Decarbonising Built Environments using Hempcrete and Green Wall Technology

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AUSTRALIAN HEMP MASONRY

Urbanisation

- Built environment associated with:
  - Increased urban heat islands [1]
  - Poor air quality [2]

- Building materials are large contributors to poor air quality [3]:
  - Structural materials
  - Synthetic building materials
  - Heating, Ventilation, and Air Conditioning (HVAC)

Yang et al., 2016; Uhde & Salthammer, 2007; Kumar et al., 2023

Importance of SDGs and Building Materials

- Importance of building materials used is increasingly important in meeting UN SDGs 9, 11, and 12.

- Criteria should consider [4]:
  - Thermal comfort
  - Environmental and human health risks

Liu et al., 2022

Insulative Performance of Building Materials

- Concrete has higher thermal conductivity [5, 6].
- Brick has slightly lower thermal conductivity, still resource-intensive [7].
- Hempcrete efficient regulator of temperature and humidity [5, 8].

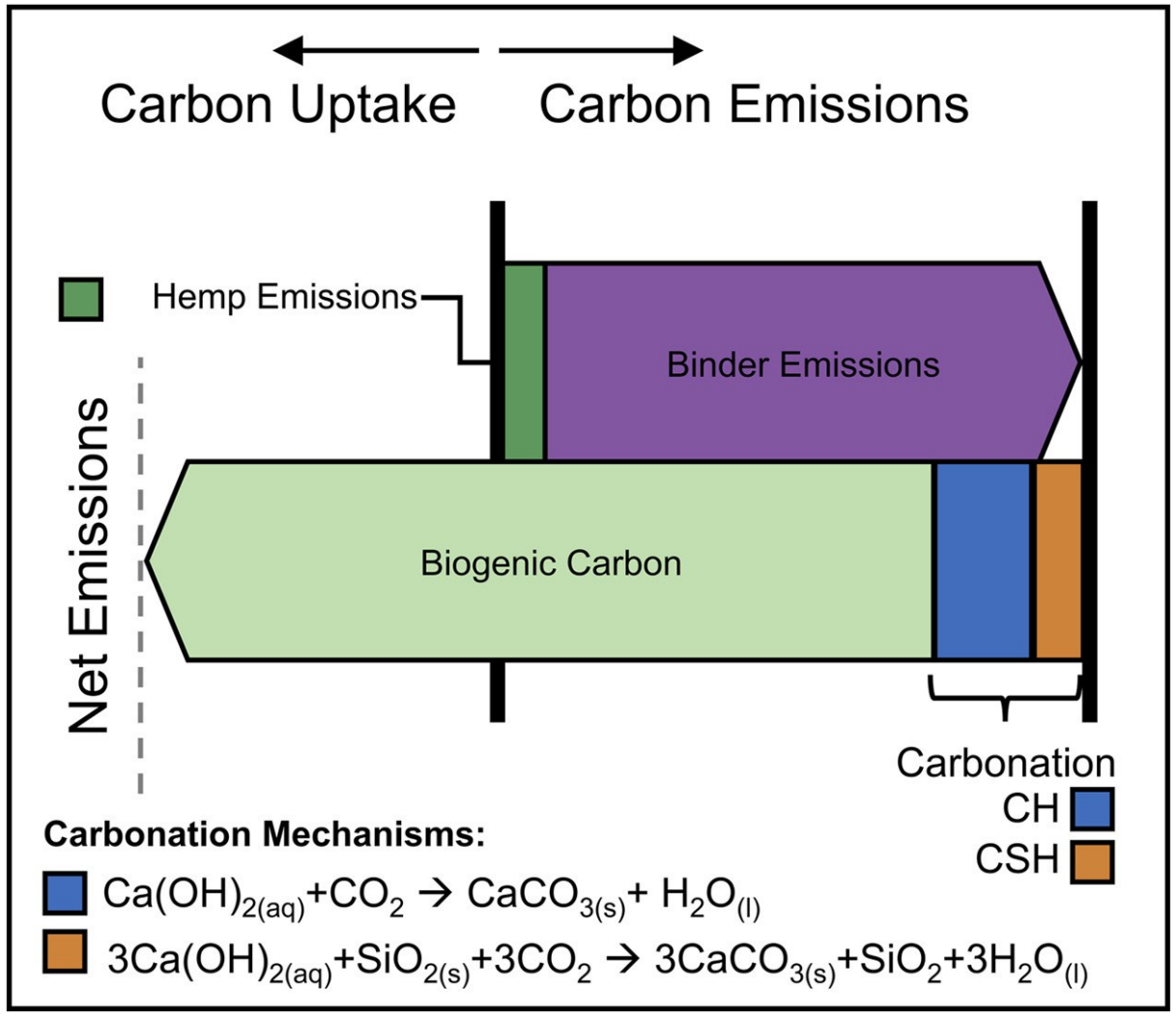
Thermal Conductivity (W/m/K) of conventional building materials compared to hempcrete [6, 7, 8].

Material	Thermal Conductivity (W/m/K)
Concrete	0.62–3.30
Brick	0.43–0.84
Hempcrete	0.05-0.14

Bennai et al., 2022; Shahedan et al., 2019; Dickson & Pavia, 2021; Dhakal et al., 2017

Hempcrete

- Limits energy consumption and poor air quality [5, 9].
- Sequesters carbon through cultivation and carbonation during the building's life cycle [10].



Comparison of carbon sequestrated and emitted by hempcrete [10].

Bennai et al., 2022; Chau et al., 2023; Arehart et al., 2020

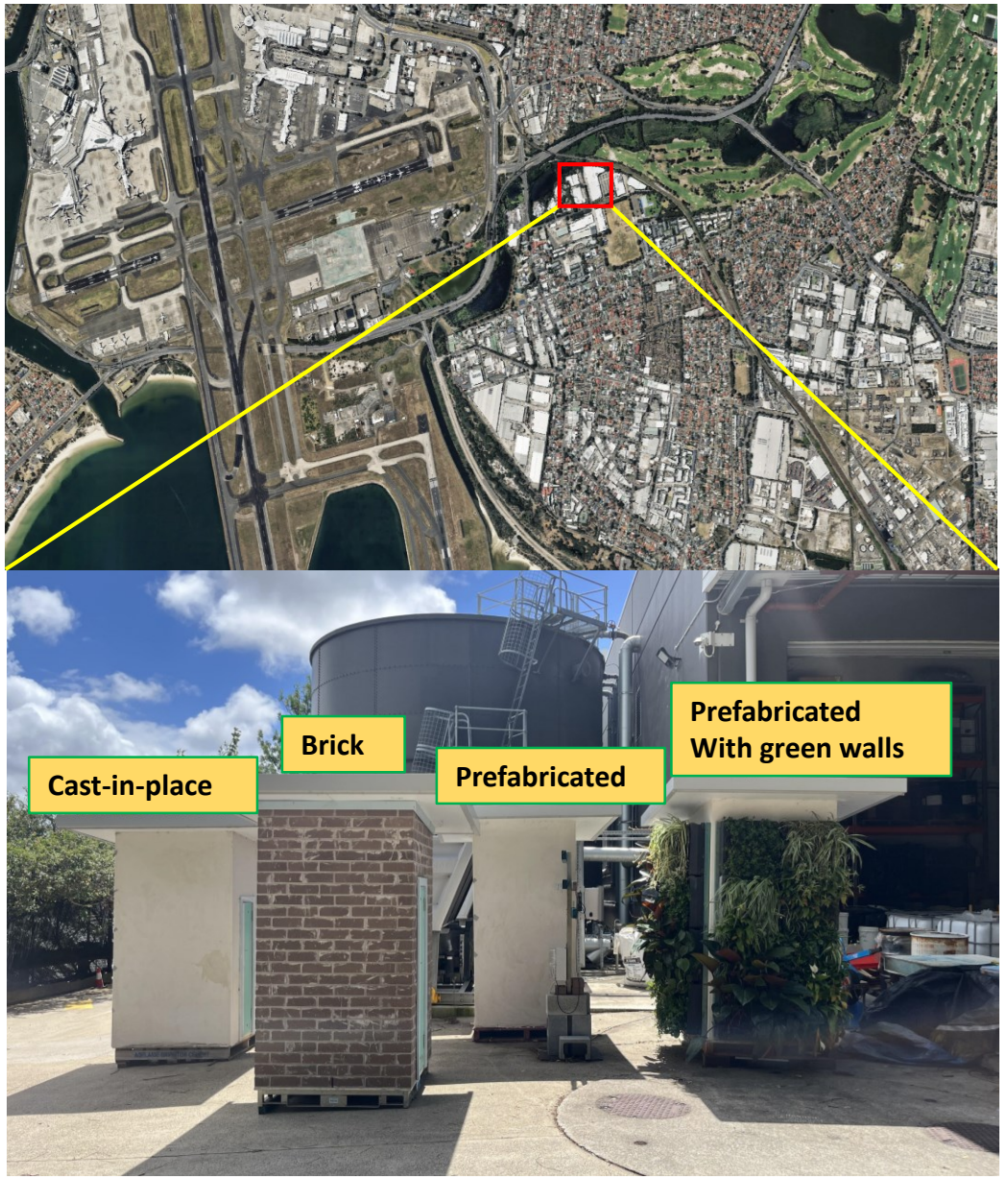
Nature-Based Solutions: Green Walls

- Multi-functional green walls improve air quality [3, 11].
- Evapotranspiration and photosynthesis regulate temperature, humidity, and CO_2 [11, 12].
  - Remediation influenced by microbiome in plants phyllosphere and rhizosphere [13, 14].

Kumar et al., 2023; Irga et al., 2023; Torpy et al., 2017; Cuce, 2013; Ysebaert et al., 2021

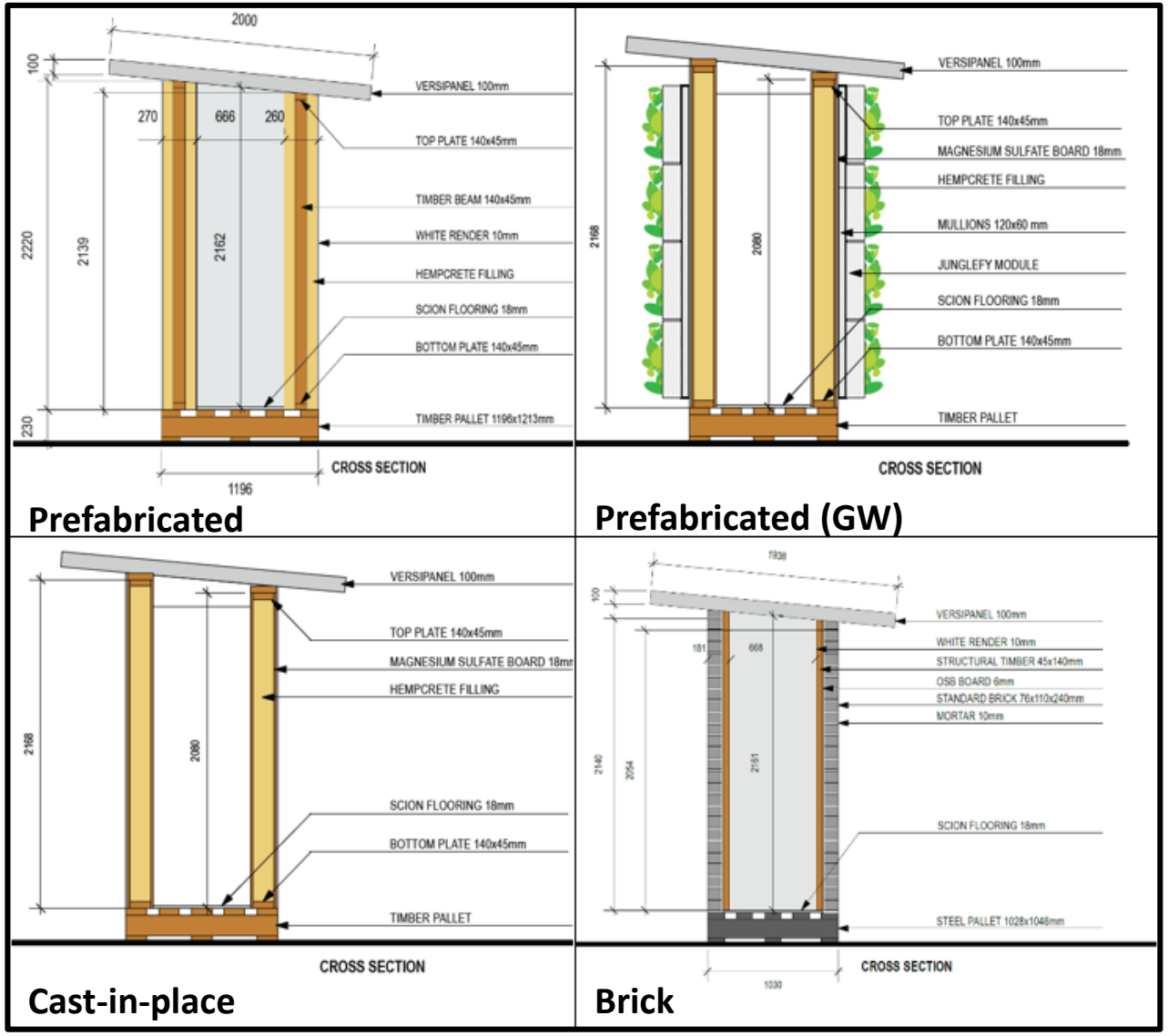
Study Aims

- Are hempcrete structures effective thermal insulators?
- Is thermal performance of hempcrete affected by green wall technology?
- How effective is hempcrete combined with green walls in improving indoor air quality?



Frontal view of study area at UTS Tech Lab, with respect to the surrounding location at Botany, Sydney. Top image credit to Google Maps.

Cross-sectional diagrams of the four mini-structures. Image credit to Faculty of Design, Architecture, and Building, UTS.



Research Methodology

- **Hempcrete:**
  - Cast-in-Place (1196 * 2220 * 1214mm)
  - Prefabricated (1016 * 2168 * 1016mm)
  - Prefabricated with green walls (1016 * 2168 * 1016mm)
- **Brick** (1030 * 2140 * 1030 mm)

- Ventilation rate: 1 ACPH

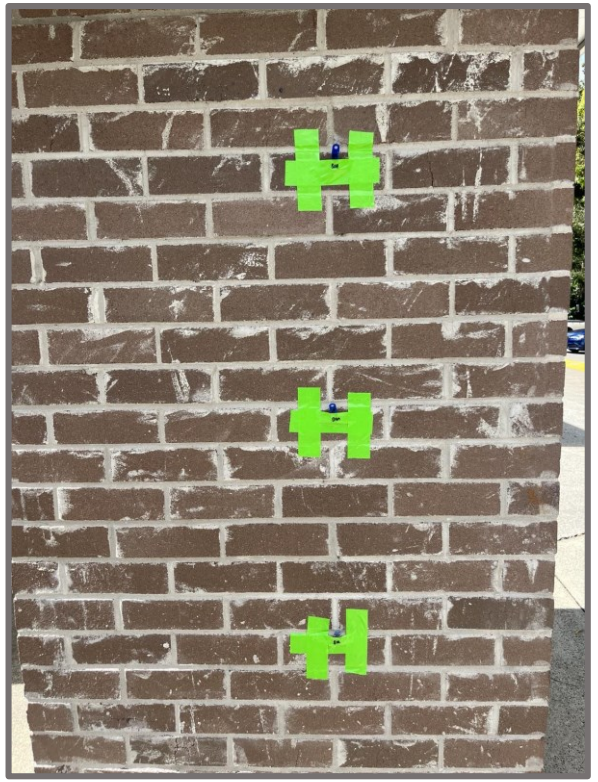
Plant Species

Plant species used in green walls.

Species	Common Name
Chlorophytum comsosum	Spider Plant
Peperomia obtusifolia	Baby Rubber Plant
Nematanthus wettsteinii	Goldfish Plant
Spathiphyllum wallisii	Peace Lily
Spathiphyllum chico	Peace Lily
Philodendron erubescens	Blushing philodendron
Philodendron hedeaceum	Heartleaf philodendron

Research Methodology

- Outdoor and indoor air quality parameters measured from August 2023 to January 2024.
- Surface temperature was measured using temperature loggers.
- Data was collected and compiled at 5-minute intervals over six-months.



Implications

- Relative Humidity was similar across all building types and remained within indoor standards.
- Ozone was consistently lower indoors across all building types.
- Volatile Organic Compounds not at hazardous concentrations.
- Hygrothermal properties of hempcrete just as good as brick; added sustainability benefits including CO_2 and $PM_{2.5}$ reductions [4, 9, 16].

Bennai et al., 2022; Arehart et al., 2020; Di Capua et al., 2021

Future Considerations

- Biodiversity coming soon; current research shows strong performance if a diverse plant community is available.
- Brick with green walls compared with hempcrete with green walls.
- Substrate type? Difference in insulation between green walls.
- Ventilation rates to re-measure indoor air pollutants.

Wooster et al., 2022

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