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Developing hemp-lime low-carbon construction for mainstream uptake

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Partners

- University of Bath
- Lhoist
- BRE (Building Research Establishment)
- Hansen
- Lime Technology
- Wates
- Hemp Technology
- Feilden Clegg Bradley studio
- NNFCC (National Non-Food Crops Centre)



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Project Objectives

To address barriers to commercial development of hemp-lime through:

- Scientific characterisation of material properties.
- Developing optimised material specifications.
- Construction details.
- Improved knowledge and robust data for building performance.
- Improved building environmental models.
- Life cycle analysis of the material.
- Increasing awareness through dissemination.



Project Details

- Characterise materials.
- Optimise mix proportions.
- Monitor, characterise and review performance of existing and new hemp-lime buildings.
- Construct hemp-lime test building & characterise performance (energy use, environment, acoustic, air quality).
- Develop thermal performance modelling of hemp-lime.
- Promote and support uptake of hemp-lime construction.



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The story of hemp-lime construction

Harvesting hemp



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Retting hemp



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Hemp shiv



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Mixing hemp-lime



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Hemp-lime mix



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Casting hemp-lime



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Spraying hemp-lime



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Finished Building



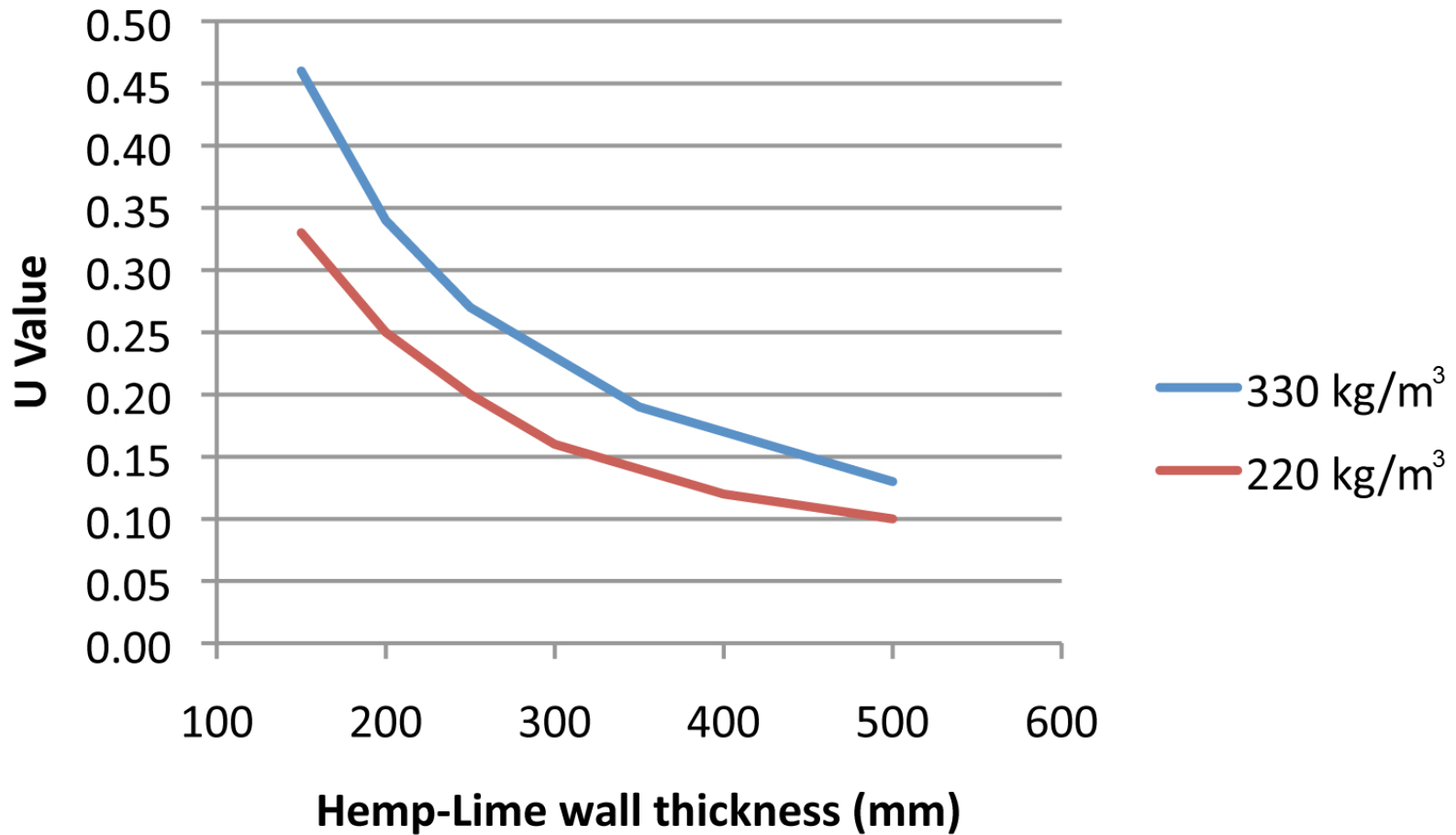
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U-values



Hemp-Lime U values

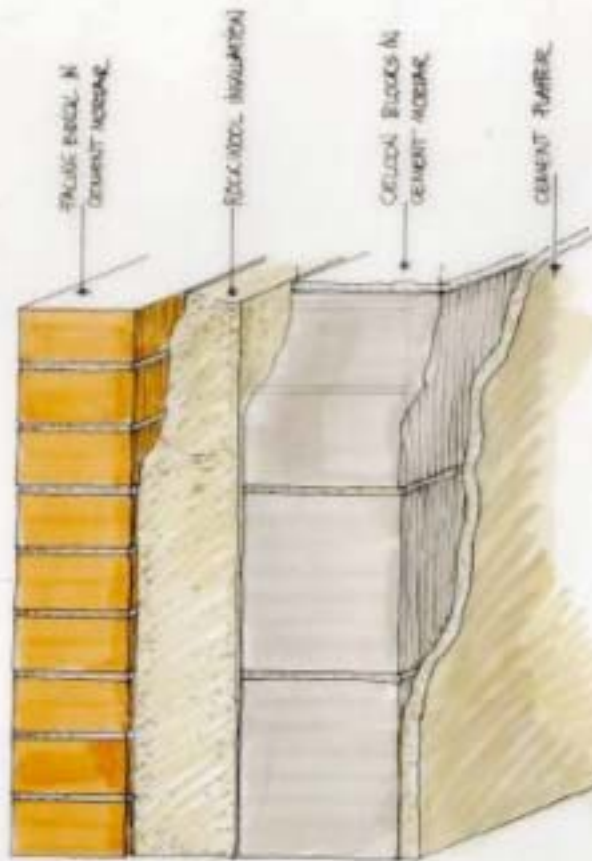


Carbon footprint

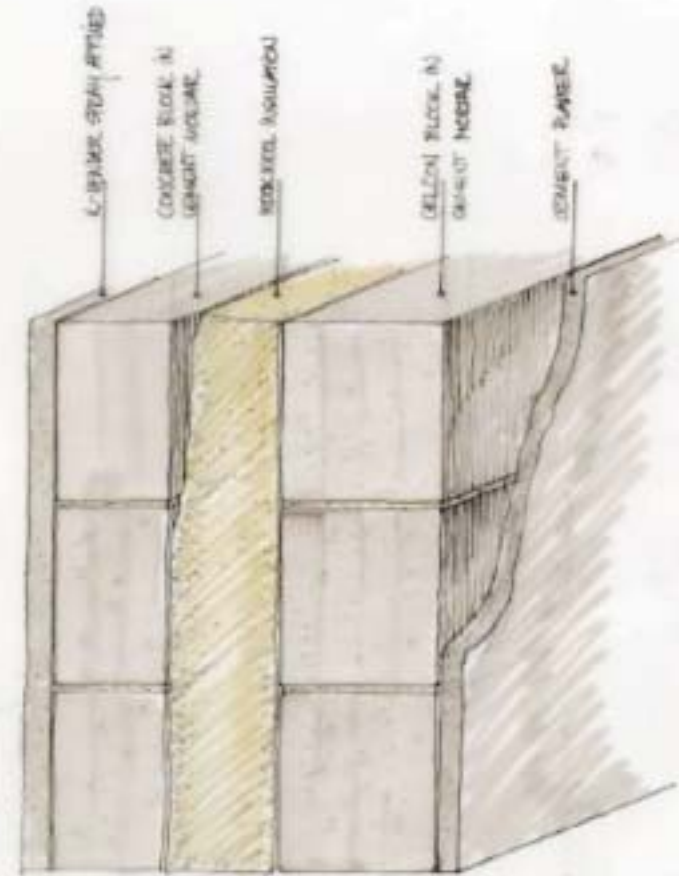


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Typical cavity walls emit around 100 kg CO₂/m² of wall



△ CAVITY WALL 1.



△ CAVITY WALL 2.

Carbon footprint

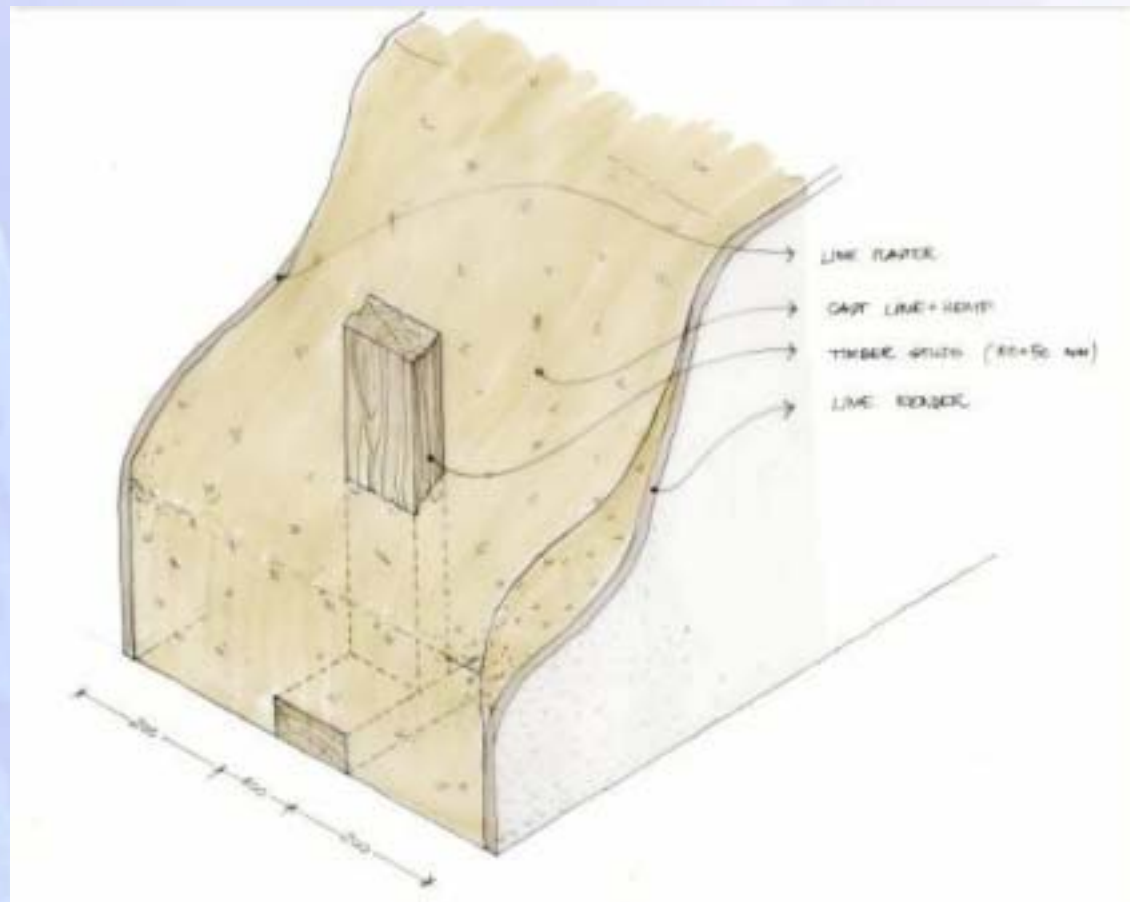


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Hemp-lime walls lock up CO₂

300mm ~31 kg CO₂/m²

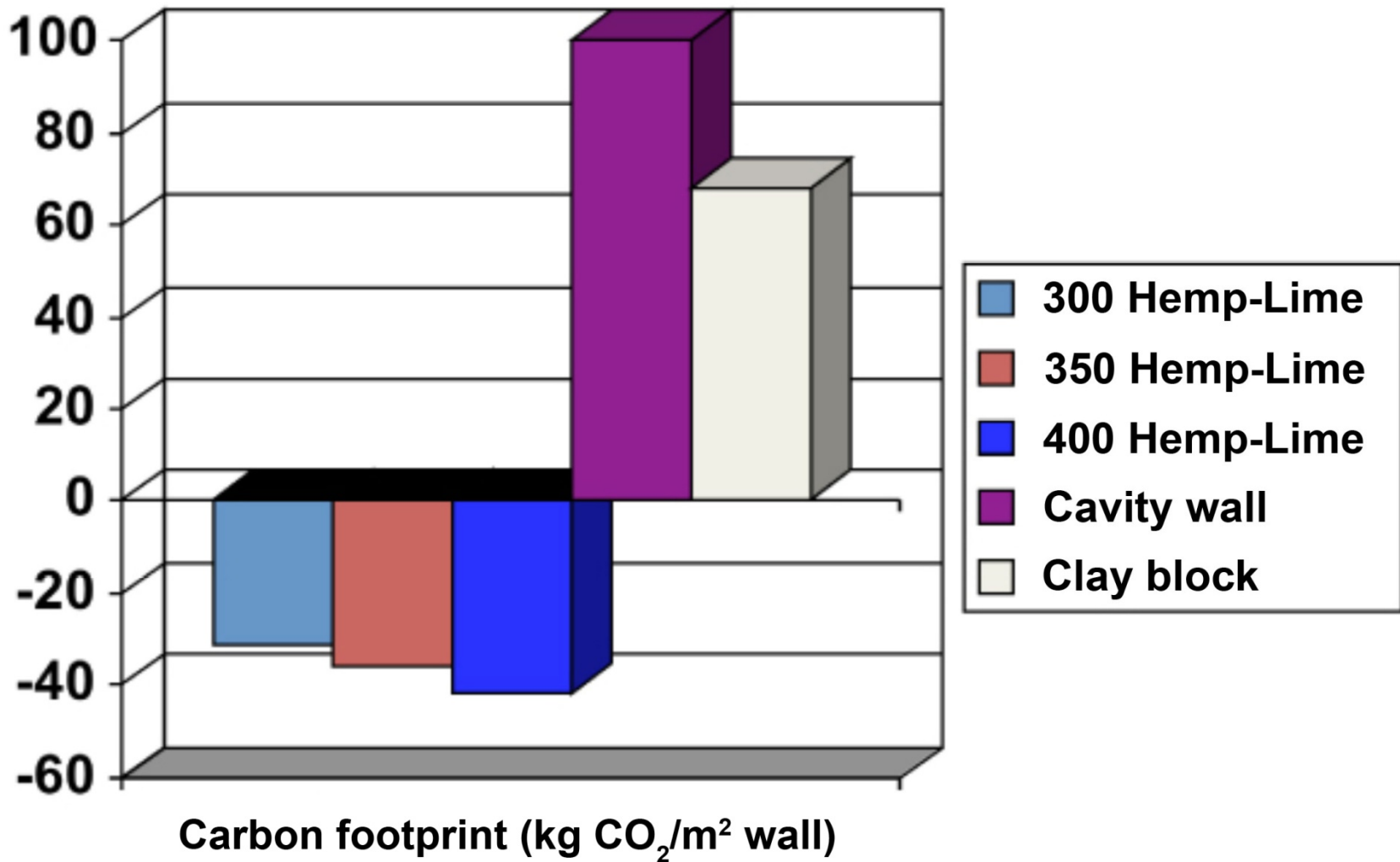
500mm ~ 53 kg CO₂/m²



Carbon footprint



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Acceptance



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Approvals and Insurance

- Radical® Hemcrete® has been awarded LABC system approval
- Radical® Hemcrete® is now approved by *all* 376 Building Control Districts
- Radical® Hemcrete® can be insured through LABC insurance



Prefabrication



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Hemcrete® Blocks and Panels



Testing to date



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- **Mechanical tests**

To establish structural integrity of hemp-lime mixes

- **Carbonation of lime**

To establish how much atmospheric CO₂ is re-absorbed by hemp-lime

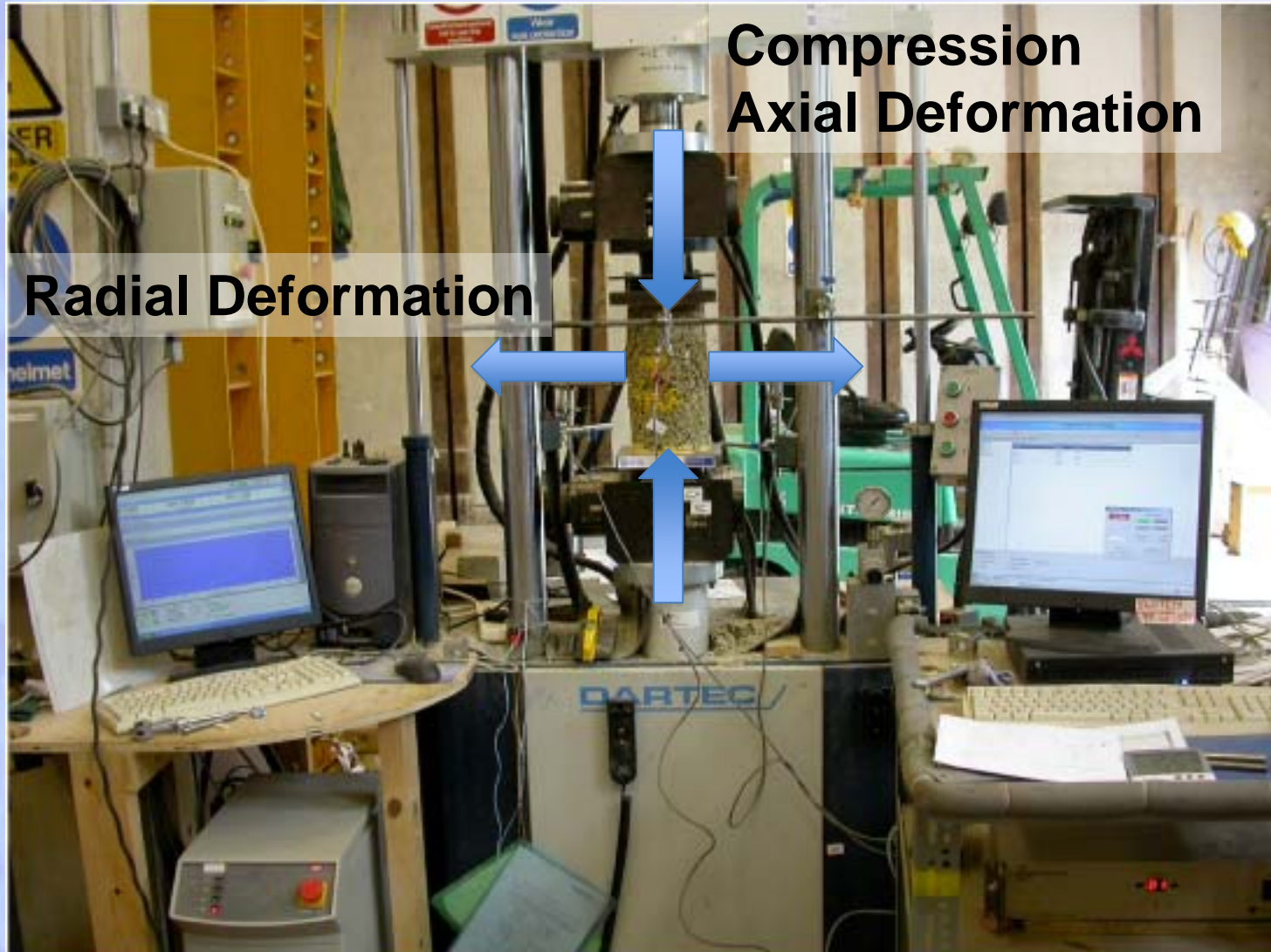
- **Pore structure**

To understand the hygro-thermal properties of hemp-lime

Mechanical tests



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Mechanical tests



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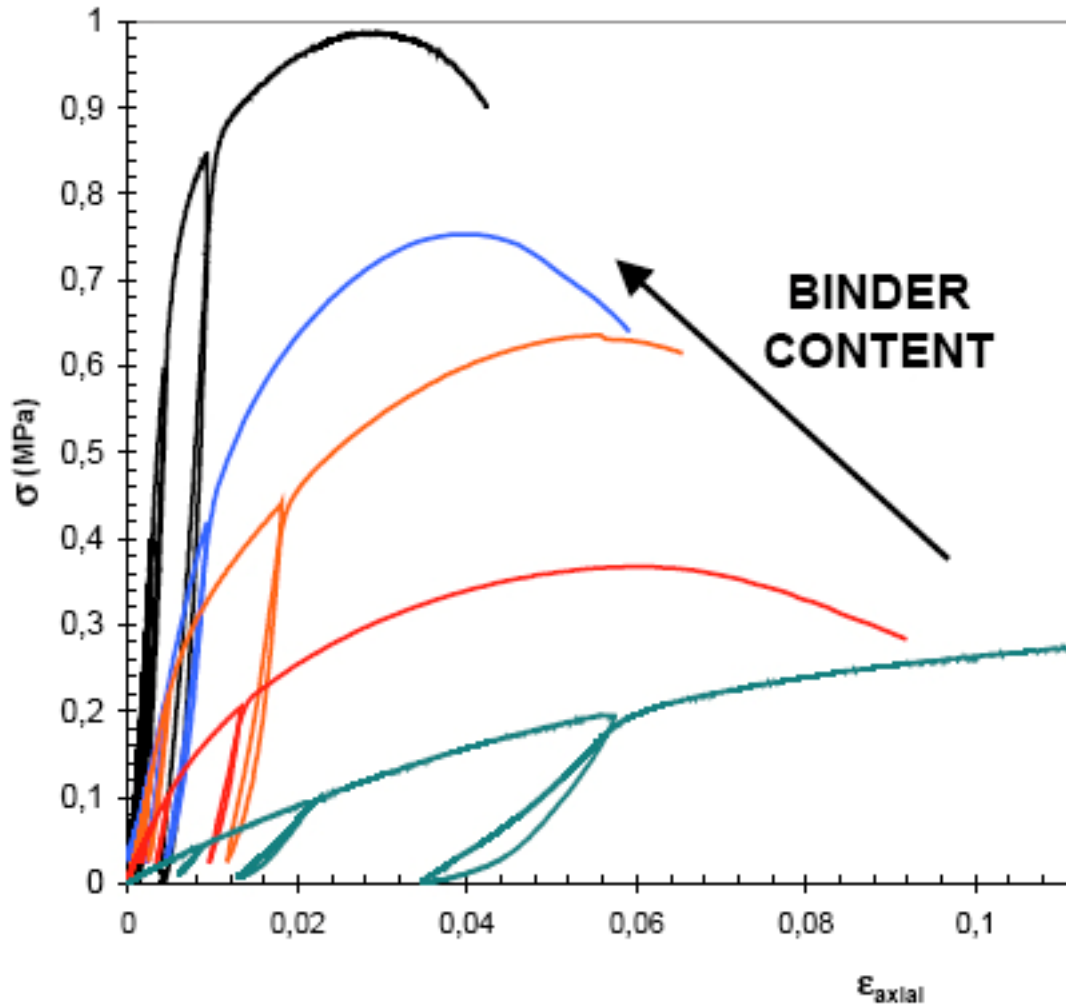


Mechanical tests



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Compressive strength
after 1 year



Carbonation



Techniques that can be used include:

- Phenolphthalein staining – which picks up high alkalinity associated with uncarbonated lime.
- Thermogravimetric analysis – extremely accurate technique which analyses chemical content.

Carbonation



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Phenolphthalein
staining at
28 days

Carbonation



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1 tonne of binder will absorb 151.5 kg CO₂ if the binder fully carbonates

In a typical hemp-lime mix, if the binder fully carbonates, 1 tonne of hemp-lime will absorb 21.05 kg CO₂

Pore structure



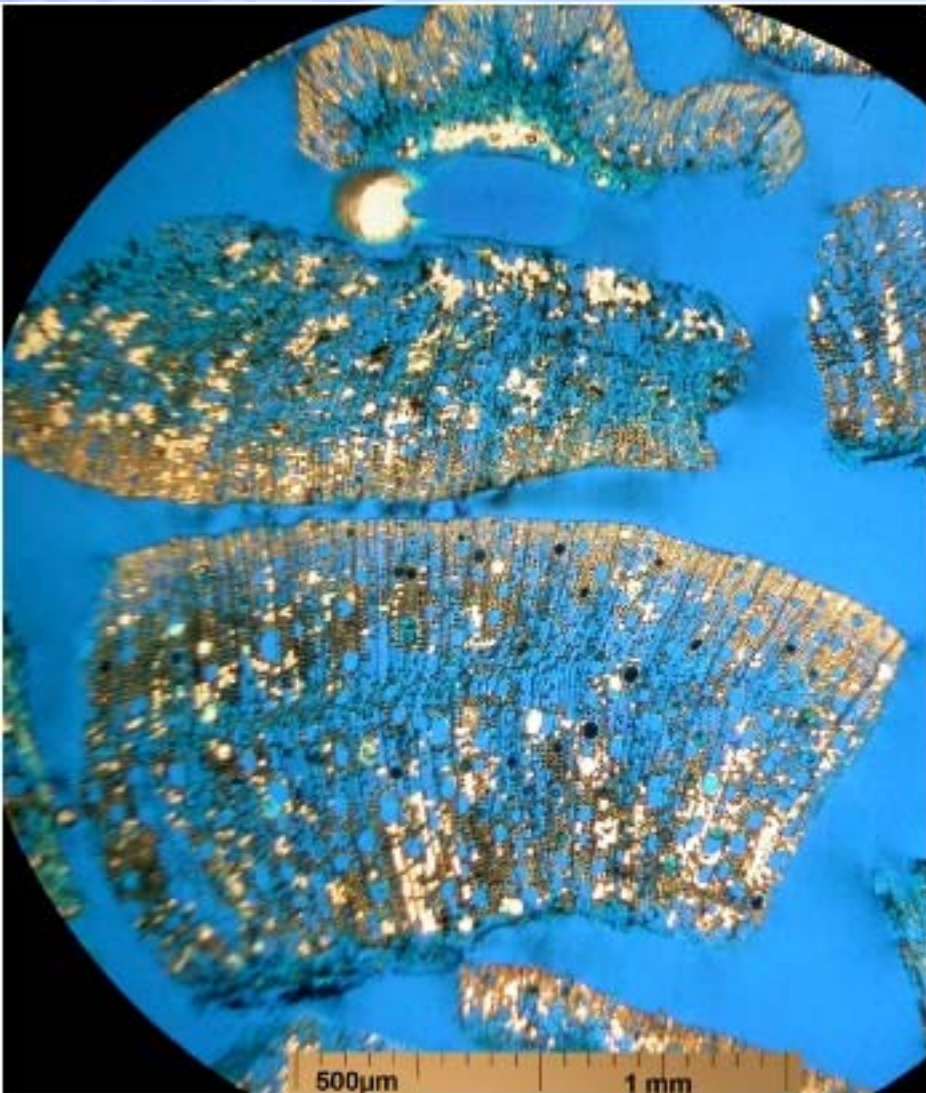
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- Hemp-lime displays unusual thermal properties. Measured heat transfer implies higher thermal mass than expected.
- Properties probably associated with pore structure involving phase changes (condensation / evaporation / re-condensation).

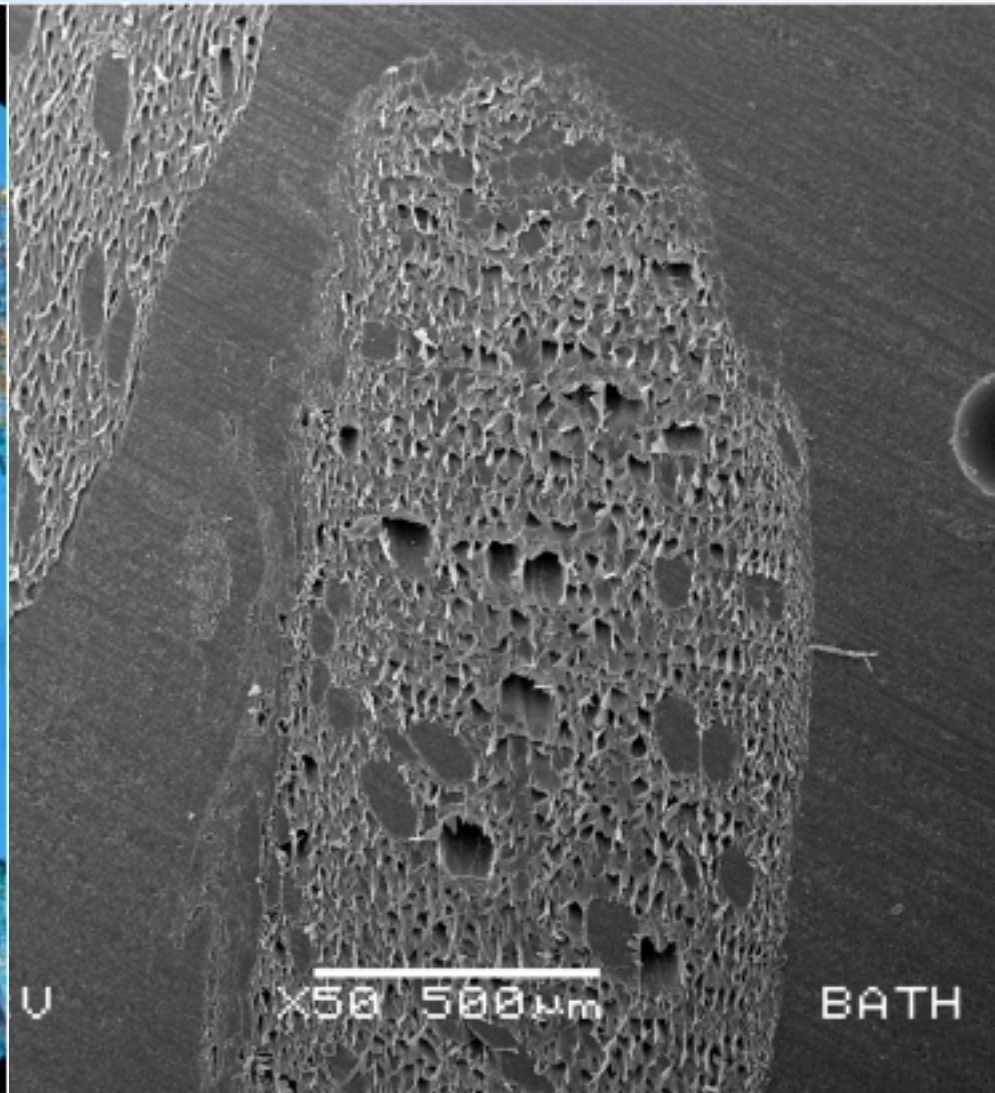
Pore structure



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Optical



SEM

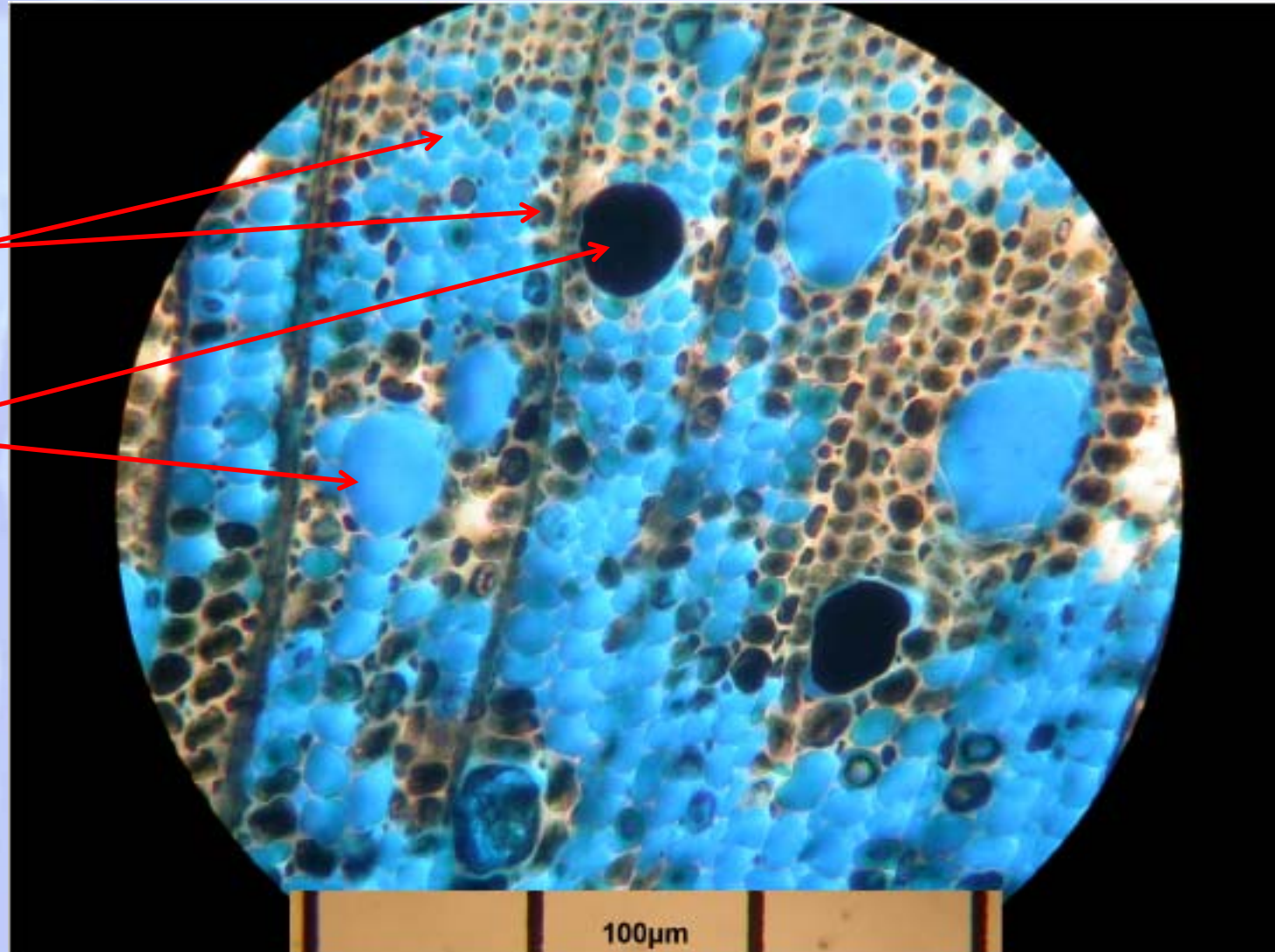
Pore structure



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parenchyma
~10 μ m

xylem
~50 μ m

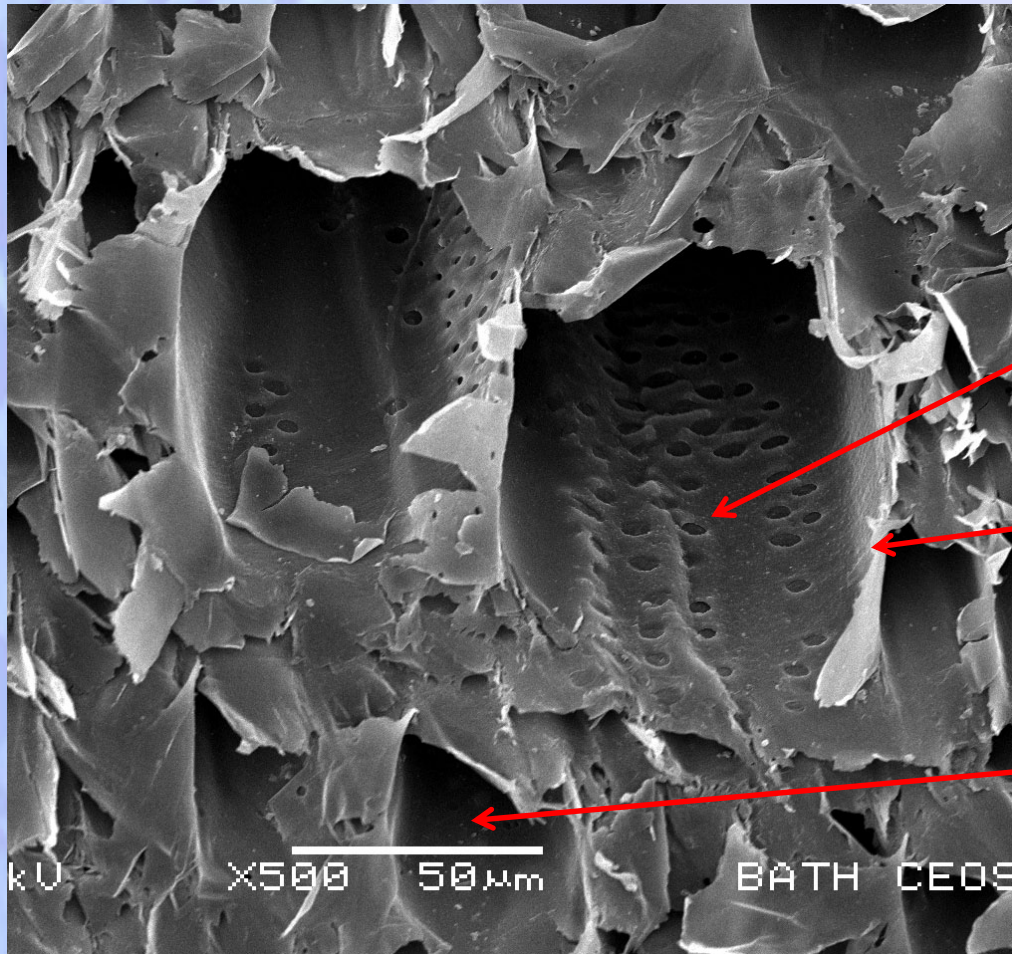


Pore structure



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Hemp shiv - xylem



pits

hydrophobic cell
wall

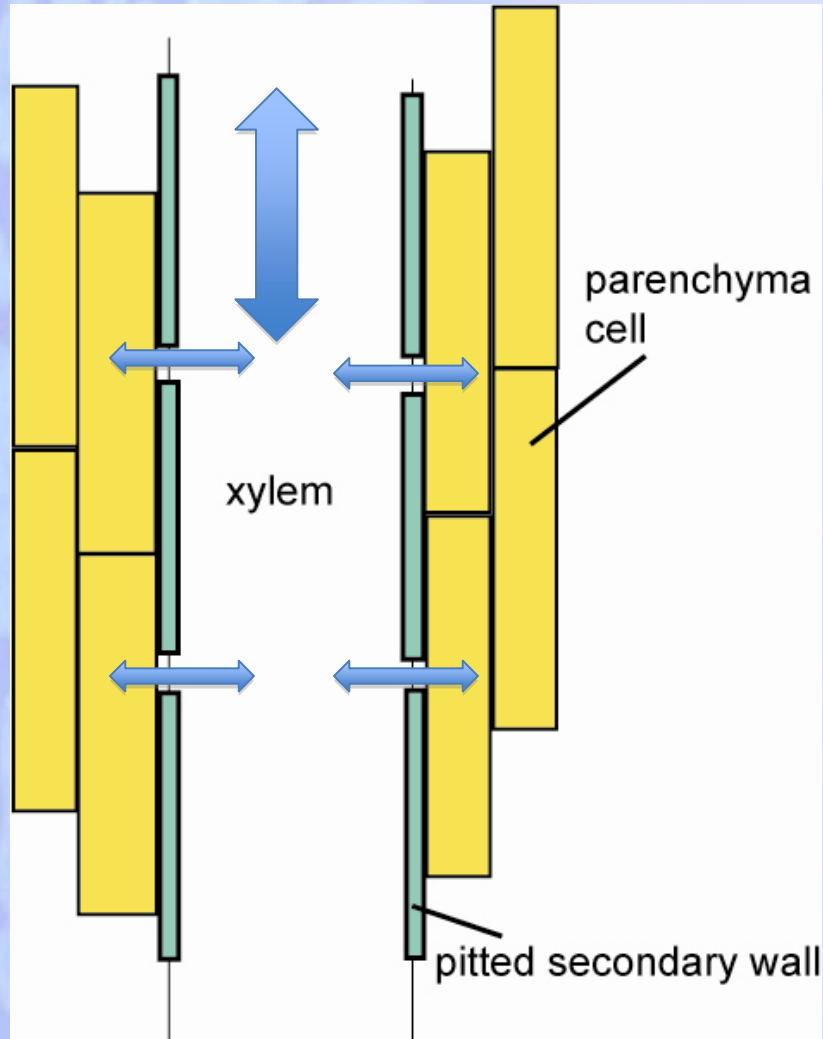
parenchyma

Pore structure



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Hemp shiv – schematic structure



Water access the system via the xylem, and is absorbed / desorbed into / out of the parenchyma via the pits.

Xylem diameters are of the order of $50\mu\text{m}$.

Pit diameters are of the order of $1\text{-}5\mu\text{m}$.

Parenchyma cells are of the order of $10\mu\text{m}$ and are interlinked.

Summary



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- Hemp sequesters CO₂ from the atmosphere.
- Lime re-absorbs some of the CO₂ emitted during manufacture.
- Hemp-lime is UK grown and manufactured which reduces transportation costs.
- Hemp-lime has low U-values.
- Hemp-lime has high thermal mass.
- Hemp-lime buildings have the potential to contribute to low / negative carbon housing.

Ongoing work



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- Mechanical & Carbonation tests
 - Complete testing to 365 days
- Hygric performance
 - Characterise hygric performance (capillarity, vapour permeability, absorption/desorption isotherms.....)
- Pore structure
 - Determine pore size distribution
 - Understand 'virtual thermal mass' phenomenon

Ongoing work



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- **Hemp-lime test building**
 - Construct, instrument and test building performance
- **Hygro-thermal testing**
 - Test hygro-thermal performance and develop a model to reflect test data
- **Dissemination**
 - Publish technical and non-technical papers to increase awareness of the value of hemp-lime construction



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Questions?