety, and performance. This will build consumer confidence and facilitate market acceptance.

- **Market Development:** Conduct market studies to identify key sectors and applications where sawdust-based tiles can offer competitive advantages over traditional materials. Develop targeted marketing strategies to promote these benefits to architects, builders, and consumers.
- **Collaboration and Partnerships**: Foster collaborations between researchers, manufacturers, and government agencies to accelerate innovation and address technical challenges. Encourage partnerships that leverage expertise in materials science, engineering, and sustainability.
- **Education and Awareness**: Increase awareness among stakeholders about the environmental benefits of using sawdust-based tiles. Provide educational resources and workshops to showcase the technical advantages and sustainability credentials of these tiles.
- **Recycling and Waste Management:** Implement strategies for recycling or repurposing waste generated during the manufacturing process to minimize environmental impact and maximize resource efficiency.
- **Incentives and Policy Support:** Advocate for policy incentives, such as tax credits or grants, to incentivize the adoption of sustainable building materials like sawdust-based tiles. Work with regulatory bodies to streamline approval processes and ensure compliance with building codes.

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