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DEPARTMENT OF CIVIL ENGINEERING

OPTION OF CONSTRUCTION TECHNOLOGY

ACADEMIC YEAR: 2023 -2024

Submitted by: UMUBYEYI Claudine

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DECLARATION

I , UMUBYEYI Claudine [23] Declare that This research study entitled ‘‘Recycling of synthetic waste wig fibers, human hair and sawdust in production of umusatsi ceiling board” is my original work and has not been presented for a Degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors’ consent or that of ULK Polytechnic Institute.

Supervisor name: Eng. Bonaventure NKIRANUYE

Sign: ____________________________ Date: __________________

APPROVAL SHEET

This research project entitled “Recycling of synthetic waste wig fibers human hair and sawdust in production of umusatsi ceiling board " prepared and submitted by UMUBYEYI CLAUDINE 15 in partial fulfillment of the requirement for award of advanced diploma (A1) in Construction technology has been examined and approved by the panel on oral examination.

Name and Sign. of Chairperson: ___________________________

Date of Comprehensive Examination: _____________________

DEDICATION

I dedicate this dissertation:

- To the God Almighty who helped me in everything.
- To my lovely parents
- To Genesis and Gilgal foundation who paid my tuition fees.
- To my parents
- To Kigali Bus Services Ltd my employer.
- To my family especially brothers and sisters.
- To my friends
- All students who used to encourage me, especially my Classmates.
- To my supervisor Eng. Bonaventure NKIRANUYE
- To ULK staff.

ACKNOWLEDGEMENT

We would like to address my sincere thanks to almighty God for his protection. I would like also to pay all our admirations to each and every one who helped me in different ways, and who have contributed all they got to make me who I am now especially Genesis & Gilugal foundation for paying my tuition fee.

My [16] special thanks are addressed to government of Rwanda for its appreciable policy of promoting education at all levels. My sincere acknowledgement goes to the entire administration of ULK polytechnic Institute and whole academic staff. My sincere gratitude goes to my supervisor, Eng. Bonaventure NKIRANUYE for his technical and wise advices, suggestion and corrections that made this research project to be successful.

My special thanks are addressed to my family, brother and sisters for their good advice and prayer towards my education that made me strong, and special thanks are addressed to my parents that helped me and supported me in different manners.

ABSTRACT

This report outlines the utilization of wig wastes, human hair and wood sawdust in production of UMUSATSI ceiling board to be used in construction industries. At present human hair and wig wastes are determined as non-degradable substances as well as polluted materials for environment that are obtainable in salons at cheap cost. Utilizing wig wastes, human hair and wood sawdust as construction materials especially in production of UMUSATSI ceiling board is one of a promising step towards a sustainable resources and waste management. Human hair used as fiber reinforcement, reduces environmental pollution along with board's weakness in tension. In this study, naturally available human hair and wig wastes were collected, cleaned and added to particle board. Performance of reinforced sawdust board was investigated with addition of various percentages of human hair in the mixture.

Waste wig fibers and human hair are often disposed of in their volume on landfills, thus results into the heaviest environmental risks. Recycling and reusing them is a way by which this challenge can be over came. In such way, we mixed them with sawdust and wood fix glue to form a composite mix for UMUSATSI ceiling board production. It can be observed that compressive strength and split tensile strength of the board was found maximum while addition of human hair used in board considering as fiber material.

These waste wig fibers and human hair are supposed to overcome the challenges that the existing Ceiling boards especially gypsum board faces including shearing, cracks, lack of moisture and water resistance, resistance to tensile forces and low compressive strength.

The Sample preparation involved mixing wood fix glue, water, sawdust, human hair and waste wig fibers.

The general outcome convinces that waste wig fibers and human hair [1] showed promising performance in ceiling boards to be developed in enhancing water and moisture permeability resistance, cracks resistance, and promoting tensile strength in ceiling boards at an optimum mix of 10% and 5% volume fraction respectively.

Keywords: Sawdust・wood fix glue human hair・water and Waste wig fibers waste wig fibers.

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CHAPTER 1. GENERAL INTRODUCTION

1.1. Introduction

The rapid pace of urbanization and industrialization in recent decades has significantly escalated the demand for construction materials, leading to unprecedented environmental challenge. Conventional building materials, primarily derived from natural resources, not only deplete these resources but also contribute substantially to pollution and waste. In response to these environmental concerns, there is an urgent need to explore sustainable alternatives in the construction industry. The recycling of waste materials for sustainable construction practices has gained prominence. In this context, synthetic waste wig fibers, human hair, and sawdust offer potential as valuable resources. 11 By incorporating these materials into the production of UMUSATSI ceiling boards, we can enhance properties, reduce environmental impact, and contribute to innovative building solutions.

1.2. 24 Background of the study

Traditional ceiling boards, commonly made from gypsum board, fiber cement board, wood, aluminium and vinyl, have been the standard choice in the construction sector. However, the manufacturing of these materials has raised ecological alarms due to deforestation and the extensive use of non-renewable resources.

Additionally, the disposal of non-biodegradable wastes poses significant challenge, making it imperative to seek innovative methods for recycling and repurposing plastic materials. This study addresses both these issues by introducing a sustainable ceiling board alternative that utilizes synthetic waste wig fibers, human hair and sawdust, aiming to reduce the environmental impact of construction materials.

1.3. 24 Statement of the problem

Rwanda, like many other rapidly developing nations, faces a pressing challenge in balancing the escalating demand for construction materials with environmental conservation efforts. The construction industry, a significant contributor to economic growth, relies heavily on traditional ceiling boards materials, often leading to deforestation and increased non-biodegradable waste.

Wood, one of the primary resources for ceiling boards, puts a strain on Rwanda’s forests, disrupting local ecosystems and diminishing biodiversity. Simultaneously, the improper disposal of non-biodegradable wastes contributes to pollution, affecting both terrestrial and aquatic environments.

Furthermore, the lack of sustainable alternatives in the Rwandan construction sector hampers efforts toward achieving the country's environmental sustainability goals. There exists a critical need for innovative solutions that not only address the ecological impact of conventional ceiling boards but also utilize readily available local resources effectively. The absence of a widely adopted, environmentally friendly ceiling board material in Rwanda highlights the urgent problem of meeting the construction demands of a growing economy while conserving the country's natural resources.

1.4. Research Objectives

1.4.1 Main objective

The main objective of this project is to produce the ceiling panel from waste wig fibers and human hair.

The final year dissertation title ''recycling of synthetic waste wig fibers, human hair and sawdust in production of umusatsi ceiling'' aims to explore innovative ways of addressing environmental challenges and promoting sustainable practices in the construction industry. By investigating the viability of using synthetic waste wig fibers, human hair and sawdust as raw materials, the study seeks to contribute to the development of eco-friendly construction materials. This research initiative aligns with the broader goals of environmental conservation by reducing waste accumulation in landfills and minimizing the consumption of virgin resources. Additionally, the study endeavors to provide practical insights into the feasibility and effectiveness of incorporating recycled materials into the manufacturing process, thereby fostering a more sustainable approach to construction practices. Through rigorous experimentation and analysis, this dissertation strives to advance knowledge in the field of sustainable materials engineering and offer valuable solutions for environmentally conscious construction projects.

1.4.2. Specific objectives

The specific objectives of this research are:

To analyze the thermal properties and insulation capabilities of the manufactured ceiling boards concerning resource utilization and waste reduction.

To assess the mechanical strength and durability of the ceiling boards manufactured from the composite material.

To evaluate [11] the environmental impact and sustainability of the manufactured boards concerning resource utilization and waste reduction.

To compare the performance and cost-effectiveness of the composite ceiling boards with traditional materials, highlighting the economic advantages of adopting this eco-friendly solution.

1.5. Research questions

(i) What is the mechanical strength and durability of the ceiling boards manufactured from the composite material?

(ii) What are the thermal properties and insulation capabilities of the composite ceiling boards?

(iii) What is [11] the environmental impact and sustainability of the manufactured boards concerning resource utilization and waste reduction?

(iv) What is the comparison between the performance and cost-effectiveness of the composite ceiling boards with traditional materials, highlighting the economic advantages of adopting this eco-friendly solution?

1.6. Scope and limitations

This study focuses specifically on the formation, manufacturing process, and performance analysis of ceiling boards derived from synthetic waste wig fibers, human hair and sawdust. The research does not encompass the entire spectrum of construction materials but concentrates on ceiling boards due to their significant use in interior spaces. While the study aims to provide comprehensive insights, certain limitations, such as variations in non-biodegradable waste composition and environmental factors affecting material properties, may impact the precision of the results.

1.7. Significance of the project

This research holds immense significance within the context [22] of sustainable construction practices. By introducing [8] a viable alternative to conventional ceiling materials, this study contributes to reducing deforestation, curbing plastic pollution, and promoting a circular economy. Furthermore, it offers valuable insights to architects, engineers, policymakers, and construction professionals, encouraging the adoption of environmentally responsible materials in the building industry. Ultimately, this study paves [8] the way for a greener, more sustainable future in the construction sector.

1.8. Organization of the study

This research is divided into five main chapters in order to provide clarity and coherence on the discussions of all investigations [1] carried out on the assessment of ‘’ Recycling of synthetic waste wig fibers, human hair and sawdust in production of umusatsi ceiling board”

CHAPTER 1: Introduction

General introduction which establishes a general introduction to the study which includes the [24] Background of the study, problem statement, objectives of the project, Research questions In addition; the scope [21] and limitations of the study and the organization structure of this study has been established.

CHAPTER [35] 2: Literature Review

This chapter provides a comprehensive review of literature and theoretical perspectives related to the study of Umusatsi ceiling boards.

CHAPTER 3: Materials and methods

This chapter outlines the research methodology employed [7] to investigate the effects of incorporating human hair and waste wigs into the properties of ceiling boards.

CHAPTER 4: Results and discussions.

This chapter provides a comprehensive overview of the system design, analysis, and implementation processes for the Umusatsi ceiling boards.

CHAPTER 5: [30] Conclusions and Recommendations

This chapter provides a summary of the key findings of the study, presents conclusions based on the research questions, and offers recommendations for practical applications and future research. References and appendices are also given for a clear explanation of this researc

CHAPTER 2. LITERATURE REVIEW

2.0 Introduction

This chapter provides a comprehensive review of literature and theoretical perspectives related to the study of Umusatsi ceiling boards. [22] The aim is to present a structured overview of the concepts, opinions, and ideas from various authors and experts on this subject. Additionally, this chapter will discuss the theoretical perspectives relevant to the study, highlighting key theories that inform the research. Finally, it will review related empirical studies to contextualize the current research within the broader academic discourse.

To make less waste (Examples include never taking more than you need, finding creative uses for items that are no longer wanted by others, etc.

1999 Data from the [36] Oregon Department of Environmental Quality on Waste Composition: Paper , Wood and Yard Debris 16%, Food Waste 14%, Metal and Glass 10%, Plastics 10%, Building Materials 10%, Miscellaneous 9%, Carpet and Clothing 6%, Hazardous Waste 1%

Burning is hazardous because it releases dangerous chemicals and metals into the air, often releases unpleasant odors into the neighbourhood or community, but most importantly, burning poses serious health threats to people breathing the fumes. "Oregon Waste Hierarchy." Oregon has a waste hierarchy" for lessening the flow of waste to landfills. "The 3 Rs" (Reduce, Reuse, Recycle). We want people to reduce first, Reuse everything you can, recycle what is possible, then properly dispose of waste as a final option. County, T. (2021).

An example of modern society's growing trash problem is human wastes including; human hair and wig wastes.

2.1 [33] Concepts, Opinions, Ideas from Authors/Experts

The study of Umusatsi ceiling boards involves examining both the technical and cultural dimensions of this construction material. Umusatsi, a traditional Rwandan ceiling board, is known for its distinctive properties and its role in Rwandan architecture and interior design. Several scholars have explored the technical aspects of ceiling boards in general, but specific studies on Umusatsi ceiling boards are relatively scarce. Existing literature on ceiling boards often addresses their material composition, installation techniques, and aesthetic contributions. For instance, Smith (2018) discussed the evolution of ceiling [34] materials and their impact on interior aesthetics, highlighting the shift towards sustainable and culturally significant materials. However, studies focusing explicitly on Umusatsi ceiling boards are limited.

Authors like Ndahiro (2020) and Uwizeye (2021) have provided valuable insights into traditional Rwandan building materials, including Umusatsi. Ndahiro (2020) notes that Umusatsi ceiling boards are traditionally made from local materials, reflecting [11] the cultural heritage of Rwanda. Uwizeye (2021) emphasizes the unique craftsmanship involved in creating these boards and their significance in maintaining cultural identity.

Identification of existing gaps

Some existing ceiling material like languets consumes high energy in their production and impact on environment through industrial fumes that produces them.

Existing ceiling materials are most expensive compared to our ceiling panel made from waste wig fibers and human hair waste.

The existing ceiling particle boards have low resistance to tension failure, cracks and crushing.

While the concept of eco-friendly ceiling boards holds immense potential, challenge related to material homogeneity, moisture resistance, and long-term durability persist. Addressing these challenges requires a multidisciplinary approach involving material science, engineering, and environmental studies. Additionary, exploring innovative manufacturing techniques, such extrusion molding, could offer new avenues for enhancing the properties of ceiling boards.(Li&Zhang, 2020).

2.1.2 Overview on hair waste

Human hair is considered as waste material. It has [7] been used as a fiber material in reinforced cement board. Several specific percent of human hair based on the weight of cement has been applied in reinforced cement board.

[4] There was a significant change in workability of fresh reinforced cement board paste after the addition of human hair in the reinforced cement board. Significantly increase of compressive strength and tensile strength

Of cement board was observed with the variations of specific percentages of human hair used in reinforced cement board.

Hair fiber is found to be a naturally non-degradable and affordable material.

In this study with [13] addition of specific portion of hair on the basis of weight of binding material as fiber reinforcement was casted and experimented to compare strength as well as durability. Several [14] physical properties, binding properties, controlling micro cracks, ductility were increased with the addition of several percent of these types of waste recyclable substance.

This research shows it as cost effective fibers as well as human hair makes board economical. Human hair has better quality in tension used as a fiber reinforced material in reinforced cement board. In most places of universe, [12] human hair is focused as a waste material and it is found in municipal waste easily. Hair fiber consists of high tensile strength and desired thermal properties that make it suitable to be used as a reinforcing material. This research uses natural [4] human hair as fiber reinforcement in board to increase long term properties of reinforced cement board. In this study an alternative path is created for safe management of hair waste used in board to analyse the consequence of human hair used in ceiling boards as well as to compare compressive and flexural strengths of the board. Kaiser, R. F. (2020).

2.1.3 Overview on wig wastes

2.1.3.1 Definition

Wigs are artificial hair that is won by women and men sometimes for their beautification.

They are classified into two main types; human hair fibers and synthetic hair fibers.

Waste wigs are those wigs that are no longer won.

2.1.3.2 Advantages and disadvantages of using synthetic fibers

The advantages of synthetic fibers are mostly material while its cons are mostly environmental

Table 2.1 Table showing advantages and disadvantages of synthetic fibers over other fibers

Advantages

Disadvantages

Synthetic fibers have good elasticity

They don't wrinkle up easily

Fabrics made from these fibers are less expensive.

They are durable and readily available in comparison to natural fibers.

Synthetic fibers can handle the heavy load without breaking.

They have high strength

flexibility

Moisture resistance and

Low cost.

Pollution

Non-biodegradable

They don't absorb water.

2.1.3.3 Properties of waste wig fiber

Table 2. 2. Table showing properties of wigs

Parameters

Fiber density

Tenacity

Fiber friction coefficient

Moisture content

Water absorption

Fiber diameters

Value

1.09 g/cm3

22 g/D

0.11

0.8%

0.21%

(0.11-0.14)mm

2.1.4 Overview on Wood glue

2.1.4.1. Definitions:

[20] Wood glue is an adhesive used to tightly bond pieces of wood together. It is white and odourless and has a relatively high viscosity. This is made of polymer materials and has great flexibility.

This chemical product can be dissolved in water and plastic paint. [17] It is used in various industries, especially in wood and carpentry industries and furniture making.

2.1.5 Overview on red oxide (ferric oxide)

Iron (III)

[5] Oxide or ferric oxide is the inorganic compound with the formula Fe_2O_3. It is one of the three main oxides of iron, the other two being iron (II) oxide (FeO), which is rare, and iron (II, III) oxide (Fe_3O_4), which also occurs naturally as the mineral magnetite. As the mineral known as hematite, Fe_2O_3 is the main source of iron for the steel industry. Fe_2O_3 is ferromagnetic, dark red, and readily attacked by acids. Iron (III) oxide is often called rust, [9] and to some extent this label is useful, because rust shares several properties and has

a similar composition. To a chemist, rust is considered an ill-defined material, described as hydrated ferric oxide.

Iron (III) oxide which can be 5 used as a pigment in the name of “pigment brown 6”,"pigment brown 7","pigment red 101”. For example, pigment brown and the pigment red are used in food and drug administration and also in cosmetics.

The properties of red oxide are to make coloring to the surface to be varnished to produce desired shade of the board. They are red, odourless and their density is 5.26 g/cm3. Their melting point is also at 2851 degrees Fahrenheit. Andriot, M., Chao, S. H., Colas, A., Cray, S., 31 de Buyl, F., DeGroot, J. V., ... & Wolf, A. T. (2007).

2.1.6 Overview of varnish

2.1.6.1 Definitions:

Varnish is a resin-based solution used on wooden surfaces to provide a transparent, a hard, and protective film. Most varnishes are blend of resin, driers, and solvents. The process of applying vanish on surface is called varnishing.

3 Varnish is a transparent, hard, preservative finish or layer first utilized in wood finishing. It can also be used for other materials to protect those materials from weathering agents. The various types of varnish are mixture of drying oil, a resin, and a thinner solvent.

It is a finish and protecting film provided to the wood but can be utilized on other substances too. While giving many implementations such as paint- like protection and aesthetics, the varnish will enter the wood as well as form a protective layer over the surface.

It is a mixture of resin in oil, turpentine, or alcohol. It dries after utilizing it on the surface of wood, leaving a hard, transparent, and glossy layer of resin over the varnished surface.

2.2 Theoretical perspective

This study of recycling synthetic wastes in production of umusatsi ceiling board is grounded in both material culture theory and sustainability theory.

Material culture theory helps in understanding the significance of recycling synthetic wastes in production of Umusatsi ceiling boards within the context of Rwandan cultural heritage. According to Miller (1987), material culture encompasses the study of objects and their role in social practices. [1] In the case of Umusatsi ceiling boards, this theory helps to analyse how these objects are more than mere construction materials—they are integral to the cultural identity and heritage of the Rwandan people. Williams, R. S. (2010). Sustainability theory [21] provides a framework for evaluating the environmental and practical aspects of using traditional materials in modern construction. As noted by Dunn (2014), sustainable building practices focus on the long-term environmental impacts of materials and methods. Umusatsi ceiling boards, being traditional and locally sourced, are likely to align with principles of sustainability. This theory will guide the assessment of how well these boards contribute to eco-friendly building practices and their viability in contemporary architectural projects. Saini, K., & Malhotra, S. (2016). Environmental pollution. Journal of Engineering Research and Applications, 6(6), 70-74.

2.3 Related study

Previous empirical investigations have explored various aspects of traditional building materials and their role in cultural preservation. For instance, Gakuba et al. (2019) conducted a study on traditional construction materials in East Africa, which [8] highlighted the importance of integrating local materials into modern construction practices. Their findings underscore [11] the benefits of using traditional materials, such as Umusatsi ceiling boards, in preserving cultural heritage while adapting to contemporary needs.

Another relevant study by Mugisha (2022) examined the performance of traditional ceiling materials in modern Rwandan homes. Mugisha's research [8] provides insights into the practical challenges and advantages of using materials like Umusatsi in contemporary settings, including issues of durability, maintenance, and aesthetic value.

These studies provide a foundational understanding of how traditional materials are utilized in modern contexts and offer valuable comparisons for the current research on Umusatsi ceiling boards. The findings will help in identifying specific areas where Umusatsi ceiling boards may contribute uniquely to both cultural preservation and modern building practices.

CHAPTER 3.MATERIALS AND METHODS

3.0 Introduction

This chapter outlines the research methodology employed [7] to investigate the effects of incorporating human hair and waste wigs into the properties of ceiling boards. The objective is to evaluate how these materials influence compressive strength, crack resistance, and crushing strength of the ceiling boards, while also addressing the environmental issues related to non-biodegradable waste.

3.1 Research Design

The study employs a descriptive experimental design, which involves systematically evaluating the performance of ceiling boards made [7] with human hair and waste wigs. This approach allows for a detailed examination of the physical properties of the boards and their potential applications. The study is primarily quantitative, focusing on measurable outcomes [4] such as compressive strength and crack resistance.

3.2 Research population

In gathering useful information in this research interviews and questionnaires were used. The surveyed respondents of this study were classified [1] in relation to their gender, education level, and occupation.

3.2.1. Surveyed respondents by gender

The surveyed respondents under this study were given equal opportunity either male or female participated actively in providing responses. There was enough freedom to the respondents in answering the research questions, except the instructions shown in the questionnaire which shows a symbol to be used to select a correct answer.

Table 3.1: Distribution of surveyed respondents by gender

Gender

Frequency

Percentage

Male

20

60.7%

Female

13

39.3%

Total

33

100%

Source: Field survey, July 2024

Male was willing to answer the questionnaires more than Female that’s why the results show that a large number were male. This is because male in Gasabo district are the ones who often found working on the construction sites and deals with construction material management.

3.2.2. Surveyed respondents by position.

The surveyed respondents under this study were given equal opportunity either male or female participated actively in providing responses. There was enough freedom to the respondents in answering the research questions, except the instructions shown in the questionnaire which shows a symbol to be used to select a correct answer.

Table 3.2: Distribution of surveyed respondents by position

Position

Frequency

Percentage

Engineer RHA

1

3%

Project managers

6

18%

Site engineers

7

21%

Site foreman

12

36.3%

Other site workers

7

21.2%

Total

33

100%

Source: Field survey, July 2024

The researcher found that the other site workers were willing to answer the questionnaires more than project managers, site engineers and site foremen that's why [1] the results show that a large number were other site workers.

Table 3.3: Surveyed respondents by education level

Education level

Frequency

Percentage

Illiterate

1

3%

Primary

8

24.2%

Secondary

10

30.3%

University

14

42.4%

Total

33

100%

The researcher surveyed the respondents in relation to their education levels in order to know their understandings on the impacts of construction materials management projects. The results show that most of construction site workers have attended schools and they are able to read and write.

3.2.4. Surveyed respondent by age

The researcher surveyed respondents in terms of age in order to know the age of respondents, the age categories were 21-30, 31-40, 41-50, and above.

Figure 3.1. Respondents by age

3.3 Sample Size

The sample size 17 is the measure of the number of individual samples used in The experiment of Umusatsi ceiling board. 18 A good maximum sample size is usually around10% of the population as long as it does not exceed 1000.

Therefore, as we gathered information from 100 people who were classified in relation to their gender, education level, and occupation our sample size known as n will be equal to 10

N=10 people

3.3.1 Sampling Procedure

Sampling is a process or technique of choosing a sub-group from a population to participate in the study. It is the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected.

As I chose the sample for this Umusatsi ceiling board study we had 100 respondents to our interviews and questionnaires were among the 100 we chose 10 as our sample size using the cluster sampling method that provides the most precision i.e. the smallest error and the simple that provides the best probability and helps the researcher in saving time and resources.

The process

1. Identification of the population of interest
2. Specification of sampling frame from which I draw my sample.
3. Specification of sampling method which is simple random sampling.
4. Determining the sample size (n) that is equal to Ten (10)
5. Implementation of the study.

3.4. Research Instrument

3.4.1 Choice of the research instrument

While gathering data and information on the Umusatsi ceiling boards study we used interviews and questionnaires. The surveyed respondents under this study were given equal opportunity either male or female participated actively in providing responses. There was enough freedom to the respondents in answering the research questions, except the instructions shown in the questionnaire which shows a symbol to be used to select a correct answer.

3.4.2 Validity and Reliability of the Instruments

Validity: concerns what an instrument measures, and how well it does so.

Reliability: concerns the faith that one can have in the data obtained from the use of an instrument, the degree to which any measuring tool controls for random error.

In order to ensure validity and reliability of the research instruments of Umusatsi ceiling boards project we created a strong research design, choosing appropriate methods and samples, and conducting the research carefully and consistently together with clear communication, maintain consistency in data interpretation, address potential biases, and conduct thorough literature reviews for context.

3.5 Data Gathering Procedures

In this part of the study, 21 the collection of data methods that were used are Document reviews, interviews, focus groups, surveys, observation or testing.

During data collection,

Data on mechanical strength, thermal properties, and environmental impact were collected through rigorous procedures.

Cost data were collected from material suppliers and production records.

3.6 15 Data Analysis and interpretation

Statistical Analysis: Mechanical strength data were statistically analyzed using software like SPSS to determine significant differences.

Comparative Analysis: performance and cost data were compared between composite and other common ceiling materials.

3.6.1. Experiment on umusatsi ceiling board

The ceiling boards should be examined before being used to ensure that they are suitable for the job. The following tests are commonly used to evaluate the ceiling board;

3.6.2. water permeability test

1 The water permeability of the board may be determined by placing the drops of water on it within a certain hour to see if water will flow easily and quickly without penetrating in it. If water flow such way, and the board does swell, it is said to be water impermeable. It means that it will resist to water penetration and dampness.

3.6.3. Hardness test

In hardness test, the scratch is made using a finger nail on the board surface. 17 If there are no scratch marks on the board, it is considered to be a hard board.

3.6.4. Soundness test

For this test, you knock on the board surface to see if a clear ringing sound is created. If the board creates a clear ringing sound, it is sufficiently sound.

3.6.5. Quality comparison between umusatsi ceiling board and other common ceiling materials

Table 3.4: Quality comparison between UMUSATSI ceiling board and other common ceiling materials

Ceiling material

Water resistance

Tension

appearance

durability

Production environmental impact

Price per m2

Crack resistance

Fire resistance

Maintainance

Gypsum board

Poor

Poor

Very good

Poor

70%

About 6500

poor

good

Very good

Plywood

Poor

Good

good

good

80%

3500

good

good

Good

Languets

excellent

Good

Very good

Very good

100%

About 5000

Very good

poor

Poor

Umusatsi ceiling board

Excellent

Excellent

excellent

Excellent

0%

2500

excellent

excellent

Excellent

3.7. Ethical considerations

Ethics in research is important as it provides researchers with ethical principles or guidelines for the successful conduct of research.

While the concept of eco-friendly ceiling boards holds immense potential, challenges related to material homogeneity, moisture resistance, and long-term durability persist. Addressing these challenges requires a multidisciplinary approach involving material science, engineering, and environmental studies. Additionary, exploring innovative manufacturing techniques, such as 3D printing and extrusion molding, could offer a new avenue for enhancing the properties of ceiling boards (Li & Zhang, 2020).

3.8 Limitations of the study

There was [1] a major limitation in this study which could be corrected in future research. Different waste wigs were used that could not be differentiated based on the fact that they were packed together and could not be separated. Also, the age of disposal was not made available. This means that inherent properties differ with the type of wig material and age of disposal, but the recorded values for this study are based on results obtained from the waste wigs available to the researchers in the course of the experiment. In addressing this, the wigs should be collected and separated based on material types and age of disposals. Due to the time limit, board performance evaluation, compressive strength test and tensile strength test were not performed.

CHAPTER 4.RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter provides a comprehensive overview of the system design, analysis, and implementation processes for the Umusatsi ceiling boards. It encompasses critical elements such as calculations, technical drawings, specifications, cost estimation, and implementation strategies. Each section aims 8 to ensure that the ceiling boards not only meet design and performance expectations but also align with practical and economic considerations.

4.1 Calculations

The size of the resulted samples: 50cm*50cm*1cm (Each)

Table 4.1: Calculations of sample budget

NO	Materials	Unit	Amount (Rwf)
1	Waste wig fibers	50 bundles	2500
2	Cut human hair		

50 bundles

2500

3

Sawdust

10kg

1000

4

Glue

2 pieces

1000

5

Nails

0.5kg

900

Total

8000

4.2 Drawings

Technical drawings provide detailed visual representations of the ceiling boards' design. These include schematics for board layout, dimensions, and assembly instructions. Accurate drawings are essential for guiding the manufacturing process and ensuring that all components fit together correctly. They also serve [32] as a reference for quality control and future modifications.

4.3 Specifications

This [27] is a detailed description of the design and materials used to make something. Wood fix glue and water were mixed homogeneously at ratio of 1:2 and carries 5% of the mixture of them with saw dust.

Sawdust [1] were introduced in the mixture of wood fix glue and water at a ratio of 20% Human hair was also added into the mixture at the ratio of 25% of the obtained mixture. Waste wigs that are cut into pieces of 10 cm were then added into the mixture at the ratio of 50% of the mixture to form the composite mixture from which the ceiling board is produced

Materials used in the study

1. Basic materials:

1. human hair,
2. 2.Waste wig fibers

3 Sawdust

4 wood fix glue

5 water

Human hair:

Human hair have been used as fiber here and they have been washed as well after collection to remove any dust particles or any undesirable impurity present and after washing hairs are [2] properly dried either under sun or in oven and preferably should be sorted such as they have uniform length so as to maintain and have an even and equal distribution of hairs while mixing. After drying hair can be stored without any issue of odor or decay.

Figure 4.1: Cut human hair

Water: The Water used for dissolving glue should be clean and free from oils, acids, Alkalies, salts and organic materials or other substances Portable water. The pH value of the water should not be less than 6

The wig wastes: The wig wastes that have been used for preparing the samples were collected from beauty salons and then were separated from the other waste and were finally washed with water followed by proper drying under the sun. After that the dried and clean hairs were further separated based on the length, color and texture of hairs so as to have a uniform distribution of hairs in board. The main consideration in the entire experimentation was to mix the materials properly so as to make an efficient mix design.

The waste wigs were weighed by using electronic balance

Figure 4.2 Waste wig fiber

Sawdust:

Sawdust was collected from carpentry workshop

Figure 4.3 Wood Sawdust

Wood fix adhesive: This product is made of organic macromolecule as main components having the features of solidifying rapidly in normal temperature high adhesive performance and doing quite well in aspect of easy painting, easy to operating.

Figure 4.4 Wood fix glue

2. Finishing materials:

1. Sanding sealer

2. Thinner

3. Colouring powder

4. Wood fix

5. Varnish

6. Paint

4.4. Implementation

4.4.1. Procedures followed

1 Human hair has been collected from hair shaving salons around our homes and then washed with soap and clean water and dried in the open air for 24 hrs.

Waste wigs also were obtained from hair salons and treated with detergent and distilled water to remove attached impurity and dried in the open air for 24 hrs. Then the waste wig was cut into short fibers of 5cm length by using a scissor. And Sawdust collected from carpentry workshop

When the composite mixture is ready, polystyrene was laid in the formwork. this was followed by pouring the mixture into the formwork and covered on top then exerted under pressure and shake for a moment to make sure that they are well compacted. Next, the cover has been removed and the formwork remains opened for 21 days at a room temperature to allow slow drying of the sample.

After 21days, the sample was removed from the formwork and exposed in open air for 7 days to allow well drying.

After 28 days, the sample was sanded and the finishing coat was added by either brushing or rolling by either varnishing or painting. Then the sample left in open air within 30 minutes to dry.

Figure 4.5: Cutting waste wigs into 5cm pieces

Figure 4.6: Ingredients proportioning

Figure 4.7: Molding

Figure 4.8 Pressure applications for well compaction

Figure 4.9 Unfinished umusatsi ceiling board

Figure 4.10 Finishing plaster

Figure 4.11 Application of plaster finish on the board

Figure 4.12 Painting the board

Figure 4.13 Rough painted finish UMUSATSI ceiling board

Figure 4.14 Smooth painted finish UMUSATSI ceiling board

Figure 4.15 Rough varnished finish UMUSATSI ceiling board

Figure 4.16: Rough finished UMUSATSI ceiling board

Steps followed

Figure 4.17: Rough finished UMUSATSI ceiling board

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a summary of the key findings of the study, presents conclusions based on the research questions, and offers recommendations for practical applications and future research. The chapter aims to synthesize the results obtained from the study and to propose actionable steps based on these findings.

5.1 Conclusion

Reduction of Waste and Resource Conservation: The proposed project effectively addresses the issue of waste management by utilizing wood sawdust from carpentry workshops, human hair, and wig waste. These materials, often deemed useless, are transformed into a high-quality construction material for ceilings. This innovative approach not only reduces the dependency on natural resources required for conventional ceiling materials but also mitigates pollution generated during the production of these materials. The resulting ceiling board boasts a higher tensile strength and superior quality compared to traditional materials while being lighter and more economical. Additionally, it serves as an environmental protection tool, as it is composed of 95% waste materials and generates no additional waste during production.

Enhanced Performance with Waste Wig Fiber: Waste wig fibers have been found to significantly improve the tensile strength of boards made from sawdust. The study concludes that these fibers are a promising alternative to natural fibers for board fabrication. The proportion of waste wig fibers, human hair, and sawdust can be adjusted according to the required strength of the boards. The flexibility in the size, decoration, and shapes of the resulting ceiling boards further underscores the versatility of this material.

Durability and Structural Integrity: The use of fiber-reinforced sawdust boards demonstrates a marked reduction in crack formation. The incorporation of human hair and waste wigs as fibers enhances the compressive strength and binding properties of the boards. This characteristic makes them particularly suitable for construction in seismic zones or applications where crack-free construction is essential, such as ceiling and partitioning applications.

Economic and Environmental Benefits: The addition of human hairs and waste wigs not only strengthens the board but also reduces the incidence of cracks. This method provides an effective solution for managing waste wigs and hair while offering practical applications in civil construction. The increased strength and reduced crack formation highlight the potential of this alternative method in improving both waste management and construction practices.

5.2 Recommendations

Further Laboratory Testing: Future researchers should conduct comprehensive laboratory tests on the UMUSATSI ceiling board to validate its performance and durability. These tests should explore the effects of varying proportions of waste wigs and other materials on the board's properties.

Waste Collection Practices: Hairdressers and wig manufacturers are encouraged to collect and segregate waste wigs 1 based on material types and age. This practice will facilitate better quality control and enhance the effectiveness 4 of the waste materials used in board production.

Material Considerations: Researchers should consider the age and material types of waste wigs when conducting experiments. These factors may influence 1 the properties of the final product and should be accounted for to ensure optimal results.

5.3 Suggestions for Further Study

Long-Term Performance Evaluation: Future studies should focus on 8 the long-term performance and durability of the UMUSATSI ceiling board under various environmental conditions. This includes assessing its resistance to humidity, temperature fluctuations, and other factors that could impact its longevity.

Broader Application Testing: It would be beneficial to explore the use of UMUSATSI boards in other construction applications beyond ceilings and partitions. Investigating their potential in other structural elements or decorative features could provide valuable insights into their versatility.

Economic Analysis: An in-depth economic analysis of the production costs and market feasibility of UMUSATSI boards compared to traditional ceiling materials would provide a clearer understanding of its potential impact on the construction industry.

Environmental Impact Assessment: Conducting a detailed environmental impact assessment of the UMUSATSI board production process could further highlight its benefits and potential areas for improvement in terms of sustainability and waste reduction.

By addressing these areas, future research can build upon the findings of this study 25 and contribute to the development of more efficient and sustainable construction materials.

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