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# Evaluating the Thermal Conductivity and Moisture Transport of Hempcrete

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## Introduction

Global climate change drives the need for more sustainable construction practices as the building sector accounts for about 50% of $CO_2$ emissions and energy consumption. Materials with excellent insulating properties enhance building's energy efficiency and improve its response to moisture and temperature variations. Hempcrete, a carbon sink alternative to traditional insulation - each ton of Hempcrete is estimated to absorb 249 kg of $CO_2$ over a 100-year lifecycle - combines hemp hurd, lime, and water. Due to its air-trapping structure (porosity) it offers excellent insulation

## Hypothesis

Hempcrete, due to its porosity and composition, is hypothesized to demonstrate low thermal conductivity and effective moisture transport regulation. These properties are expected to make it a viable material for sustainable construction, reducing energy consumption.

## Materials and Methods

This study was conducted on blocks made with raw ½” hemp hurd, lime binder and water, with a mixture ratio in grams of 4:3:5 (hemp/binder/water) and a curing time of 28 days (dry stage).

**Thermal Conductivity:** Assessed via a heat conduction test with a 12V embedded heating element, subject to a 2A current test for 2h per trial and apply the equation below to calculate the rate of heat transfer through the material

$$\dot{Q} = k \, . A \, . \frac{\Delta T}{\Delta x}$$

Where:
$\dot{Q}$ = heat flux per unit area (W/m²)
$k$ = thermal conductivity (W/m·K)
$A$ = contact area (m²)
$\Delta T$ = temperature difference (K)
$\Delta x$ = distance from the heat source (m).

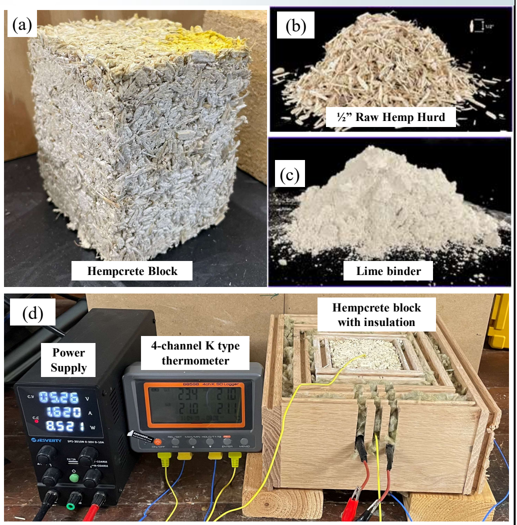


Figure 1. (a) Hempcrete block (b) ½” Haw hemp (c) Lime binder (d) Heat conduction test set up

The hempcrete blocks (3” x 3.5 ”x 4”) were stabilized at a temperature of 26 ± 1° C with a relative humidity of ≈ 60% and insulated on its sides to and force a vertical heat direction and avoid heat dissipation. A 4-channel K type thermometer SD logger was used to collect temperature data from the top, bottom, left side, and front side.

**Moisture Transport:** A programable humidifier was used to subject the samples to a consistent humidity for 18 hours. Data was recorded by Arduino-synchronized thermistors placed inside the wet chamber, on the hempcrete block and outside (“dry area”).

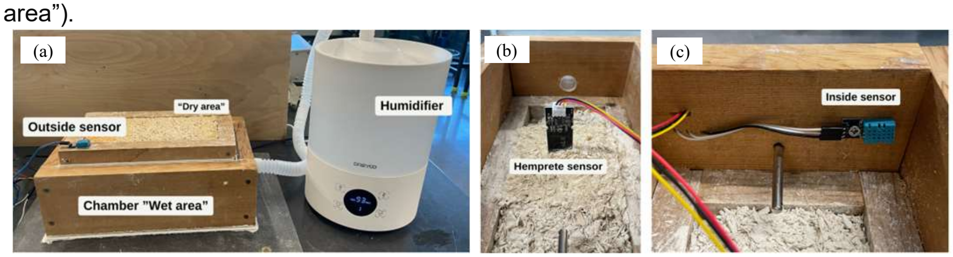


Figure 2. (a) Test set up (b) Hempcrete sensor (c) Wet chamber sensor

## Results

| Time (hr:min) | Power (W) | $\Delta T$ (°C) | k ($W/mK$) |
|---|---|---|---|
| 6:40 | 10.3 | 78.80 | 0.0705 |
| 6:50 | 10.1 | 80.40 | 0.0678 |
| 7:00 | 10.6 | 82.20 | 0.0695 |
| 7:10 | 10.5 | 83.70 | 0.0678 |
| 7:20 | 10.5 | 86.10 | 0.0658 |
| 7:30 | 10.2 | 87.10 | 0.0632 |
| | | Average | **0.0674** |
| | | Std. Dev | 0.0026 |

Table 1. A snapshot of thermal conductivity data after the steady state is reached for the 2-hour experiment

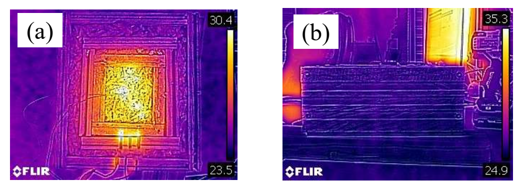


Figure 3. Thermophotometry from: (a) Top and (b) Side

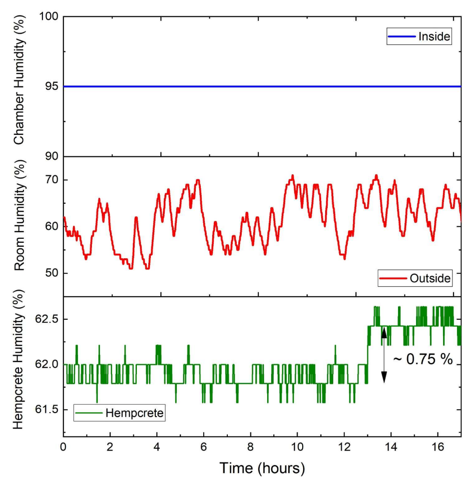


Figure 4: Humidity of the wet chamber (top), humidity of room (middle),and humidity of the block (bottom) vs time

## Discussion

The results affirm Hempcrete's ability to function as an effective thermal insulator, with an average thermal conductivity of approximately 0.0674 W/m·K. Additionally, the material exhibited strong moisture transport regulation, maintaining humidity balance with minimal moisture content change over 18 hours, which is critical for preventing structural damage caused by moisture over time. The combined properties of low thermal conductivity and moisture regulation make Hempcrete a promising alternative to conventional insulation materials, especially in environments with fluctuating humidity levels. In conclusion, Hempcrete shows promise as a sustainable material for energy-efficient construction, offering excellent thermal insulation and moisture regulation properties. Its application in modern building systems can contribute to environmental sustainability.

## Future Research

Exploring Hempcrete's scalability in large construction and its compatibility with eco-friendly materials could provide insights for wider use. Life-cycle and cost-effectiveness studies would further determine its potential for sustainable building practices.

## Acknowledgments

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