The Product Development and Performance of Bio-based Thermal Insulation for Domestic Construction Applications

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Agenda

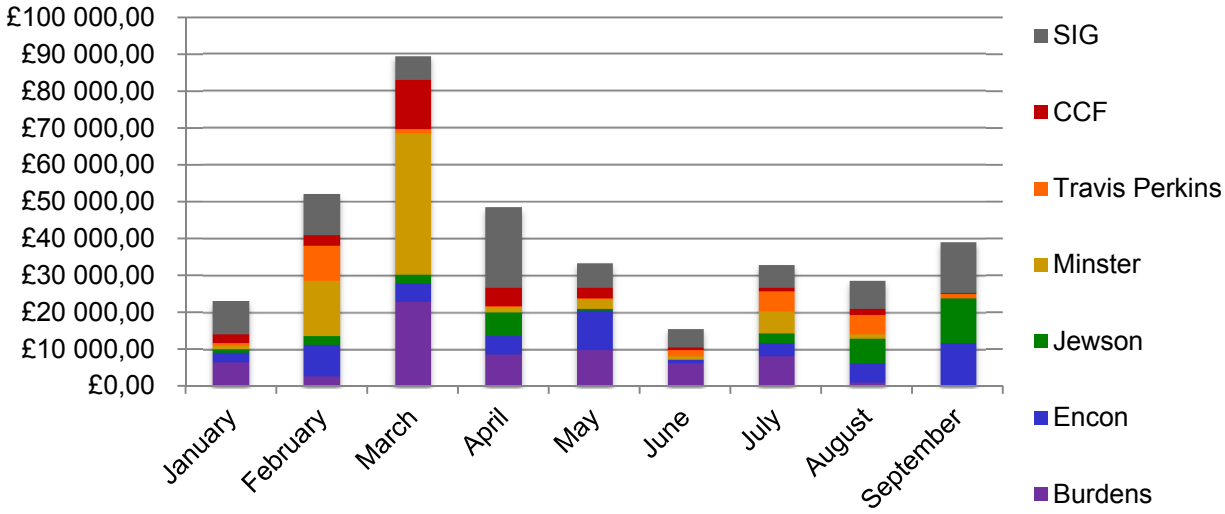
- Insulation market
- Production overview and some issues
- Performance
  - Moisture
  - Acoustic
  - Tensile strength
  - Formaldehyde and VOC absorption
- Cultural problems in the UK

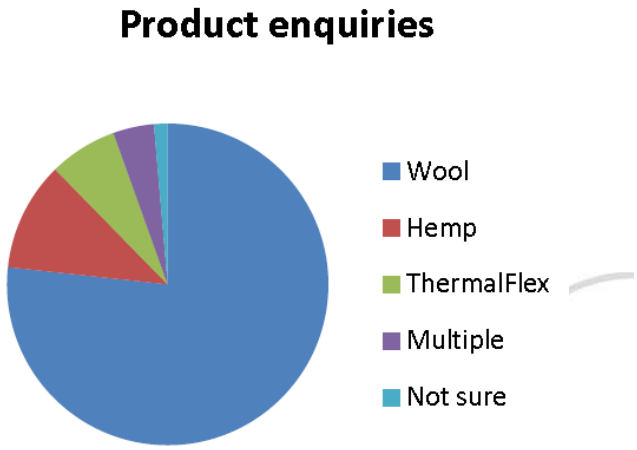
Black Mountain Insulation

- Only UK based manufacturing facility dedicated to producing natural insulations - established in 2007
- Use up to 90% less embodied energy in comparison to man-made insulation products:
- Company bought out in 2012 and moved to Yorkshire

Insulation market

- Data from 2011 for Black Mountain





Insulation market

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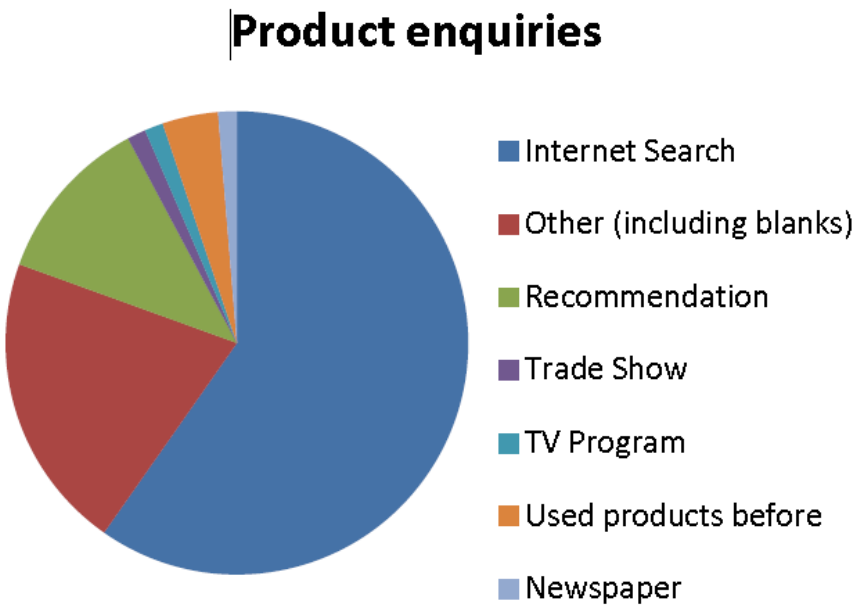
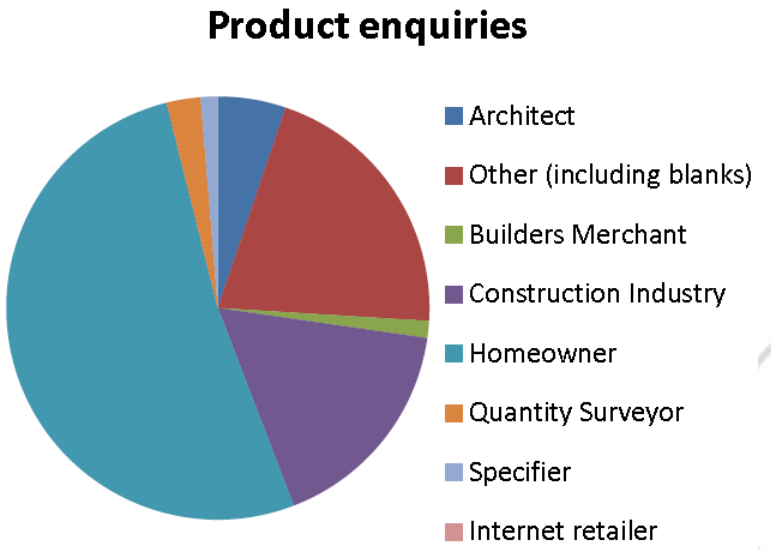
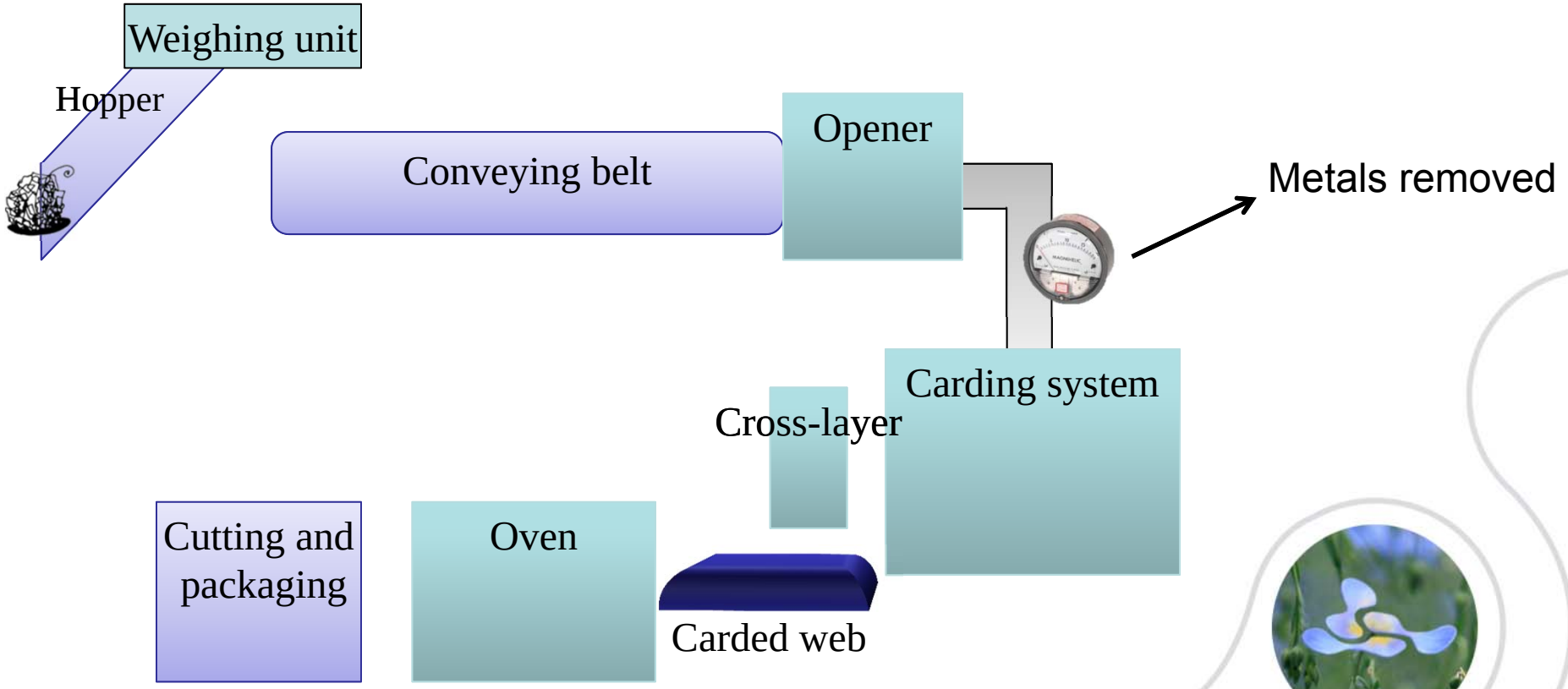




Non-woven processes

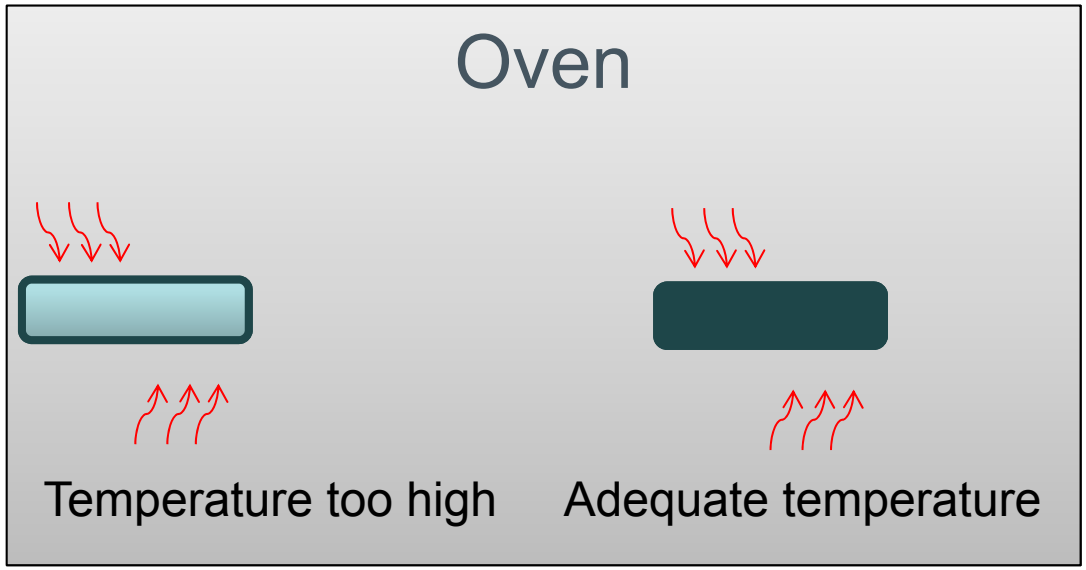
- Carding process
  - Results in a web of aligned fibres are then cross laid into several layers that overlap: Better thermal performance
- Air-laying system
  - Fibres are blown out onto a perforated belt forming a web of somewhat randomly aligned fibres: Faster production speed and can result in a thicker products
- Needle felting
  - Removes the need for a binder, but the thicker the final product the lower the structural integrity

Process overview



Production issues

- Binder and structural integrity

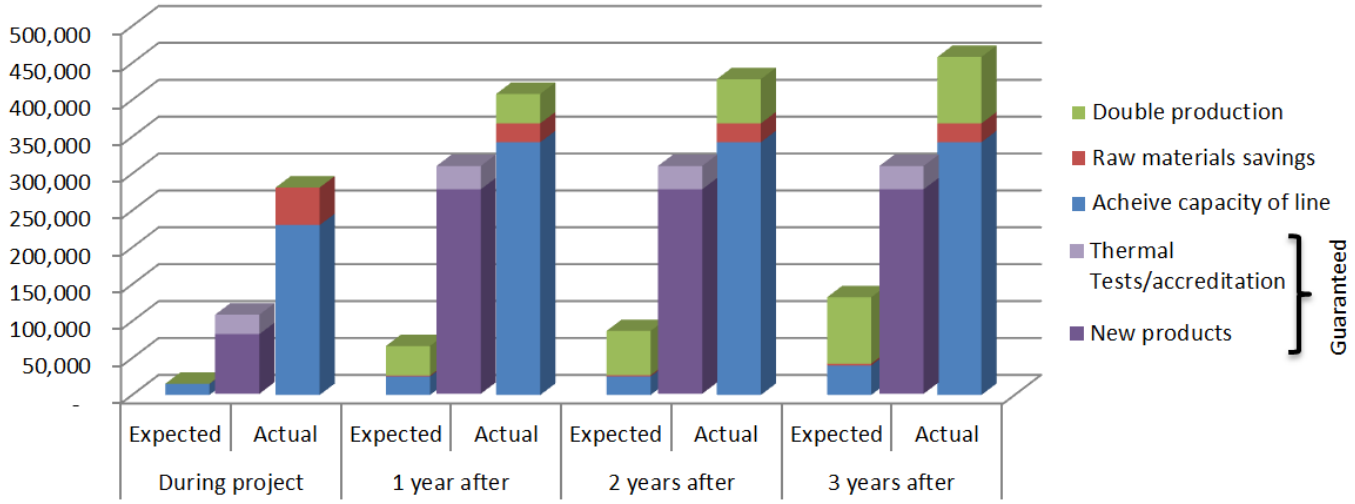


Reducing binder content

- From 15-20% to 5-10%
- Highest natural content in the market for bonded insulation

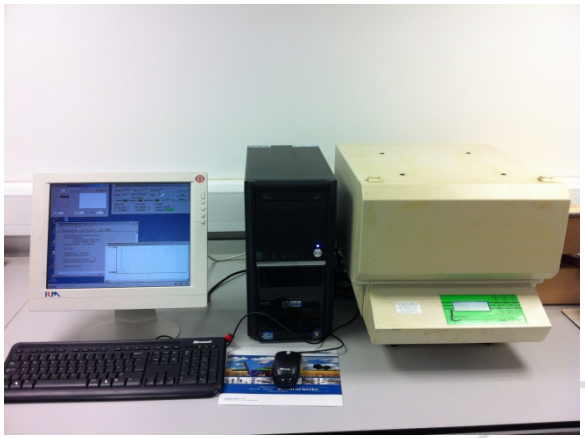
Production enhancement

- Reduction and re-use of waste fibre: £50k savings
- Downtime reduction of >10% and up to 36% increase in production speed
- Sales of new products: >£80k



Thermal performance

- Products' thermal conductivity λ=0.039 W/m.k
- Common fibreglass has λ=0.042 W/m.k
- Denser version of hemp insulation (40kg/m^3) produced, giving λ=0.038 W/m.k
  - CE marking → 3% increase in sales



Moisture problems with synthetics

- *Figure shows the inside of the loft with condensation on the foil backed insulation located between the timber rafters. Drops of moisture can also be seen spotting the horizontal insulation. Measurements of the moisture content of the timber rafters indicate that the (surface) moisture ranged from 12 to over 30 depending on position in the loft. The worst, highest readings, were located in towards the bottom of the rafters.*

Moisture buffering

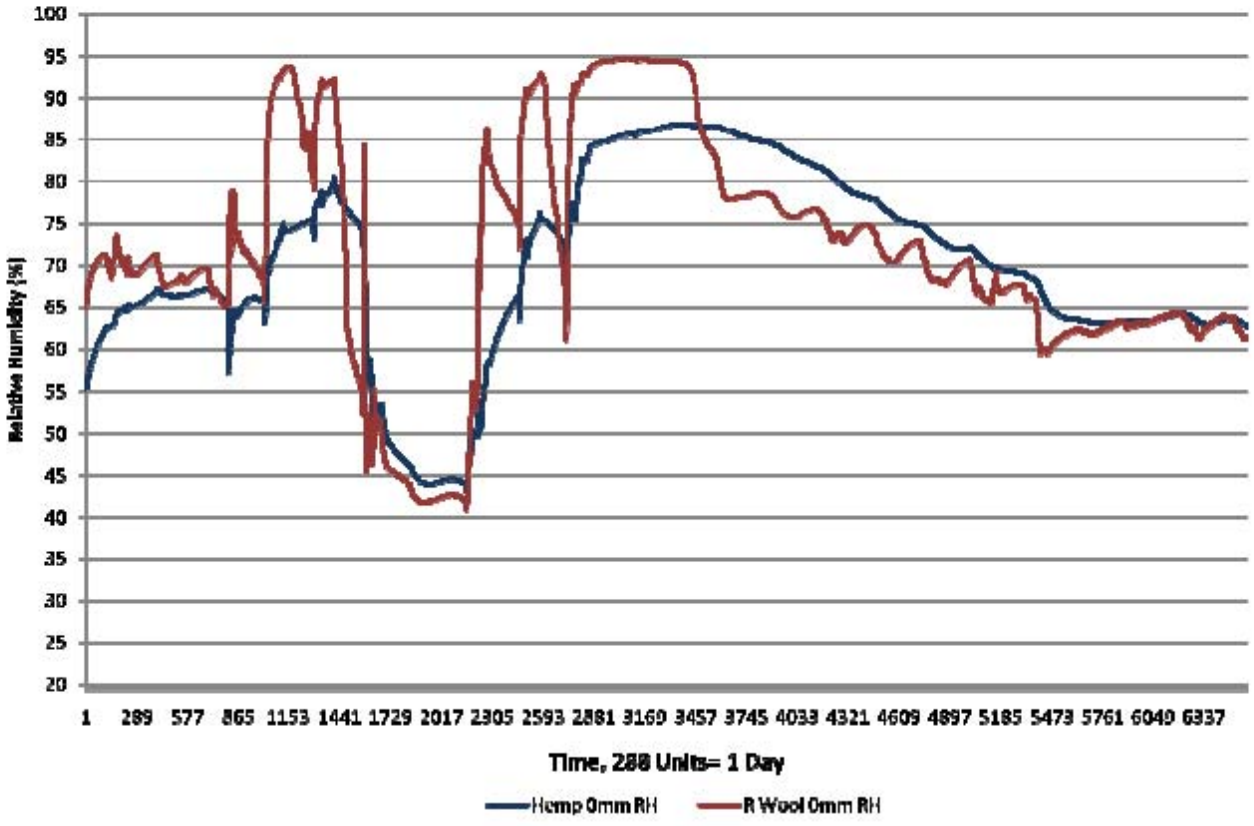
- The TSB results show clearly that the amount of water vapour above the bio-insulations can be up to three times lower than that above Rockwool insulation. The risk of condensation has therefore been reduced and the amount of water condensing at dew-point temperature will be significantly less.
  - This is done in response to changing ambient conditions, whilst retaining a proportion of their insulation properties*

*Hansen KK, Rode C, Hansen E, Padfield T, Kristiansen FH. Experimental investigation of the hygrothermal performance of insulation materials. Proc Perform Exter Envel Whole Build VIII 2001

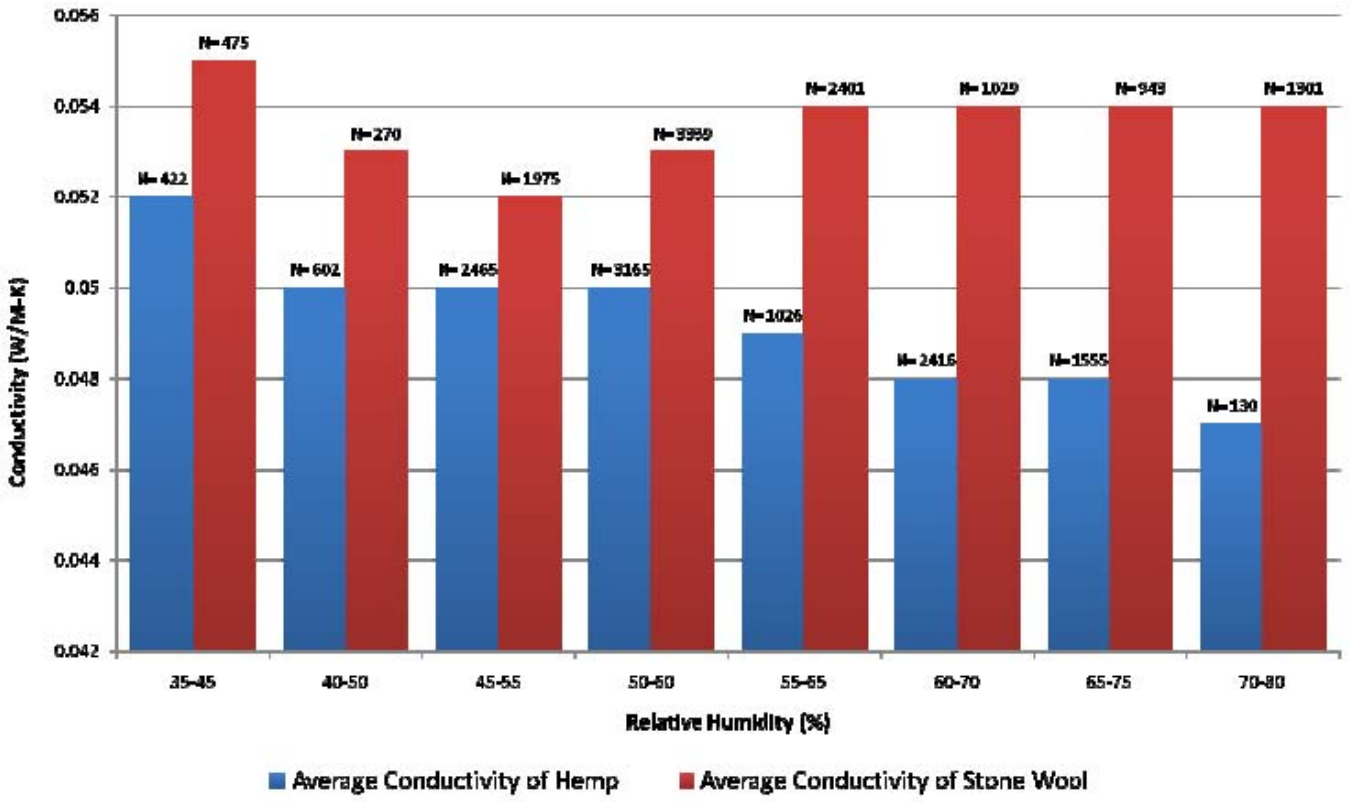
Peuhkuri R, Rode C, Hansen KK. Moisture buffer capacity of different insulation materials. Proc Build IX Clear Fla 2004

Zach J, Korjenic A, Petránek V, Hroudová J, Bednar T. Performance evaluation and research of alternative thermal insulations based on sheep wool. Energy Build 2012;49:246–53

Relative Humidity Distribution in Hemp and Rockwool External Surface



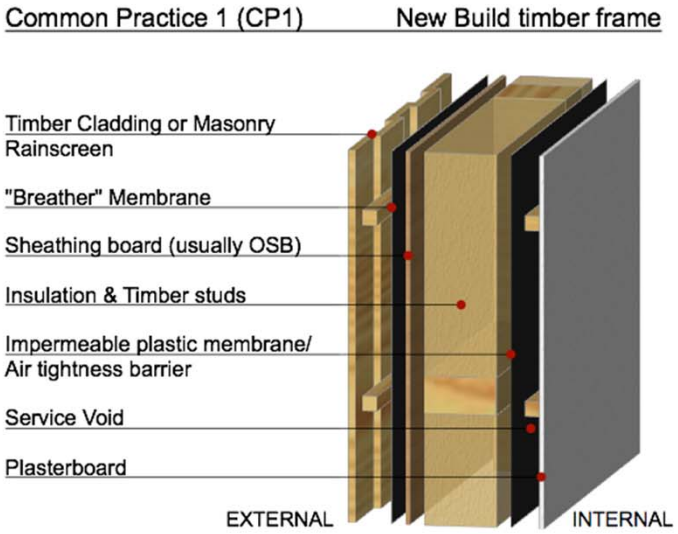
Thermal conductivity of naturals vs synthetics at different RH

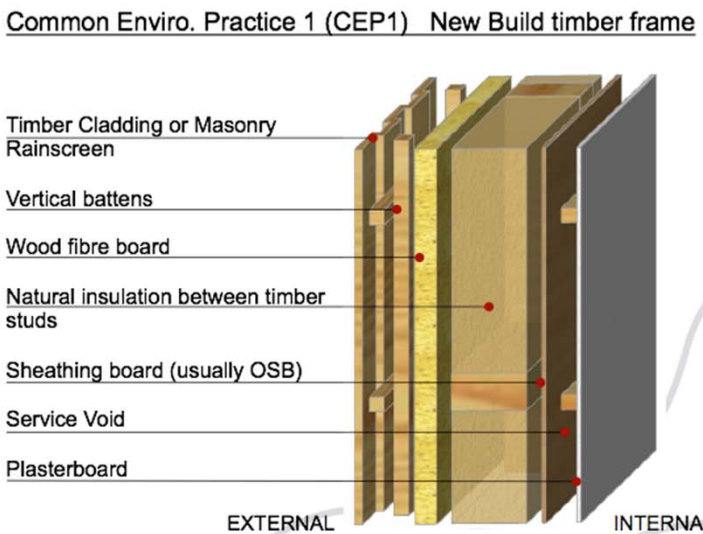


Interstitial condensation

Effect of breathability on designs

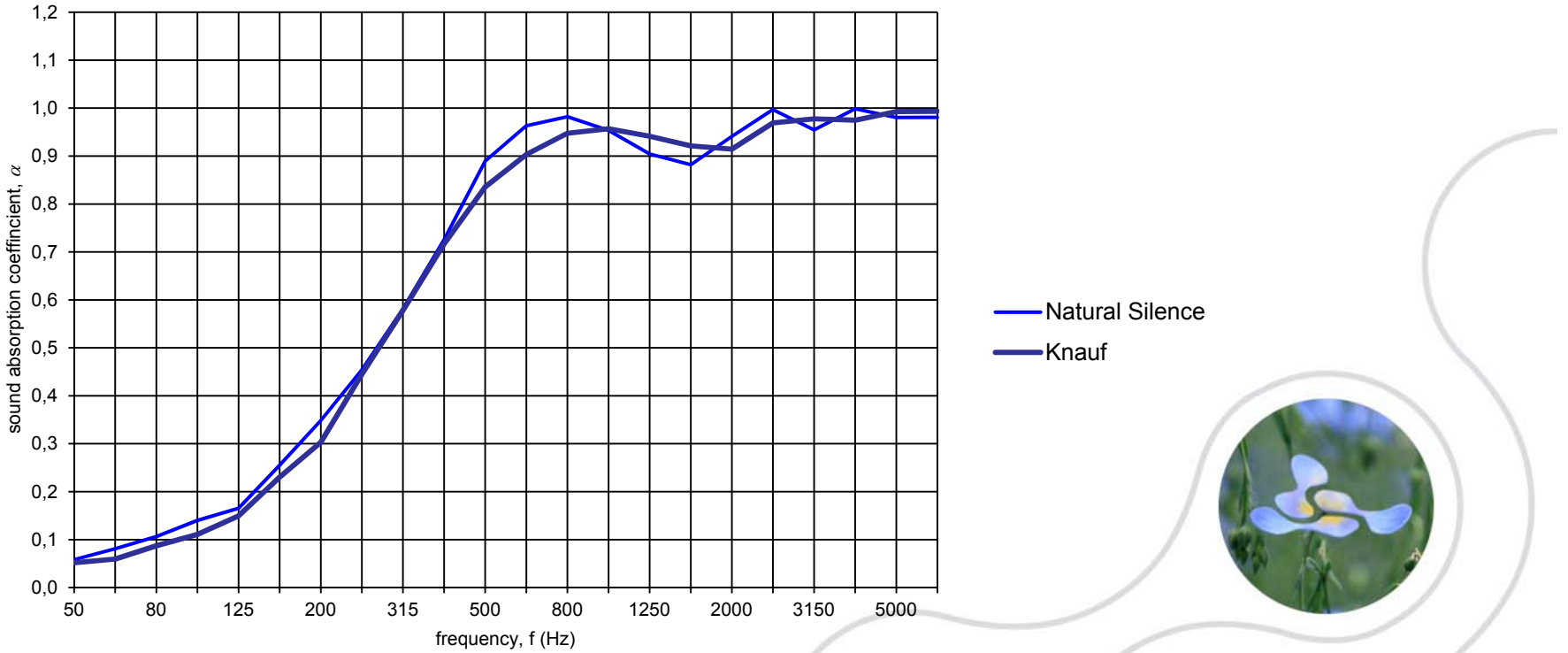
- No breather membrane needed



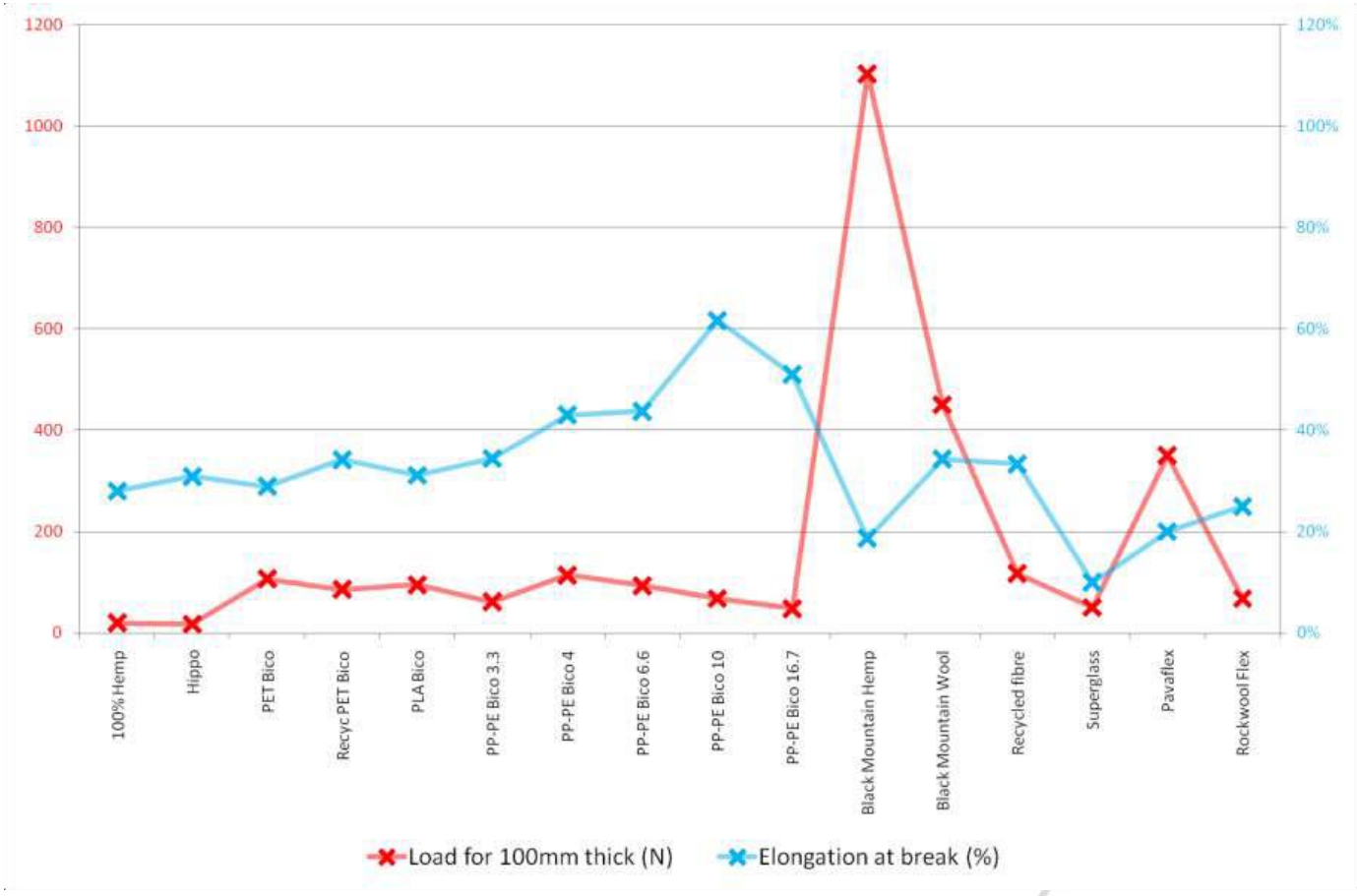


Acoustic performance

- Tested using incidence tube (University of Salford)

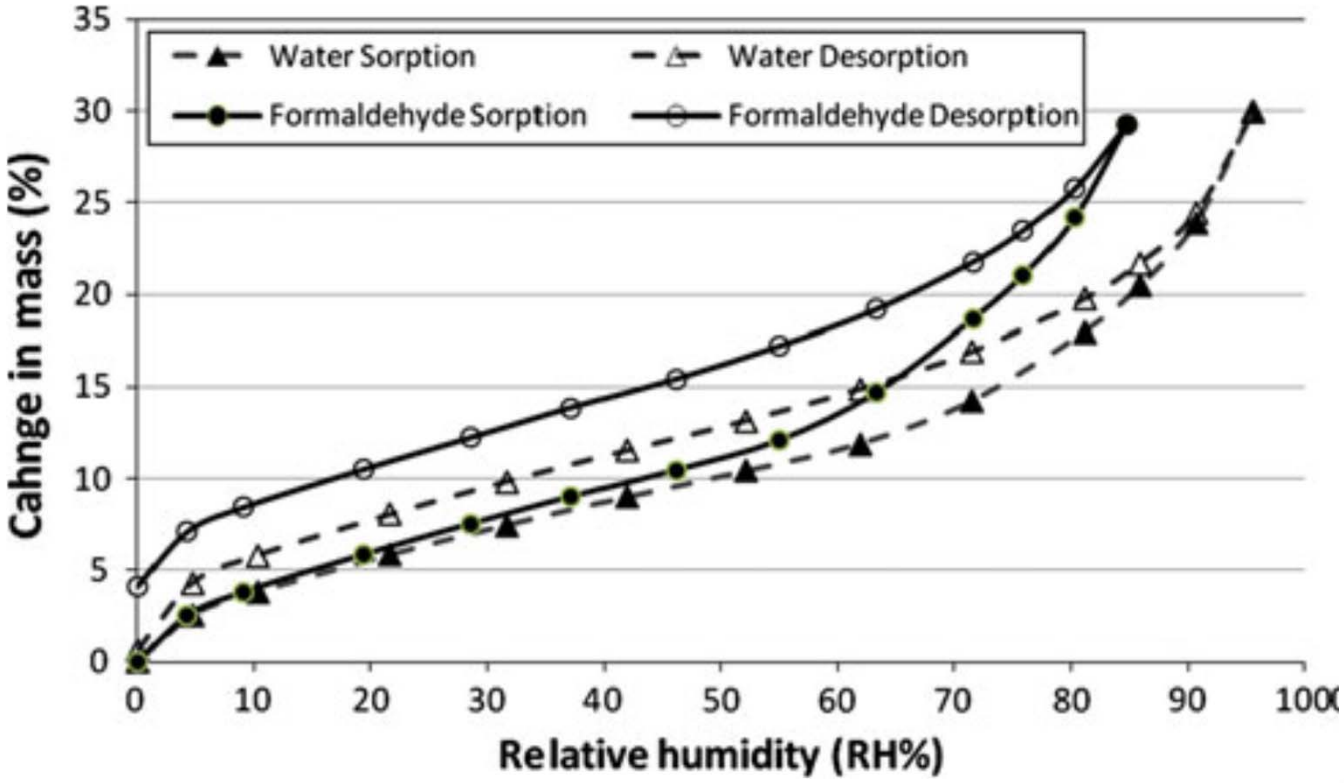


Tensile strength



- Hemp, wool and Pavaflex (woodfibre) outperform synthetics

Absorption of formaldehyde



Curling SF, Loxton C, Ormondroyd GA. A rapid method for investigating the absorption of formaldehyde from air by wool. J Mater Sci 2012;47(7):3248–51

Absorption of VOCs

- Eco-innovative, Safe and Energy Efficient wall panels and materials for a healthier indoor environment (ECO-SEE)
- Investigating insulation products, in addition to panels and photocatalytic coatings

Cultural problems in the UK

- Performance
  - General perception of inferiority
  - Need for FR (hemp) or pesticide (wool)
- Economical
  - Market size, customers are mainly the ‘green home buyer’
  - Subsidies for synthetics available, not for naturals
- Social
  - Fixtures and general structure overshadowing thermal comfort at planning and construction stages

Thank you for your attention