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Assessing Hempcrete's Environmental and Performance Benefits in Interior Applications

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***Abstract*—This study explores hempcrete as a sustainable material for low-impact interior design, focusing on its environmental and performance outcomes. Hempcrete, composed of hemp shives and lime binder, offers multiple benefits including carbon sequestration, natural humidity regulation, thermal insulation, acoustic absorption, and non-toxicity. Despite these advantages, its use in interior spaces remains limited due to lack of awareness, inconsistent material standards, and insufficient design guidelines. The research integrates literature review, questionnaire analysis, and performance evaluation to assess hempcrete's suitability for interior walls, partitions, and finishes. Survey results indicate a positive perception of sustainable materials, with most participants willing to adopt hempcrete in future projects, although knowledge gaps persist.. The study highlights the material's potential to contribute to environmentally responsible design and low-impact building strategies. Recommendations include further standardization, technical validation, and increased availability to encourage mainstream adoption. Overall, hempcrete represents a promising eco-friendly alternative to conventional interior construction materials, aligning with the growing demand for sustainable design solutions.**

***Index Terms*—Hempcrete; Sustainability; Thermal properties; Durability properties; Acoustic properties; Carbon sequestration ; Low Impact.**

I. Introduction

Sustainable construction materials are increasingly prioritized as the building industry seeks to reduce environmental impacts while improving occupant comfort and health. Hempcrete, a biocomposite made from hemp shiv, lime binder, and water, has gained increasing attention due to its carbon-sequestering capacity, thermal regulation, and moisture-buffering properties. This study evaluates the environmental and performance implications of using hempcrete as an innovative interior material. The global drive towards sustainable construction practices has been highlighted by significant policy developments aimed at reducing carbon emissions and promoting environmental sustainability.

II. Literature Review

(Paper 1)

A holistic sustainability overview of hemp as building and highway construction materials.

The study aimed to evaluate hemp-based materials—especially hempcrete and hemp fibers—for their environmental, economic, and technical sustainability in building and highway construction.It sought to assess their performance, benefits, and limitations through a holistic sustainability framework.The researchers also aimed to identify current challenges and research gaps hindering widespread adoption.Overall, the study intended to determine whether hemp materials can serve as viable, low-carbon alternatives to conventional construction materials.

(Paper 2)

A comprehensive review of hempcrete as a sustainable building material.

The study aimed to comprehensively evaluate hempcrete's potential as a sustainable building material. It examined its mechanical, thermal, and hygrothermal properties to determine suitability for modern construction.The review sought to analyze environmental benefits, including carbon sequestration and low embodied energy.Overall, the study aimed to identify hempcrete's advantages, limitations, and future research needs to support wider adoption.

(Paper 3)

Hemp Concrete with Mineral Additives as a Durable and Fire-Resistant Material in Green Construction.

The study aimed to investigate how mineral additives affect the performance of hemp concrete in green construction.It focused on improving durability, fire resistance, and overall mechanical properties through additive modification.The research evaluated how these enhancements influence hempcrete's suitability for long-term and safe building applications.Overall, the purpose was to determine whether mineral-modified hempcrete can serve as a more resilient and sustainable construction material.

III. Material and methods

1) Hempcrete in building construction

Lime hemp concrete (hempcrete) is made using a mix of fluid phases (air and water) and solid phases (hemp shiv and binder). Achieving the correct mix design is crucial for its performance. The hemp stalks, also known as hemp straw, are put through a hammer mill or a decorticator to be broken down into small particles, with a maximum size of 40 ± 5 mm or even smaller. The typical binder used in this process is mainly hydrated lime, along with some pozzolanic material or a commercial hydraulic lime-based binder. For off-site casting, hempcrete is meticulously prepared in planetary or helical mixers to ensure proper mixing without forming lumps.

For precast blocks, the mixture is poured into moulds and cured for a specific duration, generally 28–45 days, depending on the chosen mineral binder. Two methods for constructing hempcrete on-site are pouring the mix into a form (wall, floor, roof, or other target areas) or spraying it using a projection process. However, both methods have limitations in compaction and maturation control. Proper compaction with a tamping rod or external compacting stresses is vital, as hemp shives have low density and do not self - compact.

a) Hempcrete material composition

The hempcrete mixture consisted of hemp shiv combined with a lime-based binder and water. The component ratios were determined based on conventional non-structural hempcrete specifications commonly reported in literature.

Hemp shiv obtained from industrial hemp (Cannabis sativa L.) with particle sizes ranging from 5–25 mm was used as the lightweight aggregate in the mixture. Its porous structure provides both thermal insulation and effective moisture regulation.

A lime-based binder was prepared using the following components:

✓ **Hydrated lime ($Ca(OH)_2$)** – primary component.

✓ **Natural hydraulic lime (NHL 3.5)** – to facilitate improved curing.

✓ **Metakaolin (optional additive)** – used at **5% of binder mass** to enhance early strength.

No Portland cement was added unless otherwise stated. The binder-to-shiv ratio was maintained at **1:1.5 (by weight)**.A water-to-binder ratio of 0.6–0.7, meaning 60–70% of the binder's weight in water, was applied to produce a cohesive yet workable hempcrete mix suitable for proper casting and curing.

2) Life Cycle Assessment (LCA) of Hempcrete

Life cycle assessment (LCA) is a critical tool for evaluating the environmental impacts of building materials throughout their entire life span—from raw material extraction to end-of-life disposal. Hempcrete, being a bio-based composite made from hemp shiv and a lime-based binder, shows promising results in LCA studies due to its renewable content, low embodied energy, and carbon sequestration potential.

How LCA Supports Low-Impact Design Strategies ?

a) Hempcrete has been demonstrated to be lightweight yet dense, carbon-sequestering, recyclable, energy-efficient and non-toxic, making it a viable sustainable alternative to conventional materials.
b) Life-cycle assessments show that hempcrete exhibits a significantly lower ecological footprint over its lifetime than conventional building materials.
c) Due to its hygrothermal buffering properties, hempcrete helps maintain stable indoor conditions, reducing dependency on mechanical heating and cooling.

3) Analysis of Surveys

The survey aimed to evaluate participants' awareness, perceptions, and potential adoption of hempcrete within the context of sustainable interior design. The responses provide valuable insight into prevailing knowledge levels, attitudes toward innovative materials, and the alignment of hempcrete with commonly applied low-impact design strategies.

1 The survey results show limited awareness of hempcrete among participants, with only 23.4% having prior knowledge of the material, while 55.3% were unaware and 21.3% were unsure. This indicates a clear knowledge gap and highlights the need for greater educational outreach. Despite its sustainable benefits, hempcrete remains largely unfamiliar, emphasizing the importance of incorporating innovative materials into design education and professional training.

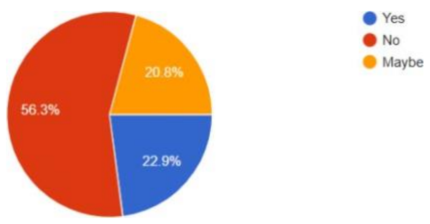

Figure 3 Awareness of hempcrete

2 Despite limited awareness, the survey results indicate a favorable attitude toward the potential use of hempcrete. A majority of respondents (53.2%) expressed willingness to utilize hempcrete in various interior applications such as walls, flooring, acoustic panels, or partitions. An additional 38.3% expressed conditional interest ("might use it"), and only 8.5% stated they would not adopt the material.This strong willingness suggests that once informed about its benefits, users and designers are open to selecting hempcrete as part of sustainable and low-impact design strategies. The results imply that acceptance is positively correlated with exposure and understanding, rather than constrained by material performance concerns.

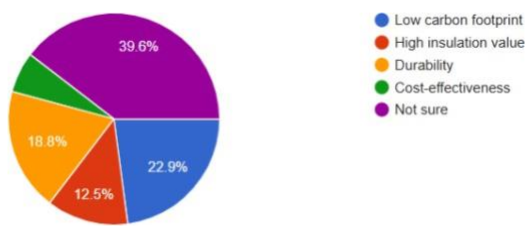

Figure 4 Willingness to use Hempcrete

3 The survey also explored respondents' existing engagement with sustainable design practices. More than half (51.1%) reported using natural or recycled materials, indicating a clear preference toward material-conscious design. This was followed by the adoption of energy-efficient lighting (29.8%), biophilic design integration (21.3%), and life-cycle assessment methods (19.1%). Passive ventilation strategies were practiced by 14.9% of respondents, while only 10.6% reported not applying any low-impact strategies.These findings reflect a growing awareness of sustainable design approaches and suggest that hempcrete aligns well with the strategies already prioritized. The prominence of material sustainability within respondents' practices further strengthens hempcrete's potential for integration into interior design.

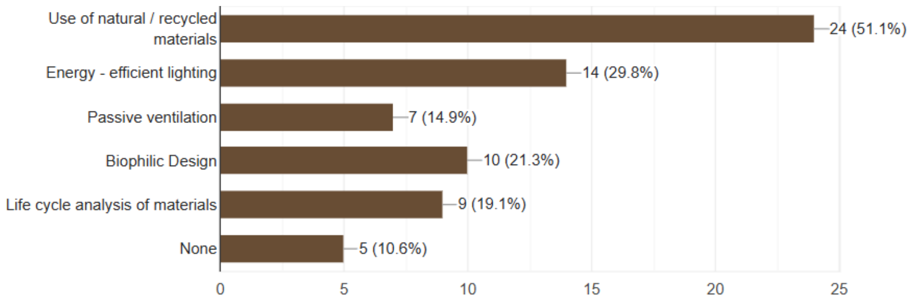

Figure 5 Use of Low - Impact Strategies

4 When asked about suitable applications, 37% of respondents identified interior walls as the most appropriate use for hempcrete. Flooring was selected by 13%, followed by acoustic panels (8.7%) and insulation elements (8.7%). Notably, 32.6% were unsure about appropriate applications.This uncertainty indicates that while respondents recognize hempcrete's potential, a more detailed understanding of its versatility is required. Clear communication regarding hempcrete's performance in thermal insulation, moisture regulation, acoustics, and flooring systems is necessary to enhance confidence in its application.

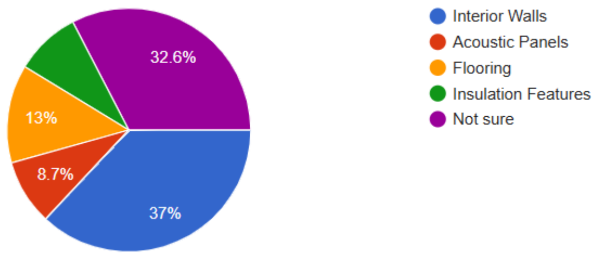

Figure 6 Perceived suitable Applications of Hempcrete

a) Overall Interpretation Of Survey Analysis

The survey results collectively show that although knowledge of hempcrete remains limited among participants, the willingness to adopt sustainable materials is high. Respondents demonstrated strong alignment with low-impact design strategies, and their positive attitude toward hempcrete indicates significant potential for mainstream acceptance if awareness and technical understanding are improved. The findings reinforce the importance of targeted educational initiatives, industry-level demonstrations, and material standardization to support broader adoption of hempcrete in interior design.

4) Analysis of Surveys

The two variables are given below :

a) **Independent Variable** : *Use of hempcrete as a sustainable material (material innovation).*
b) **Dependent Variable :** *Environmental and performance outcomes of using hempcrete.*

Hempcrete has gained attention as a sustainable construction material due to its low environmental impact and beneficial thermal and moisture-regulating properties. Examining its influence on environmental and performance outcomes helps determine its effectiveness in improving building sustainability and energy efficiency.

Declarative Hypothesis : Using hempcrete in construction is hypothesized to significantly enhance overall building performance by lowering the carbon footprint, improving indoor humidity stability, and reducing energy use for heating and cooling. Increasing the proportion of hempcrete in building elements is expected to strengthen environmental efficiency. Overall, hempcrete is anticipated to contribute to more thermally stable and sustainable structures.

c) **Material Innovation Adoption**
The use of hempcrete as a sustainable construction material is hypothesized to provide advantages over conventional building materials because of its bio-based and low-impact characteristics.

d) **Reduction in Environmental Impact**
Hempcrete is expected to lower the overall carbon footprint of buildings, as hemp plants sequester carbon during growth and require less energy for processing than traditional construction materials.

e) **Improved Indoor Environmental Quality**
Due to its hygroscopic properties, hempcrete is hypothesized to regulate indoor humidity levels, reducing moisture fluctuations, minimizing mold risk, and enhancing occupant comfort.

f) **Enhanced Thermal Performance**
The material is anticipated to improve thermal insulation and thermal mass effects, leading to more stable indoor temperatures.

g) **Performance Scaling with Material Proportion**
Increasing the proportion of hempcrete used in building elements is hypothesized to further enhance environmental efficiency and overall building performance.

h) **Overall Sustainability Contribution**
Overall, hempcrete is expected to support environmentally sustainable, energy-efficient, and thermally resilient building designs.

Ⅳ. Results and discussion

Even though hempcrete is not widely used, participants clearly see its environmental benefits. This means it has great potential to become a popular sustainable material in interior design.Most people do not fully understand how to use hempcrete or what applications it works best for.This shows that **education, training, and awareness programs** are needed so designers feel confident using it .

Concerns about cost, availability, and building codes make designers hesitant.
For hempcrete to grow in the market, there must be:

- More suppliers
- Clear regulations
- Affordable options
- Real examples of successful projects

1) Applications of Hempcrete

Due to its lightweight, breathable, and thermally efficient nature, hempcrete is primarily used in **non-structural** applications within buildings. It demonstrates experimentally that hempcrete masonry walls provide excellent thermal performance, affirming the viability of hempcrete in wall masonry for energy-efficient building.

a) Walls

Hempcrete is primarily used as a non-structural infill material, cast around a timber or light-steel frame to form breathable and highly insulating wall assemblies. Its low thermal conductivity enables significant reduction in heat loss, contributing to stable indoor temperatures and improved energy efficiency. In addition to its thermal performance, hempcrete exhibits excellent moisture-buffering capacity, naturally regulating indoor humidity levels and preventing issues such as condensation and mold growth.

b) Flooring

Hempcrete is effectively utilized in flooring systems as a lightweight insulating subfloor layer that improves overall thermal and acoustic performance. Its inherent thermal mass helps moderate indoor temperature fluctuations, contributing to enhanced energy efficiency and occupant comfort. As it has low density and ease of application, hempcrete flooring is particularly well suited for retrofitting older buildings where heavier materials may be structurally unsuitable.

c) Roofing

In roofing assemblies, hempcrete is applied as a high-performance insulating layer, either cast in place or sprayed to fit various roof geometries. Its low thermal conductivity helps minimize heat transfer through the roof, improving year-round energy efficiency and reducing heating and cooling loads. The lightweight nature of hempcrete reduces structural demands on roof framing systems, making it an advantageous choice for both new construction and renovation projects.

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Figure 6 Hempcrete Wall- Infill

Figure 7 Flooring Installation

Figure 8 Hempcrete Formwork Installatio

V. Conclusion

This research highlights hempcrete as a highly promising sustainable material for interior design, offering significant environmental and performance advantages such as carbon sequestration, thermal insulation, humidity regulation, and non-toxicity. Despite its strong potential, the study finds that awareness and understanding of hempcrete remain limited, with most participants unfamiliar with its properties and applications. However, survey responses show a clear willingness to adopt hempcrete once its benefits are understood, indicating strong future market potential.

The analysis also reveals that hempcrete aligns well with existing low-impact design strategies commonly used by designers. Key barriers to adoption include limited availability, lack of standard material guidelines, higher perceived costs, and insufficient real-world demonstrations. Addressing these challenges through education, training, and industry-supported technical validation is essential. Expanding supply chains and establishing standardized performance criteria will further support its integration into practice. Overall, hempcrete emerges as an effective, eco-friendly alternative to traditional interior materials. With increased awareness and improved accessibility, it can contribute meaningfully to sustainable and resilient built environments.

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