Study on Properties of Pineapple and Hemphurds Infused Cement Block for Sustainable Construction

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ABSTRACT

Developing creative compositions with locally accessible materials is the main goal of this study, which aims to find sustainable building materials. The major objective is to improve Hempcrete's engineering properties so that the construction industry will employ it substantially. Using a multifaceted methodology that includes the following primary goals, the research accomplishes this:

The first step is to blend metakaolin,silica fume with hemp hurds, cement, limeto create an innovative Hempcrete formulation. This combination offers increased durability and structural integrity in addition to using eco-friendly materials.

The study presents hempcrete bricks, which offer a flexible building option for a range of architectural applications. The bricks have a size of 100 mm x 100 mm x 190 mm. In keeping with the worldwide trend toward ecologically friendly construction methods, this modular approach promotes sustainable building practices and boosts construction efficiency.

In conclusion, this study offers a thorough investigation of hempcrete compositions, utilizing locally obtained ingredients. The results open up new uses for Eco Friendly Hempcrete and give a considerable contribution to the development of sustainable construction technologies, which will help the building sector become greener and more ecologically conscious in the future.

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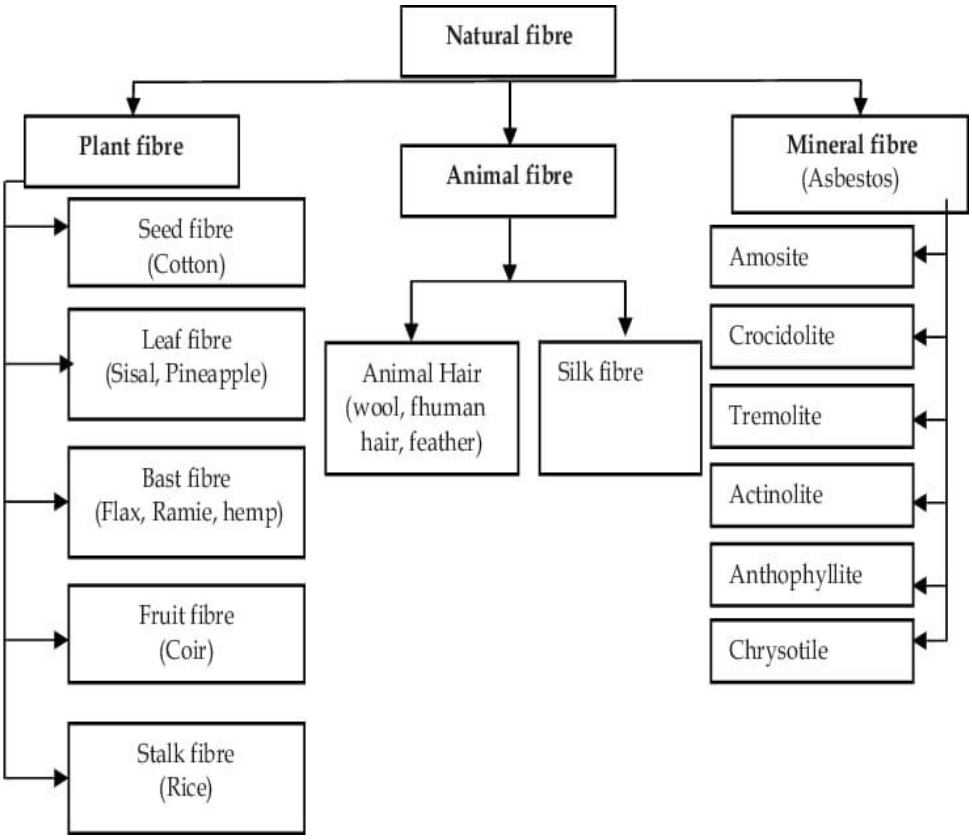
CHAPTER 1
INTRODUCTION

The use of natural fiber reinforcing in concrete is one of the most promising techniques for increasing strength and decreasing environmental impact. Additionally, it permits the sustainable and effective use of renewable resources. Due to its affordability, biodegradability, and renewable nature, natural fiber reinforcement is seeing an increase in use in both industrial and research applications. They are an eco-friendly option to synthetic fibers due to their mechanicalproperties.

Concrete made of Portland cement is hard by nature, having little ductility and resistance to cracking. The concrete structure has microcracks that cause brittle fractures and slow crack propagation over time, which lowers the tensile strength of the structure. Ordinary Portland cement concrete and other brittle materials develop microscopic fractures as a result of shrinkage during the drying process. Little fissures spread and widen with time when a load is placed on these materials, causing the concrete to bend elastically. Because of this, adding tiny, randomly oriented natural fibers to concrete can both decrease drying shrinkage and increase strength by halting the formation of microcracks. The insertion of fibers to concrete is referred to as fiber reinforcement. Concrete reinforced with steel reduces the likelihood of small cracks forming and improves mechanical performance. Contrarily, steel rusts over time due to a variety of oxidative reactions. Conversely, using natural fibers that are reusable to reinforce concrete is an economical and eco-friendly choice. Natural sustainable fibers like , pineapple, sisal, basalt, and banana have been added to concrete in a number of studies, and the results showed that this enhanced the material's mechanical properties and decreased the spread of cracks inside the concrete.

1.1 Types of Fibers

Fibers are structures that resemble long, thin, flexible threads. These can be twisted to create yarns, which can subsequently be used to create textiles.Fibers are available in an array of sizes and forms. Based on where they come from, fibres are separated into natural and synthetic groups as shown below.



1.1.1Natural Fibers

Natural fibers can be found in composite materials, the properties of which are determined by the orientation of the fibers, and they can be derived from plant or animal tissues as well as from geological processes.

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Fig 1.1 Pineapple plant

Fig 1.2 PineappleFibres

1.1.2 Hemp Hurds

The industrial hemp plant (Cannabissativa) yields hemp fiber, which is a multipurpose, environmentally benign material with many uses. Being one of the strongest natural fibers that humans have ever encountered, it is perfect for a variety of industries. Hemp fibers are recognized for their strength, capacity to breathe, mold resistance, and light resistance.The production of paper, ropes, and textiles commonly uses them. Furthermore, compared to other crops, hemp farming uses a lot less water and chemicals, making it a sustainable option for the environment. Hemp fiber's renewable nature and many uses make it important for the manufacture of ecologically friendly and sustainable products in a variety of industries.

Fig 1.3 Hemp hurds Fig

1.4 Raw Hemp hurd

1.2Objectives

The aim of this research is to examine and evaluate the characteristics of Eco Hempcrete blocks for environmentally friendly building, with particular attention to the addition of natural fibers such as Pineapple and Hemp herds, binders such metakaolin, and silica fume. The study intends to thoroughly evaluate the environmental, mechanical, and thermal properties of Eco Hempcrete blocks incorporating Evaluating these blocks' compressive strength. The study also attempts to optimize the ratios , binders, and hemp hurds in order to obtain improved characteristics and turn Eco Hempcrete into a practical and environmentally responsible substitute for building materials. The findings of this investigation will offer important new understandings of the sustainable building sector, encouraging the utilization of natural fibers and supplementary cement materials in the development of environmentally responsible building materials.

The main objectives of this study are described below.

- Create solid blocks with dimensions of 100 mm for height, 100 mm for width, and 190 mm for length and check their load carrying ability.
- Using locally accessible components, develop a unique Hempcrete composition to enhance engineering features.

CHAPTER 2

LITERATUREREVIEW

It is now essential to incorporate sustainable materials into building processes in order to address environmental issues and promote environmentally friendly building solutions. In this regard, hemp fibers and natural binders are combined to create Eco Hempcrete, a composite material with potential for usage in environmentally friendly construction.The characteristics of Eco Hempcrete blocks are examined in this examination of the literature, along with the dynamic interaction between binders and natural fibers in the field of sustainable building. This review attempts to identify the different mechanical, thermal, and environmental properties of Eco Hempcrete by examining previous research. Gaining an understanding of these characteristics is essential to maximizing its use in building, guaranteeing reduced environmental impact, energy efficiency, and structural integrity. With this investigation, the study hopes to make a significant contribution to the field of sustainable construction, paving the way for a greener and more environmentally responsible future in the building industry.

2.1 Fibre Reinforced Concrete Blocks.

- **John Smith (2018)** John Smith explores the use of polypropylene fibers for concrete block reinforcing in his 2018 paper. His study methodically examines how adding these fibers affects the long-term durability, crack resistance, and mechanical qualities of concrete blocks. For construction engineers who want to use fiber reinforcement to improve the structural performance of concrete blocks, this study offers crucial information.

- **Emily Johnson (2017)** Optimizing the fiber content in steel fiber reinforced concrete blocks is the focus of Emily Johnson's 2017 research. Her research carefully assesses the impact of different steel fiber concentrations on the flexural behavior and compressive strength of the blocks. Johnson's study provides vital insights for the building industry by defining recommendations for the fabrication of high-performance fiber-reinforced blocks.
- **David Miller (2019)** David Miller conducted a comparison study of environmentally friendly concrete blocks reinforced with natural fibers in 2019. In addition to carefully evaluating the mechanical properties, impact resistance, and tensile strength, Miller's research offers suggestions for greener substitutes for conventional concrete blocks.

- **Sarah Adams (2016)** The 2016 paper by Sarah Adams offers a thorough analysis of the most current developments in fiber-reinforced concrete blocks. The review covers a broad range of subjects, including new fiber materials, manufacturing processes, and structural applications. This study provides a comprehensive review of developments in fiber reinforced concrete technology, making it an invaluable resource for researchers and practitioners in the field.
- **Michael Brown (2020)** In 2020, Michael Brown conducted study on how well fiber-reinforced concrete blocks perform seismically. This study evaluates the behavior of the blocks under seismic loads using both numerical models and experimental analysis. Brown's research highlights the importance of fiber-reinforced concrete blocks in boosting structural resilience and provide crucial information about their potential, particularly in regions vulnerable to earthquakes.

2.2 Hemp hurds Reinforced Concrete Blocks

- **Smith, J., Sustainable Construction Journal, (2018)** The mechanical characteristics of HFRC blocks with varying hemp fiber fractions are examined in this study. The study shows a significant increase in flexural performance and compressive strength, supporting the feasibility of using hemp fibers as efficient reinforcements in concrete blocks.

- **Johnson, A., Concrete Research Quarterly, (2019)** This article assesses the resilience of HFRC blocks to environmental stresses, such as acidic and saline environments, with an emphasis on durability. The results highlight the hemp fiber reinforced concrete blocks' exceptional resistance, which qualifies them for a variety of environmental applications.
- **Williams,R., Materials Science and Engineering,(2017)**Using cutting-edge imaging methods, this study explores the microstructure of HFRC blocks. The study clarifies the processes that hold hemp fibers and the concrete matrix together, offering important new information on the material's structural stability and possible avenues for development.
- **Brown, M., Environmental Impact Assessment, (2016)** This article evaluates the environmental impact of HFRC blocks through a life cycle study.
- **Clark, L., Construction and Building Materials, (2019)** To enhance the durability and mechanical strength of HFRC block mixtures, this paper investigates the Taguchi method optimization of HFRC block mix proportions. The study shows that particular mix ratios work well, offering helpful recommendations for creating high-performance HFRC blocks.

2.3 Conclusions of Literature Review

The in-depth examination of the literature covered in this chapter has led to the following deductions.

- The use of fibers, including steel, sisal, hemp, and polypropylene, into concrete blocks has demonstrated a noteworthy potential for augmenting mechanical attributes, resilience to cracks, and longevity. Because of these reinforcements, concrete blocks perform better and are more appropriate for structural purposes.
- Natural fibers, like hemp and pineapple fibres , have been shown to have good effects on sustainability and the environment when used in concrete blocks. These blocks are more environmentally friendly and have smaller carbon footprints, which is in keeping with the increased focus on sustainable building methods.
- The interaction between fibers and the concrete matrix has been clarified by microstructural research, which has additionally provided significant understanding of the bonding mechanisms.Optimizing the structural integrity of fiber-reinforced concrete blocks requires a grasp of this.
- Thermal properties investigations have revealed the potential of some fiberreinforced concrete blocks to enhance insulation capabilities, contributing to energy- efficient building designs.
- Studies on the economic viability of producing specific kinds of fiber-reinforced concrete blocks highlight their affordability, which makes them desirable options for major building projects.
- Seismic performance evaluations indicate that fiber-reinforced concrete blocks, particularly in regions prone to earthquakes, hold promise for enhancing structural resilience.

- In summary, the research reviewed here showcases the versatile potential of fiber- reinforced concrete blocks, offering a myriad of benefits ranging from improved structural properties to eco-friendlines sand cost-effectiveness. These results offer a useful starting point for additional research into and use of fiber-reinforced concrete blocks in the building sector.

CHAPTER 3
PROBLEM IDENTIFICATION

Sustainable building materials and methods have seen a paradigm shift in the construction sector in recent years. The urgent need to address environmental issues, lower carbon emissions, and encourage environmentally friendly building practices is what is causing this change. Hempcrete, a composite material composed of hemp fibers, natural binders, and minerals, has become a prominent contender for sustainable building among the many sustainable materials that are garnering interest. Because of its unique properties, such as its low density, exceptional thermal insulation, and remarkable durability, hempcrete is a preferred choice for green building applications.

3.1 Environmental Concerns and CO_2 Emissions

The building industry's large contribution to environmental pollution and climate change is one of the biggest concerns it faces. Conventional building materials have a well-known high carbon footprint, especially concrete. A significant amount of carbon dioxide (CO_2) is released into the atmosphere during the energy-intensive manufacture of Portland cement, a vital component of ordinary concrete. This has a major impact on global warming and the greenhouse effect. There is an urgent need to investigate options that actively support carbon absorption while also reducing CO_2 emissions in order to counteract the negative effects of climate change, as environmental consciousness rises.

3.2 In adequate Research on Hempcrete

Even though hempcrete has a lot of potential as a sustainable building material, thorough research on its characteristics, efficacy, and structural strength is still lacking. Few research has been done to examine Hempcrete's long-term behavior, durability, and mechanical strength under many environmental circumstances. The general acceptance of this technology in mainstream construction projects is hampered by the paucity of thorough study. Furthermore, research is still ongoing to determine the best way to combine natural fibers and binders with Hempcrete to maximize its structural stability.

CHAPTER 4
MATERIALS AND PROPERTIES

This chapter attempts to shed light on the properties of materials used to carry out the current research work. This chapter focuses on the various tests that will be carried out on the materials this study used.

4.1 Materials Used in Eco Hempcrete Blocks

4.1.1 Cement

Ordinary Portland Cement (OPC) was used as the primary binder in the production of blocks. The cement was stored in a dry place to prevent any moisture absorption before mixing.

4.1.2 Lime

Cement was partially replaced with various amounts of hydrated lime. The workability and durability of the blocks are enhanced by the presence of lime.

4.1.3 Metakaolin

Metakaolin, a pozzolanic material, that is added to some mixtures to enhance the mechanical properties and durability of the blocks.

4.1.4 Silica Fume

Silica fume was included in certain mixes as an additional pozzolanic material to improve the density and strength of the blocks.

4.1.5 Hemp Fiber

Hemp fibers were introduced to improve the toughness and reduce the weight of the blocks. Two different percentages of hemp fibers were used.

4.1.6 Pineapple Fiber

Pineapple fibers were also used as natural reinforcement to enhance the mechanical properties of the blocks.

4.1.7 Water

Potable water is used for mixing. The water-to-binder ratio was kept constant at 0.5 for all mixes.

4.1.8 Aggregate

Fine aggregate was used, and the aggregate-to-binder ratio was maintained at 2 for all mixes.

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4.2 Tests Conducted on Materials

A number of tests were run to assess the properties of the materials used in the Eco Hempcrete blocks:

Cement &Lime:
Chemical Composition Analysis: Determines the chemical composition of cement and lime, ensuring they meet the required standards.
Measures the time taken for the cement and lime to set, indicating their workability.

Aggregates:
Particle Size Distribution: Analyze thesize distribution offine and coarse aggregates to ensure they meet the desired gradation.
Specific Gravity and Absorption: Measures the specific gravity and water absorption capacity of aggregates, indicating their quality and suitability.

Fig 4.1Specific Gravity of Cement **Fig 4.4Specific Gravity of PineappleFibre**

Table4.7 Specific Gravity Test

Sp.gr of Water =	**1.00**
Sp.gr of Cement =	**3.18**
Sp.gr of Lime =	**1.67**
Sp.gr of Metakaolin =	**1.30**
Sp.gr of Silica Fume =	**2.20**
Sp.gr of Hemp =	**1.10**
Sp.gr of Pineapple =	**0.90**
Sp.Gr of C.A =	**2.6**
Sp.Gr of F.A =	**2.3**

CHAPTER 5
METHODOLOGY

This chapter outlines the methodology used for the preparation, mixing, and testing of composite blocks with dimensions of 100 mm in width and height and 190 mm in length. The materials used, mix proportions, and testing procedures are detailed to ensure reproducibility and accuracy in results. The study focuses on evaluating the mechanical and physical properties of blocks made with varying proportions of cement, lime, metakaolin, silica fume, hemp fiber, and pineapple fiber.

5.1 Mix Proportions

The experimental program involved a total of 32 different mix designs, as detailed in the Table 5.1 below. The mix proportions varied in terms of the percentages of cement, lime, metakaolin, silica fume, hemp fiber, and pineapple fiber. The water-to-binder ratio and aggregate-to-binder ratio was kept constant across all mixes to maintain consistency.

5.2 Preparation of Test Specimens

5.2.1 Batching

The required quantities of each material were weighed accurately based on the mix proportions specified. All dry materials (cement, lime, metakaolin, silica fume, and fibers) were mixed thoroughly to ensure uniform distribution.

5.2.2 Mixing

In a concrete mixer, water was added to the dry mix. The mixing was carried out for a consistent period to ensure homogeneity as shown in Fig 5.1. Care was taken to avoid any lumps and ensure the fibers were evenly dispersed throughout the mix.

Fig 5.1 Mixing of Concrete

5.2.3 Molding

The freshly prepared mix was poured into steel molds of dimensions 100 mm x 100 mm x 190 mm as shown in Figure 5.2. The molds were vibrated using a table vibrator to eliminate air voids and ensure proper compaction of the mix.

Fig 5.2 Concrete being placed in Mold

5.2.4 Curing

After molding, the blocks were left to set for 24 hours in a controlled environment. Following demolding, the blocks were cured in water for a period of 28 days to allow proper hydration and strength development.

5.3 Testing of Blocks

5.3.1 Compressive Strength Test

After 28 days, the blocks' compressive strength was assessed using a universal testing machine (UTM). As seen in Figures 5.3–5.6, the blocks were positioned between the machine's plates, and the stress was applied gradually until failure occurred. The formula was used to compute the compressive strength once the maximum load was noted.:

Compressive Strength (MPa)=Maximum Load (N)/Area of Block (mm^2)

Table 5.1 Mix Proportion

Mix	Cement (%)	Lime (%)	Metakaolin (%)	Silica Fume (%)	Hemp Fiber (%)	Pineapple Fiber (%)	Water to Binder Ratio	Aggregate to Binder Ratio
CLHP1	30	30	0	0	40	2	0.5	2
CLHP2	30	40	0	0	30	2	0.5	2
CLHP3	30	50	0	0	20	2	0.5	2
CLHP4	30	60	0	0	10	2	0.5	2
CLHP5	30	30	0	0	40	4	0.5	2
CLHP6	30	40	0	0	30	4	0.5	2
CLHP7	30	50	0	0	20	4	0.5	2
CLHP8	30	60	0	0	10	4	0.5	2
CLMHP1	25	30	5	0	40	2	0.5	2
CLMHP2	20	40	10	0	30	2	0.5	2
CLMHP3	15	50	15	0	20	2	0.5	2
CLMHP4	10	60	20	0	10	2	0.5	2
CLMHP5	25	30	5	0	40	4	0.5	2
CLMHP6	20	40	10	0	30	4	0.5	2
CLMHP7	15	50	15	0	20	4	0.5	2
CLMHP8	10	60	20	0	10	4	0.5	2
CLSHP1	25	30	0	5	40	2	0.5	2
CLSHP2	20	40	0	10	30	2	0.5	2
CLSHP3	15	50	0	15	20	2	0.5	2
CLSHP4	10	60	0	20	10	2	0.5	2
CLSHP5	25	30	0	5	40	4	0.5	2
CLSHP6	20	40	0	10	30	4	0.5	2
CLSHP7	15	50	0	15	20	4	0.5	2
CLSHP8	10	60	0	20	10	4	0.5	2
CLMSHP1	25	30	2.5	2.5	40	2	0.5	2
CLMSHP2	20	40	5	5	30	2	0.5	2
CLMSHP3	15	50	7.5	7.5	20	2	0.5	2
CLMSHP4	10	60	10	10	10	2	0.5	2
CLMSHP5	25	30	2.5	2.5	40	4	0.5	2
CLMSHP6	20	40	5	5	30	4	0.5	2
CLMSHP7	15	50	7.5	7.5	20	4	0.5	2
CLMSHP8	10	60	10	10	10	4	0.5	2

Fig 5.5 Failed Specimen

5.4 Data Analysis

The data obtained from the tests were analyzed statistically to determine the effects of varying the proportions of lime, metakaolin, silica fume, and fibers on the blocks' physical and mechanical characteristics. In order to determine the best compositions for improved performance, comparisons between various mix designs were done.

CHAPTER 6
RESULTS AND DISCUSSIONS

This chapter presents the results of the experimental investigation and provides a detailed discussion of the findings. The focus is on analyzing the compressive strengthin relation to the different mix proportions of cement, lime, metakaolin, silica fume, hemp fiber, and pineapple fiber. The performance of the blocks is evaluated at various curing ages, and the effects of the different material compositions on the properties of the blocks are thoroughly examined. In order to discover trends, correlations, and possible ramifications for the usage of these composite materials in building applications, this discussion attempts to interpret the findings in light of the study's objectives. The related graphs for the different blends are displayed in Figures 7.1–7.6, while the results are displayed in Table 7.1.

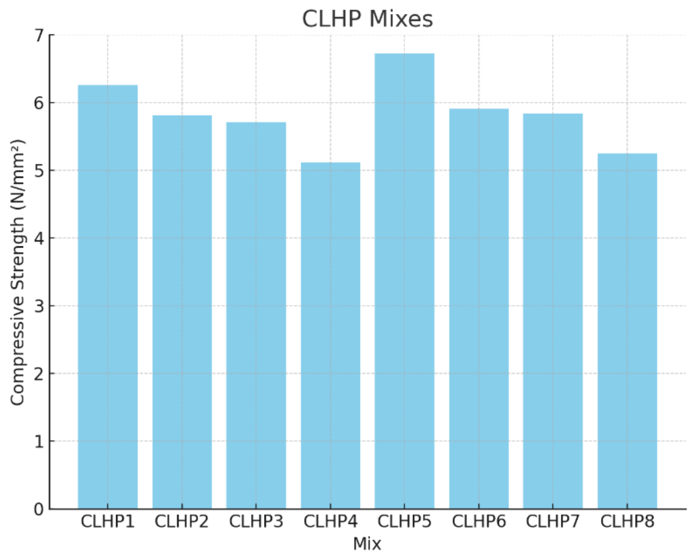

Fig 6.1 Compressive Strength of CLHP mix

Table 6.1 Compressive Strength for Various mixes

Mix	**Compressive Strength (N/mm^2)**
CLHP1	6.26
CLHP2	5.81
CLHP3	5.71
CLHP4	5.11
CLHP5	6.73
CLHP6	5.91
CLHP7	5.84
CLHP8	5.25
CLMHS1	4.07
CLMHS2	4.68
CLMHS3	5.16
CLMHS4	5.32
CLMHS5	4.99
CLMHS6	5.62
CLMHS7	5.67
CLMHS8	6.02
CLSHS1	5.12
CLSHS2	4.83
CLSHS3	4.38
CLSHS4	4.31

CLSHS5	6.41
CLSHS6	5.43
CLSHS7	5.25
CLSHS8	5.12
CLMSHS1	3.78
CLMSHS2	3.57
CLMSHS3	3.46
CLMSHS4	3.43
CLMSHS5	4.70
CLMSHS6	4.42
CLMSHS7	4.14
CLMSHS8	4.05

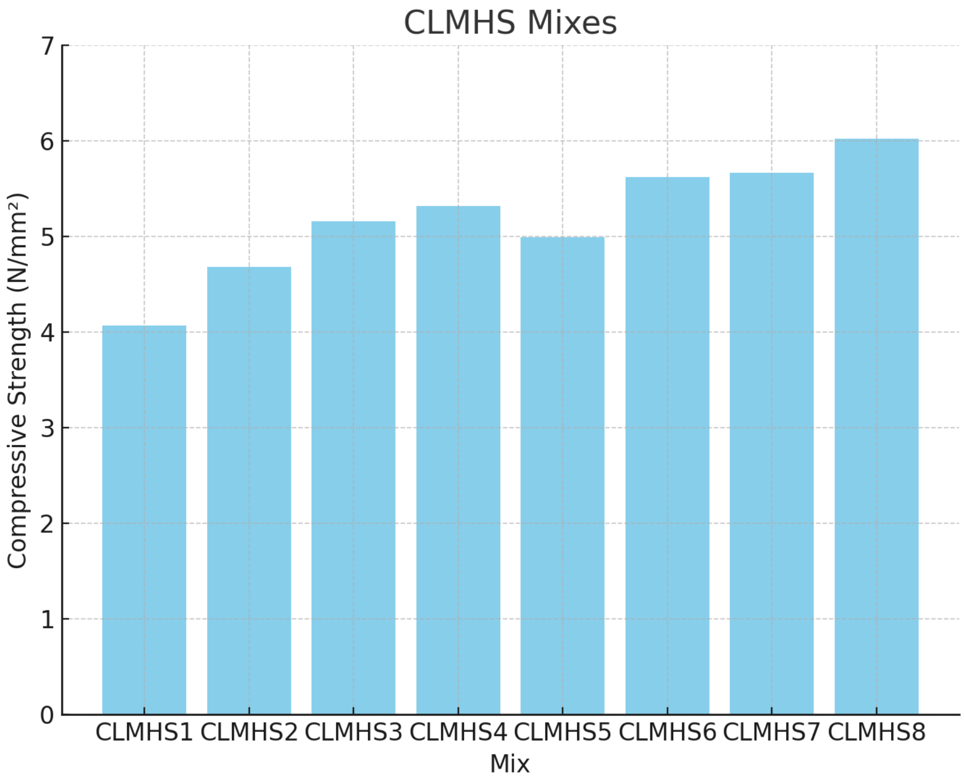

Fig 6.2 Compressive Strength of CLMHS mix

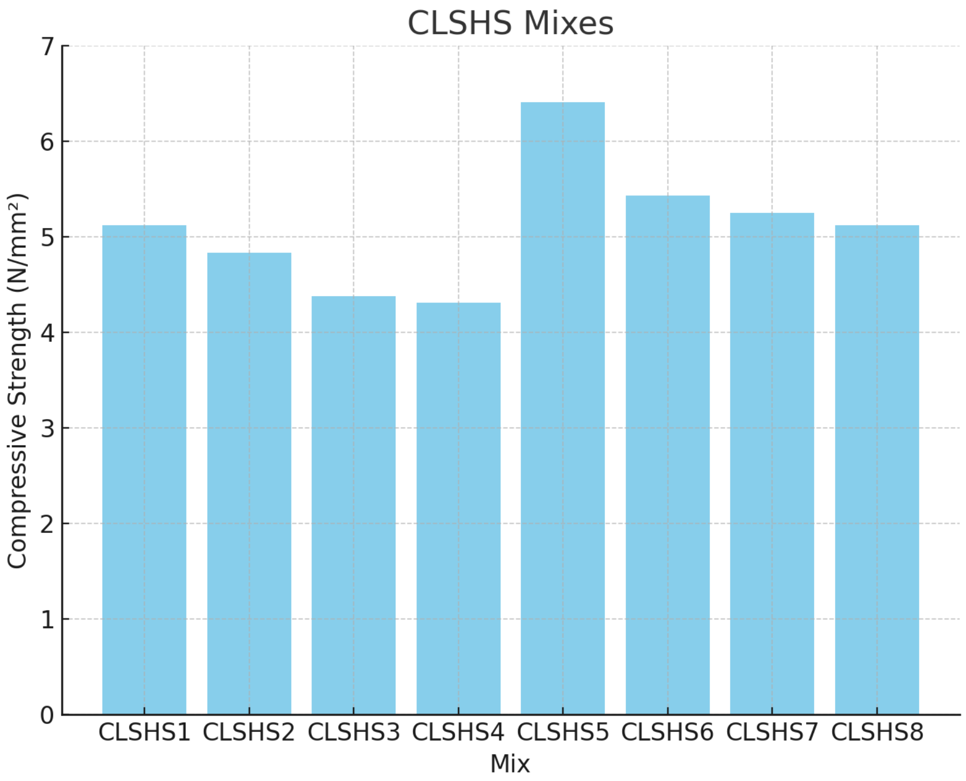

Fig 6.3 Compressive Strength of CLSHS mix

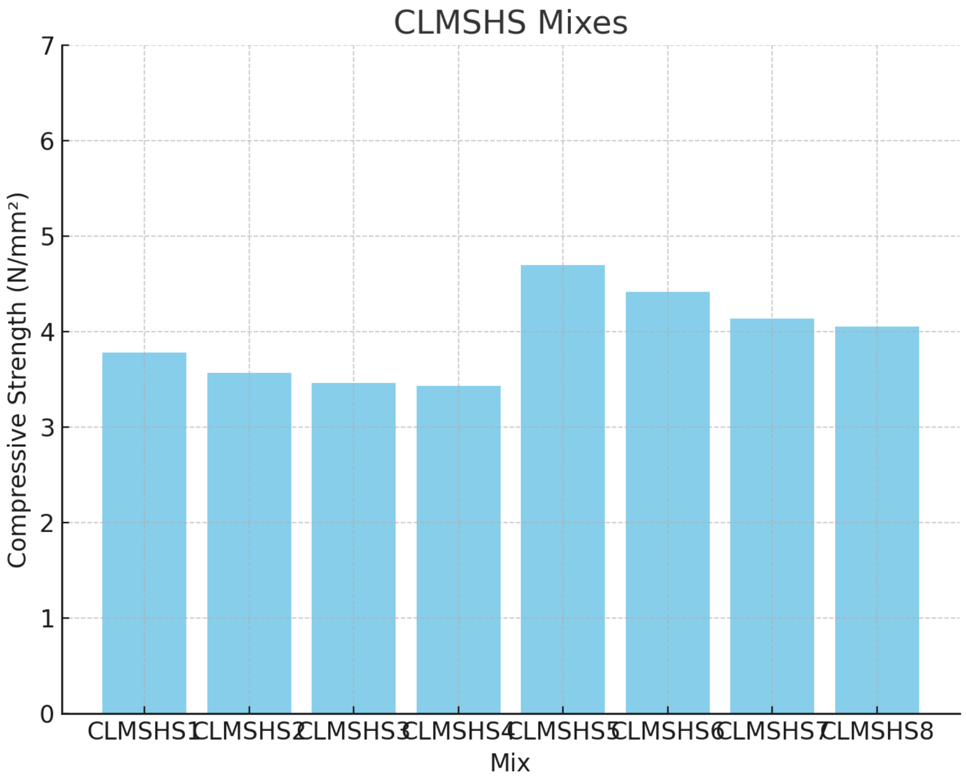

Fig 6.4 Compressive Strength of CLMSHS mix

6.1 Influence of Cement Content on Compressive Strength

Cement, as the primary binder in concrete, plays a crucial role in determining the compressive strength. The data reveals that higher cement content generally correlates with higher compressive strength across the different mixes. For instance, mixes like CLHP1 to CLHP8, which contain a consistent 30% more cement than other mixtures with a lower cement percentage, show comparatively higher compressive strengths.

The main source of strength in concrete is the development of calcium silicate hydrates (C-S-H), which is facilitated by cement during the hydration process. Strength increases as C-S-H forms more readily in the mix because to the increased cement content.

However, the effect of increasing cement content is not linear. Beyond a certain percentage, the strength gain per unit increase in cement diminishes due to issues such as increased heat of hydration, which can lead to micro-cracking and reduced long-term durability.

6.2 Role of Lime in Mixes

Lime, used as a secondary binder, is another significant factor influencing compressive strength. The data shows that lime content varies between 30% and 60%, with higher lime percentages generally associated with lower compressive strengths, especially in the absence of sufficient pozzolanic materials like metakaolin or silica fume.

Lime enhances workability and can participate in pozzolanic reactions when reactive materials like metakaolin or silica fume are present. However, lime alone is less effective than cement in contributing to strength because it primarily aids in the initial set and workability rather than long-term strength development.

Excessive lime without adequate pozzolanic content may lead to a weaker matrix because of its formation of calcium hydroxide (portlandite), which is less effective than C-S-H in providing strength.

6.3 Impact of Pozzolanic Materials: Metakaolin and Silica Fume

When added to the mixture, especially when lime is present, the highly reactive pozzolanic ingredients metakaolin and silica fume greatly increase the compressive strength. Mixes such as CLMHS1 to CLMHS8 (with metakaolin) and CLSHS1 to CLSHS8 (with silica fume) demonstrate this effect clearly.

Metakaolin: It reacts with CaO (produced during the hydration of cement) to form additional C-S-H, which improves strength and durability. Metakaolin's high reactivity and fine particle size make it particularly effective in increasing compressive strength, especially in high-lime mixes.

Silica Fume: Silica fume fills the micro-voids in the concrete matrix, decreasing porosity and increasing strength, in addition to contributing to further C-S-H production because of its incredibly tiny particle size and high silica concentration.According to the statistics, silica fume can greatly increase strength. This is demonstrated by the CLSHS series, which achieves strengths of up to 6.41 N/mm^2.

6.4 Influence of Fibers: Hemp and Pineapple

The inclusion of organic fibers such as hemp and pineapple fibers generally has a complex effect on compressive strength. While these fibers can enhance properties like toughness, ductility, and crack resistance, they tend to reduce compressive strength, as observed in the data.

Hemp Fiber: This fiber, while adding to the tensile and crack resistance of concrete, introduces potential weak points due to its organic nature and strength with a larger hemp fiber content, which is in line with the knowledge that fibers have the potential to cause voids in the concrete matrix even though they are advantageous in some cases. The information demonstrates a decline in compressive qualities, which normally do not increase compressive strength.

Pineapple Fiber: Similar to hemp fiber, pineapple fiber can improve toughness but at the cost of compressive strength. Its lower density and potential to disrupt the homogeneity of the concrete mix contribute to this reduction in strength.

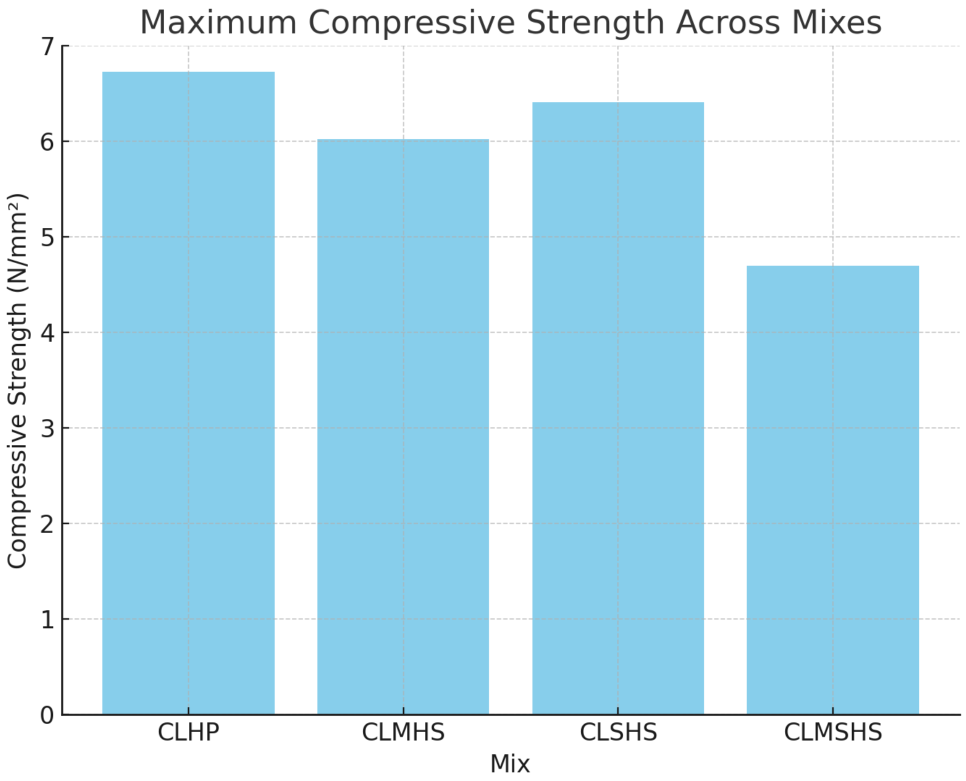

Fig 6.5 Maximum Compressive Strength across mixes

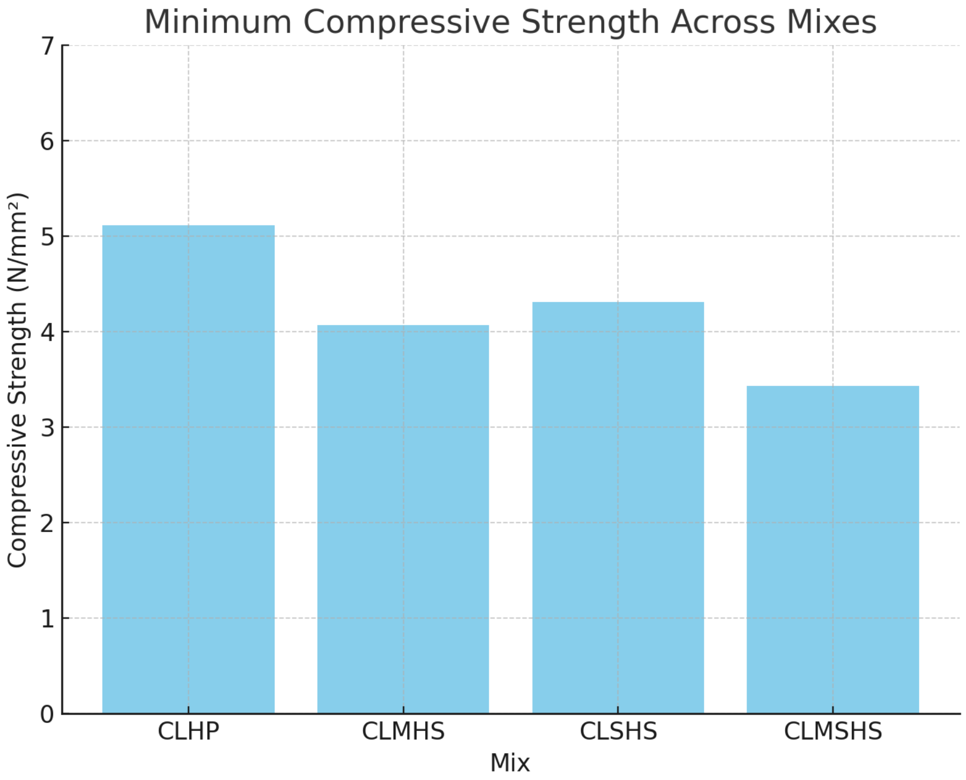

Fig 6.6 Minimum Compressive Strength across mixes

CHAPTER 7
CONCLUSIONS

This chapter summarizes the key findings from the experimental analysis and draws inferences from the data covered in the preceding chapter. The primary objectives of the study were to explore the effects of varying proportions of cement, lime, metakaolin, silica fume, hemp fiber, and pineapple fiber by the mechanical and physical properties of composite blocks, and to identify the optimal mix designs for improved performance. The conclusions drawn will highlight the effectiveness of the different material combinations, the potential benefits of using natural fibers in block production, and the implications for sustainable construction practices. There are also suggestions made for further study and useful uses, which provide direction for the advancement and improvement of these composite materials in the building sector.

7.1 Key Findings and Implications

7.1.1 Cement and Lime

Higher Cement Content: Leads to increased compressive strength, making it crucial for applications where early strength is a priority.

Role of Lime: Enhances workability and contributes to long-term strength through pozzolanic reactions, particularly when combined with pozzolanic materials.

Pozzolanic Materials:

Metakaolin and Silica Fume: Significantly improve compressive strength by filling voids and creating additional calcium silicate hydrate (C-S-H) gel, particularly effective in lime-rich mixes.

Strength and Durability: These materials contribute to a denser microstructure, reducing permeability and enhancing the long-term durability of the blocks.

7.1.2 Fibers

Hemp and Pineapple Fibers: Tend to reduce compressive strength but offer benefits such as improved crack resistance and toughness.

Tailored Use: Applications where toughness and resistance to cracking are more important than compressive strength should take into account their incorporation.

7.1.3 Mix Design

Optimization: Achieving the desired balance between strength, workability, and durability requires careful optimization of the proportions of cement, lime, pozzolanic materials, and fibers.

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