



UNIVERSITY OF  
**BATH**

# Centre for Innovative Construction Materials

Pete Walker  
Centre for Innovative Construction Materials  
University of Bath,  
Bath



- Research Centre since 2005
- Main research fields:
  - Low carbon cements and concrete materials
  - Innovative concrete structures
  - Historic materials and conservation
  - Natural materials (timber and other plant-based; mineral based)
  - Energy performance
  - Health and well-being (ambient vibrations; IAQ)



## Large Environmental Chamber (LEC):

Weather conditions including:

- Temperature (-20C to 40C),
- Humidity,
- Wind & rain,
- Solar radiation (1,200 W/m<sup>2</sup> @ 1m)



The LEC facilitates full or large-scale testing of building elements under controlled and repeatable environmental conditions.



## **Lasercomp Fox 600 Heat Flow Meter:**

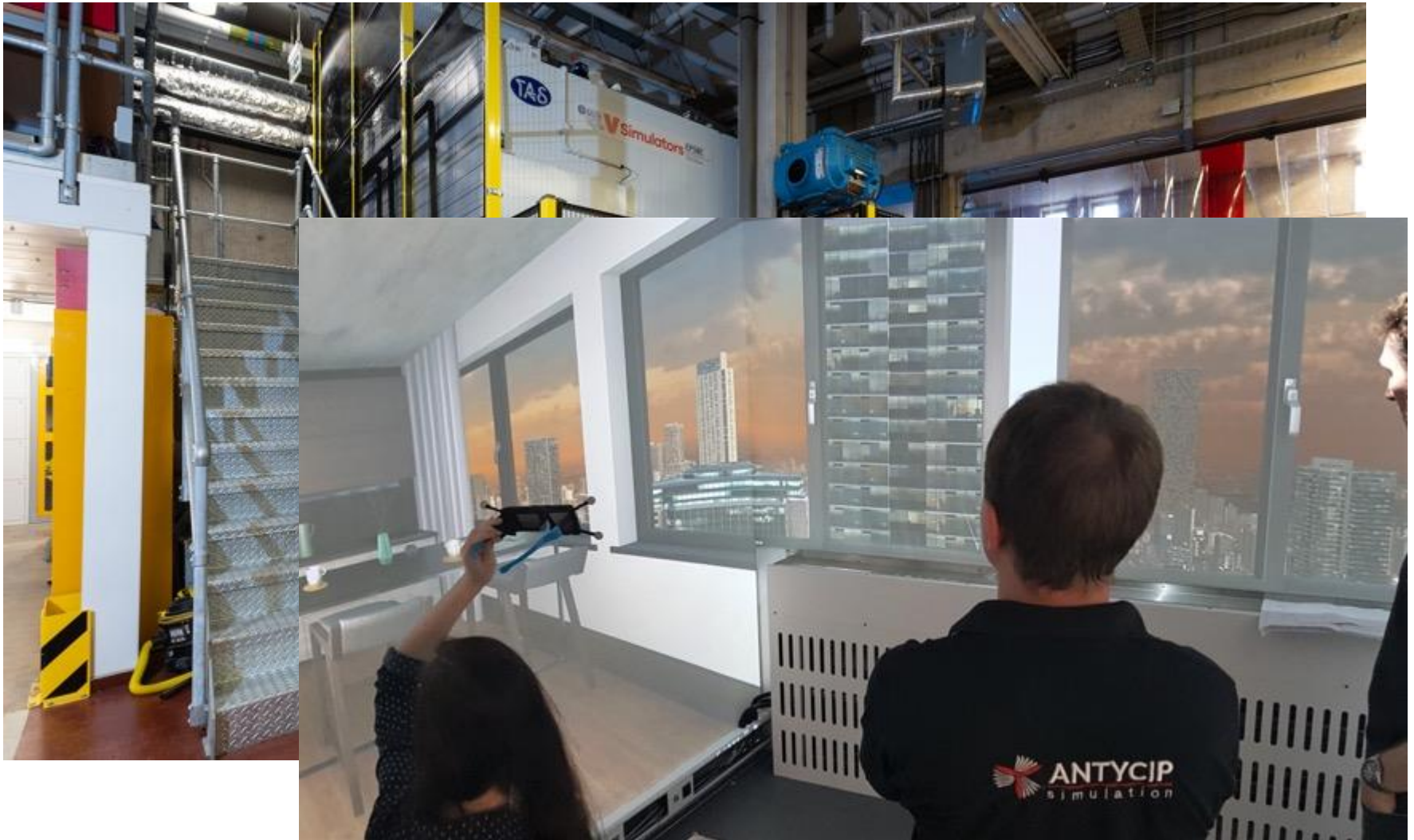
Measurement of thermal conductivity of large samples in the range 0.005 to 0.35 W/mK

## **Hot Disk TPS 3500 & TPS500(S):**

Measurement of thermal conductivity, thermal diffusivity and specific heat. Isotropic, Anisotropic, single-sided measurement capability.

Ability to test solid, powders, liquids, thin-films.

# VSimulator



# Pioneering zero carbon construction policy in B&NES



## Policy partnership

- Studying and supporting the **first UK planning policy**:
  - Requiring net zero operational energy for all new building developments
  - Capping the embodied carbon of large developments

## Research questions

- Are targets being met? How?
- What absolute carbon reductions are anticipated?
- How can the policy be refined and expanded?

## Methods

- Analysis of planning application data
- Applicant questionnaires and interviews



# Additive manufacturing – Steel Construction



**Specimen  
preparation**

## Metal 3D printing facilities at UoB



enclosure with 3 axis  
system and pyrometer

Control-

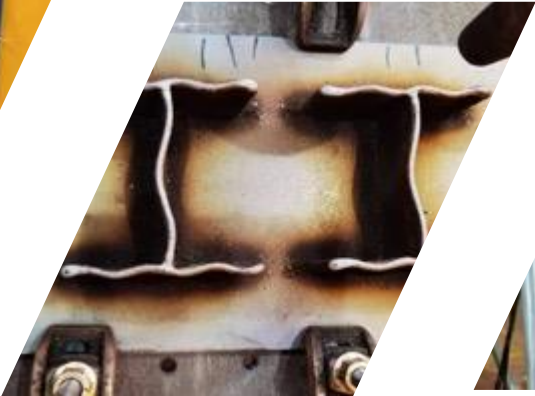


**Material Testing  
Facility**



**Material  
characterisation**

# Additive manufacturing – Steel Construction





# Characterisation of polymeric foams 3D printed from drones. Development of cementitious materials with special rheological properties optimised for 3D printing by autonomous drones

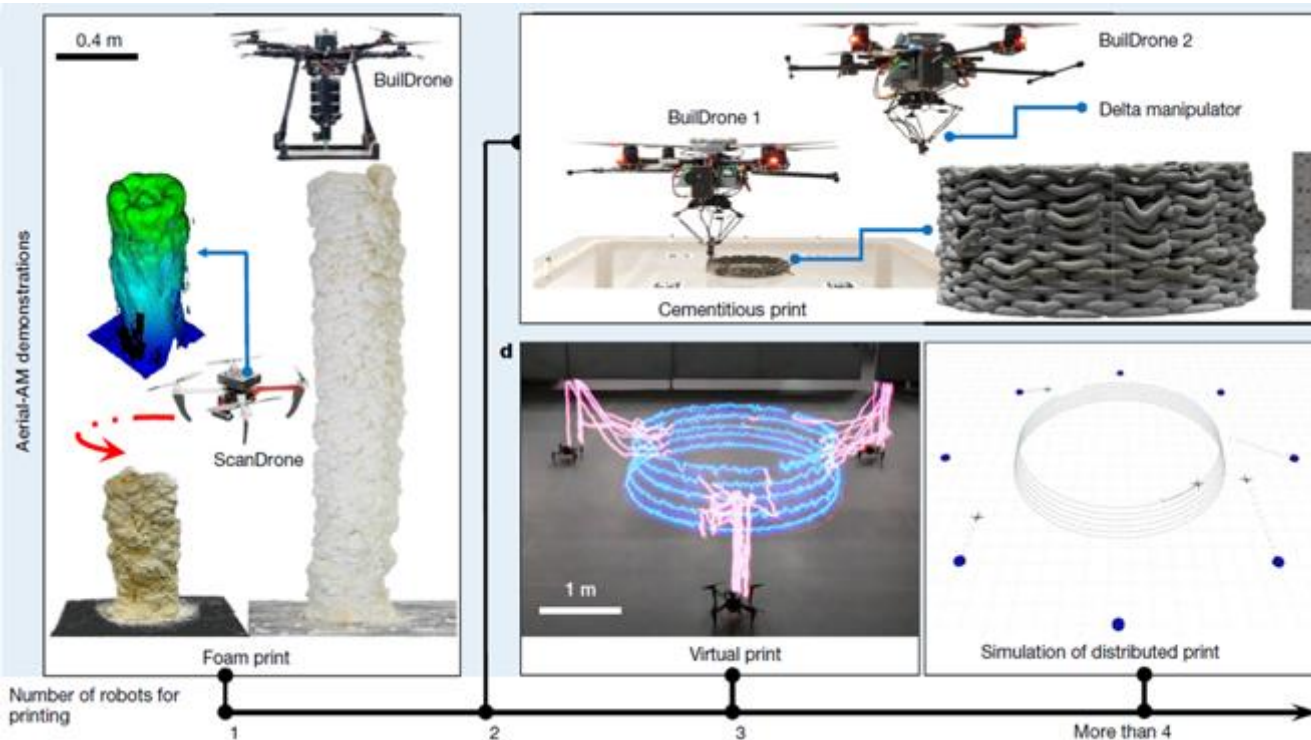


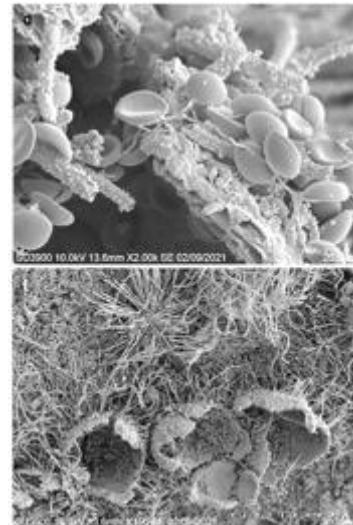
Figure above from: Zhang, K., et al, Aerial additive manufacturing with multiple autonomous robots, 22 Sep 2022, In: Nature. 609, 7928, p. 709-717 9 p.

# Investigation of the architectural history and failure mechanisms of fibrous plaster.

## Apollo Theatre: Ceiling collapses during show in London 🕒 20 December 2013

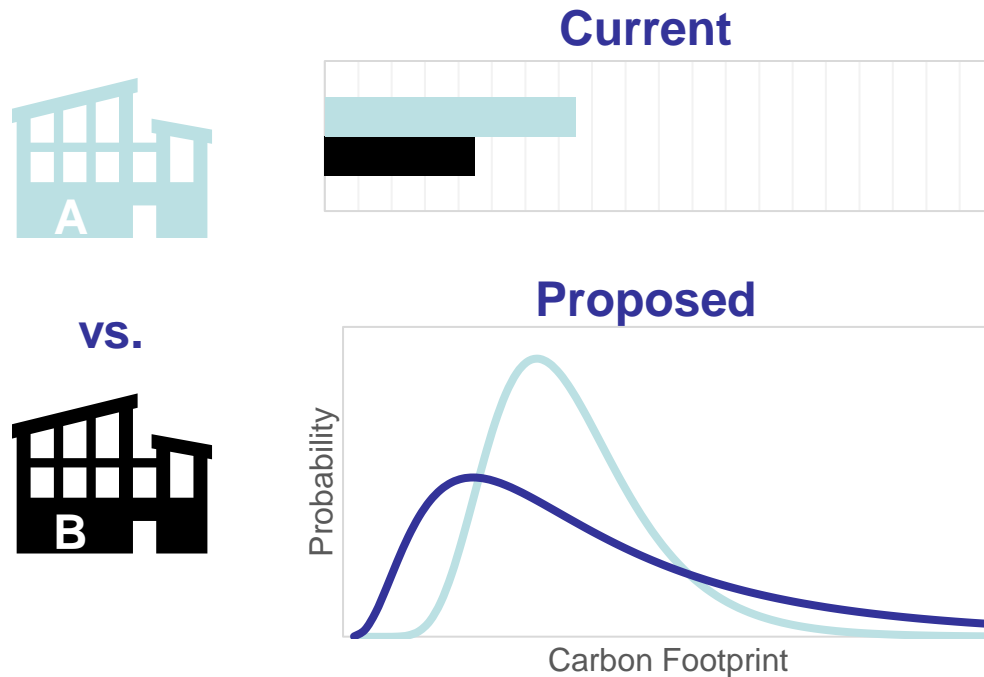


Structural testing of ceiling panel



Hessian  
Fungal  
degradation

# Tackling uncertainty when predicting carbon footprints of construction products & buildings



# Bio-based construction materials research

- Hemp-lime
- Straw Bale
- Cork
- Mycelium insulation

# Opportunities for bio-based materials in modern construction

- Reduced GHG emissions
  - Lower embodied carbon
  - Better environmental performance
- Healthier buildings
- Resource efficiency
  - Renewable
  - Reduced waste – circular construction
- New markets (agriculture)

# Hemp-lime: Materials



# Hemp-lime: Cast



# Hemp-lime: Prefabricated









# Hygrothermal panel tests

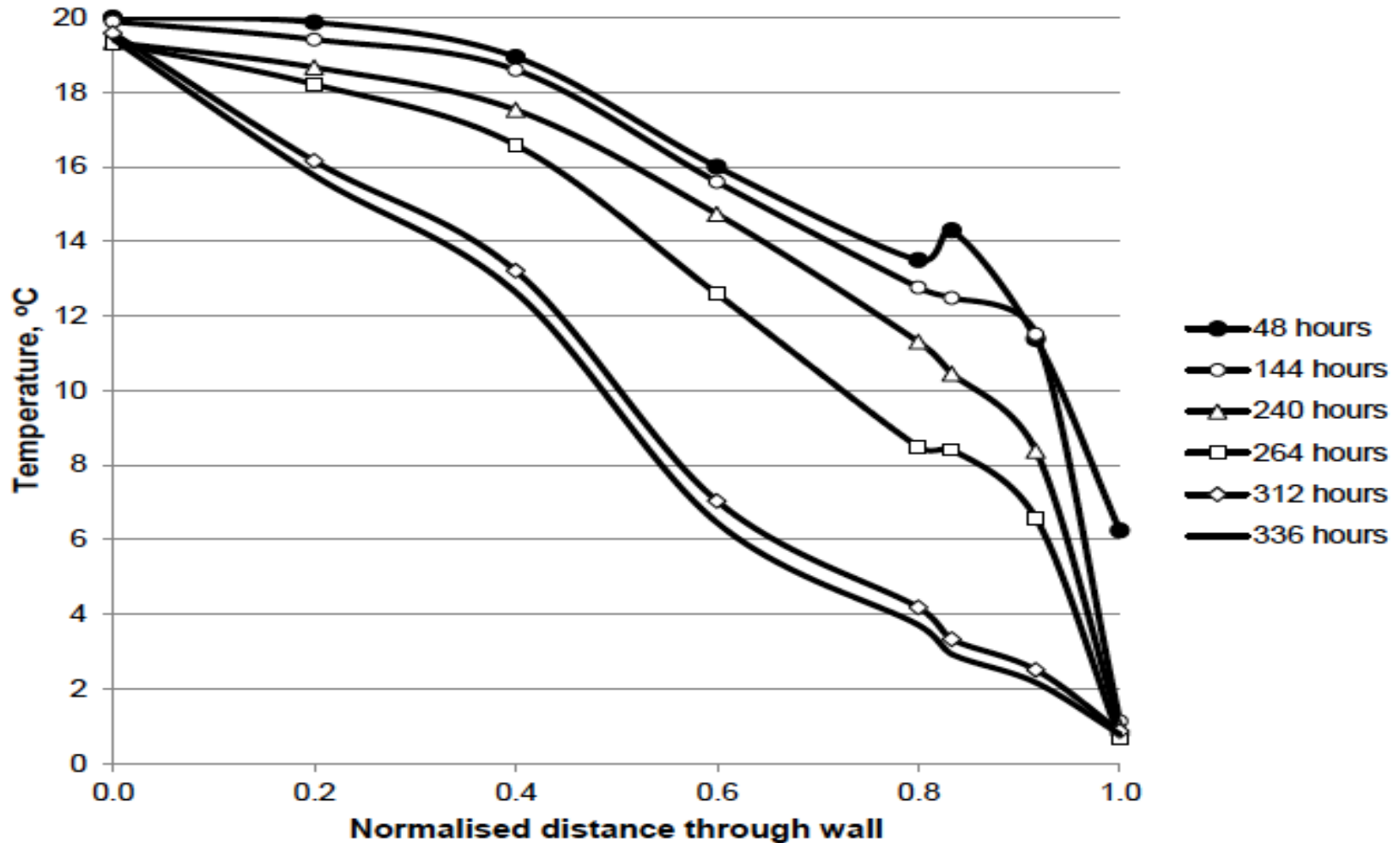


**Environmental Chamber**



**Hemp-Lime panel  
with embedded sensors**

**Temperature change in 300 mm HL wall after sudden temperature drop**



# Structural tests



# Building with straw bales



# Loadbearing Straw Bale



# Straw bale in-fill





# China, Heilongjiang Province



# Prefabricated Straw Bale: ModCell and BaleHaus





# Fire resistance

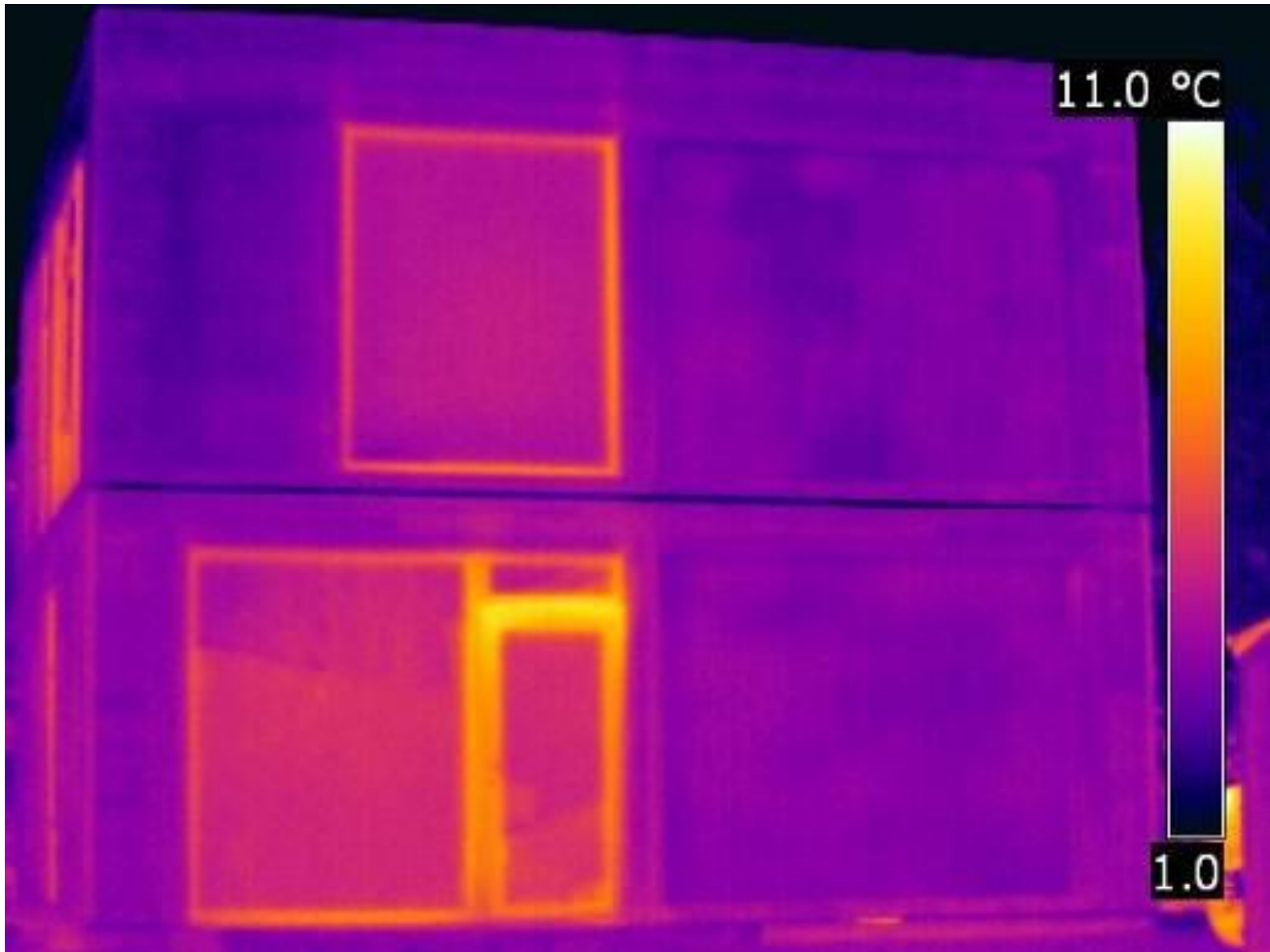
Fire test in accordance with BS EN 1364-1:1999

>1000° C

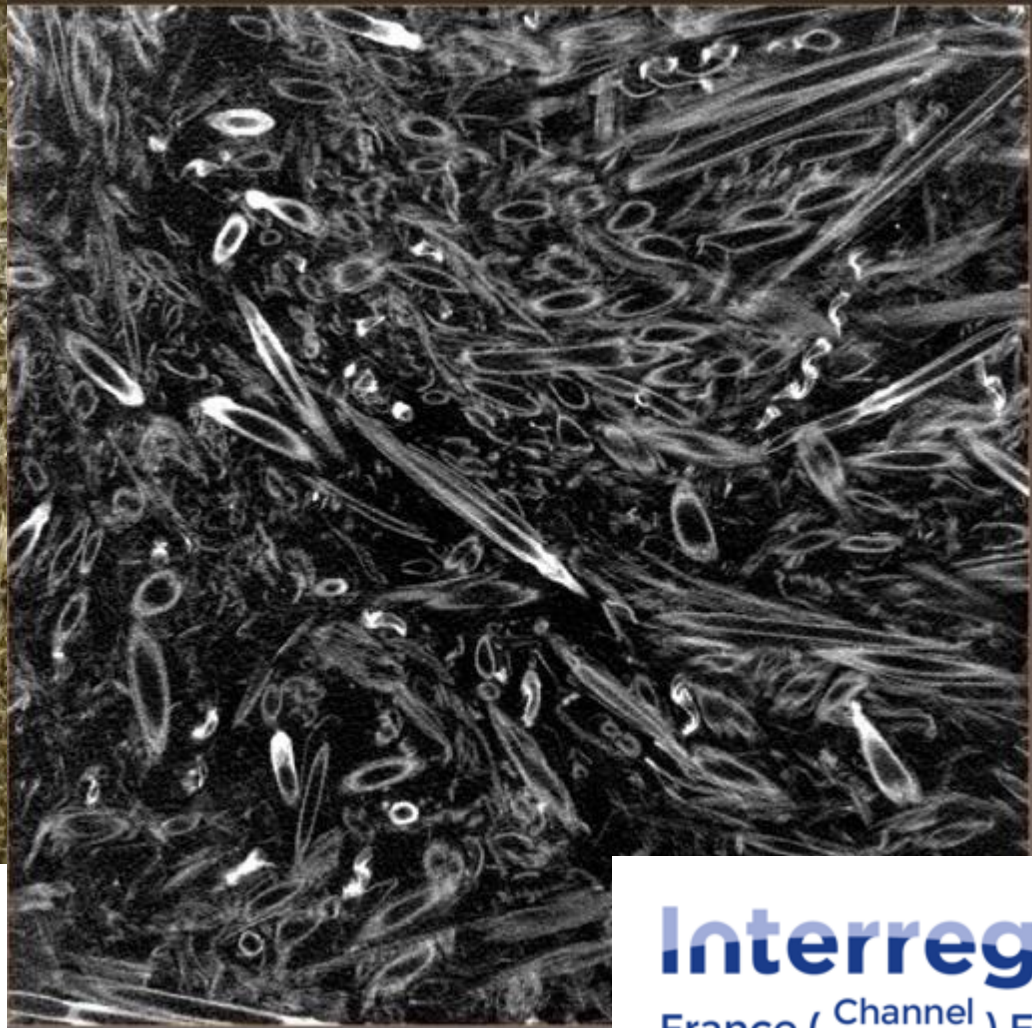
2 ¼ hours



# Thermal performance



# Straw orientation





# LILAC, Leeds





# Hayesfield School, Bath



# Shirehampton, Bristol



# Cork

- Very lightweight natural insulation
- Thermal conductivity 0.06 W/mK
- Density 65 kg/m<sup>3</sup>
- External insulation systems

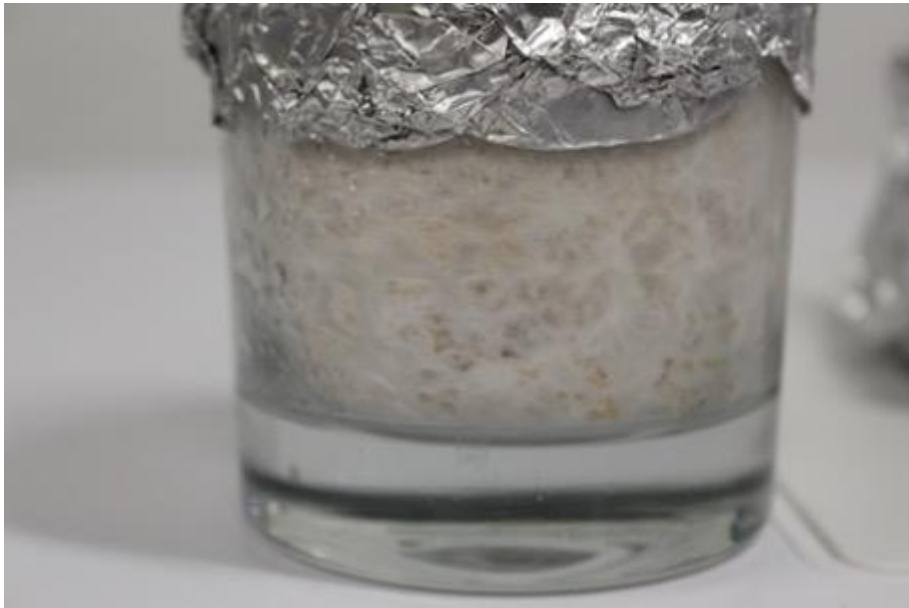






# Mycelium insulation

- Networks of filamentous hyphae
- Convert low-cost organic wastes into bio insulation products
- Technical feasibility achieved, but competitive thermal conductivities, combined with scalable and commercially viable manufacturing processing, have not yet.
- On-going research into substrates, fungal species, growing conditions etc.



# Acknowledgements



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# Thank you

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