Historic England
Damp, Timber Decay and Sustainability
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Moisture-related risks in roof spaces:
principles and effects of modern practices

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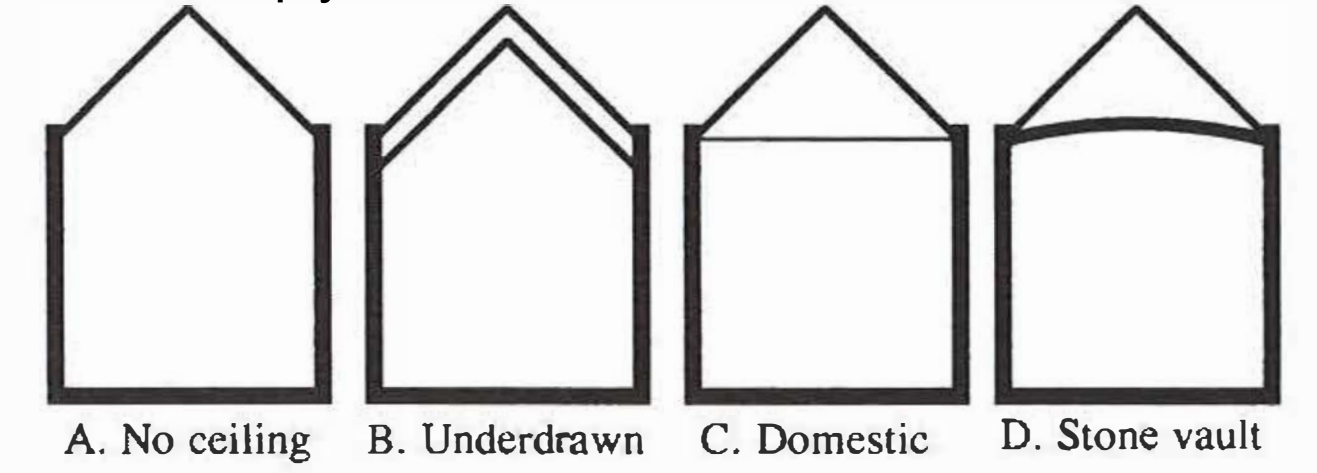
BACKGROUND

Summary of traditional situation

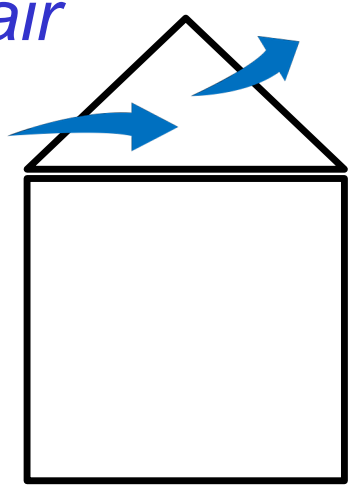
- Traditional roofs often last well, *with appropriate maintenance.*
- *Even without good maintenance,* many have lasted quite well too.
- Many do not comply with current recommendations.



"Improvements" can sometimes cause new problems to surface

SOURCE: B Bordass, English Heritage Research Transactions, Volume 1, *Metals* (April 1998), figure 4, page 36.

This talk covers only **Type C** – *Domestic pitched "cold roofs" ventilated by outside air*



Typical traditional construction:

- Plaster ceiling on timber joists
- Timber roof structure with slate or tile covering
- With or without underlays below tiling battens
- Often well-ventilated, seldom with designed openings

Typical more recent construction:

- Ceiling often plasterboard, with air and/or vapour control layer (AVCL) above, and insulation on top.
- Underlays below tiling battens impermeable to both air and moisture.
- For pitches over 15 degrees, 10 mm eaves air gap and 5 ridge gap.

Proprietary systems can replace gaps with air-permeable underlays.

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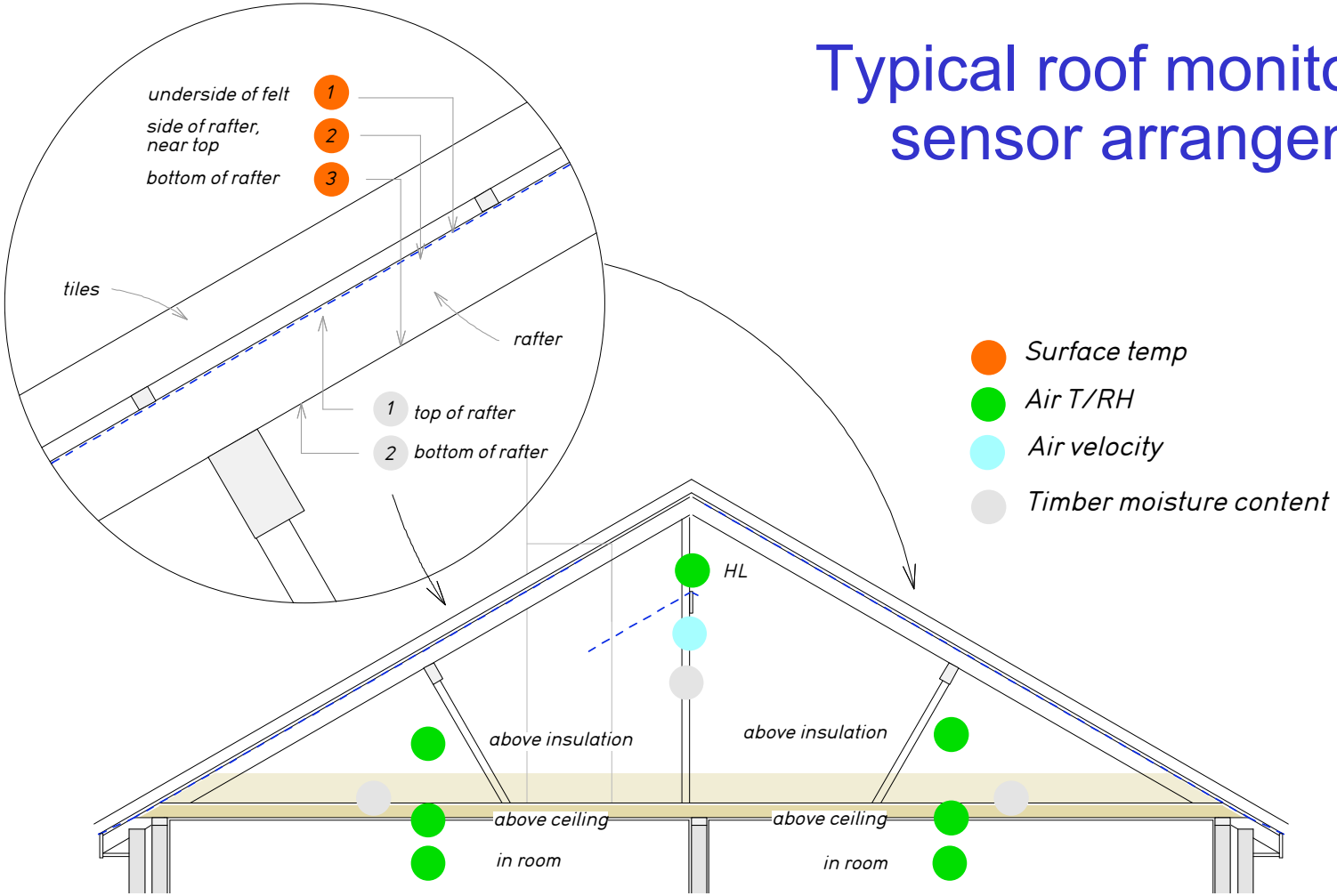
THE FOUR ROOFS STUDIED
by Historic England 2014-20

The four houses:




	1920s semi	**1830s** terrace-like	**1930s** semi	**1960s** terrace
Location	New Forest	South London	Hampshire	Worcestershire
Refurbished in	Deep retrofit 2014	Deep retrofit 2015	Stepwise 2010s	Stepwise 2010s
Ceiling material on top floor	New plasterboard	Plasterboard over original lath+plaster	Lath+plaster with some plasterboard	Plasterboard
Air and vapour control layer?	High resistance air and vapour barrier	'Intelligent' vapour control membrane	None	None
Insulation used above ceiling	Cellulose fibre *(absorbs moisture)*	Cellulose fibre *(absorbs moisture)*	Glass fibre *(non-absorbent)*	Glass fibre *(non-absorbent)*
Roof shape and Roof finish	Gabled, T-shape, Clay tiles	Slate Hip+Lean-to Lead central part	Hipped + side & rear projections Clay tiles	Double pitched, Concrete tiles
Roof underlay	Microporous breather membrane	Intelligent breather membrane	None	Impermeable bitumen felt

Typical roof monitoring sensor arrangement



Common features:




- Double, triple and/or secondary glazing *with reasonable air seals.*
- 300 mm of insulation above their ceilings, *as far as space allowed.*
- Party walls including chimney(s) in lofts.

- Interior ventilation rates of about 0.4 air-changes per hour, *Estimated by adding natural ventilation (from pressure tests) to mechanical (where present).*
- Low occupancy most of the time, *just one or two people.*
- **SO** internal moisture gains were modest, *as monitoring confirmed.*

- Quite similar loft temperatures and relative humidities in winter.
- Roof timber moisture content could rise into the low 20%s, *but no indication of adverse effects – these probably need some liquid water present.*

Differing results:




	1920s semi	**1830s** semi/terrace	**1930s** semi	**1960s** terrace
Ventilation and moisture control principles in the roof spaces	**Unventilated** Air and vapour barrier above ceiling. Air and vapour but not water permeable underlay.	**Unventilated** Air and vapour barrier between old and new ceilings. “Intelligent” underlay to slates.	**Traditional** Good ventilation through the gaps between the tiles.	**Adventitious** Small gaps above and behind the facia. Plus holes and gaps in block party walls.
Moisture issues arising on site	**Battens** damper, but probably OK.	None	None	Condensation and mould after top-up.
Airtightness of ceilings	Good site quality control. Pressure test on completion.	Good site quality control. Pressure test on completion.	Visible **holes and cracks** in airing cupboard.	No visible holes but leakage via garage+blockwork.
Estimated loft air changes/hour.	2	3	**20**	4, *but much of this via loft* ***party wall.***
Why the differences?	**Underlay** may trap condensed moisture	**Underlay** wicks away batten condensate	**Robust**, owing to high loft air changes.	**Poor loft vent. Poor isolation**

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CONCLUSIONS

Historic England's initial questions

from Morwenna Slade's introductory presentation

1. ***Why does extra insulation lead to condensation problems in some roofs but not others?***

2. ***What effects do roofing underlays, air and vapour control layers (AVCLs) and ventilation have on roof environments?***

3. ***How can the risks of condensation and moisture accumulation be minimised?***

It's a balancing act between *flows of air, heat and moisture*

MOISTURE GENERATION INDOORS

- Washing, cooking, cleaning. Flueless heaters.
- Metabolism of occupants.
- Evaporation from building fabric, *affected by heating regime*

MOISTURE REMOVAL FROM INDOORS

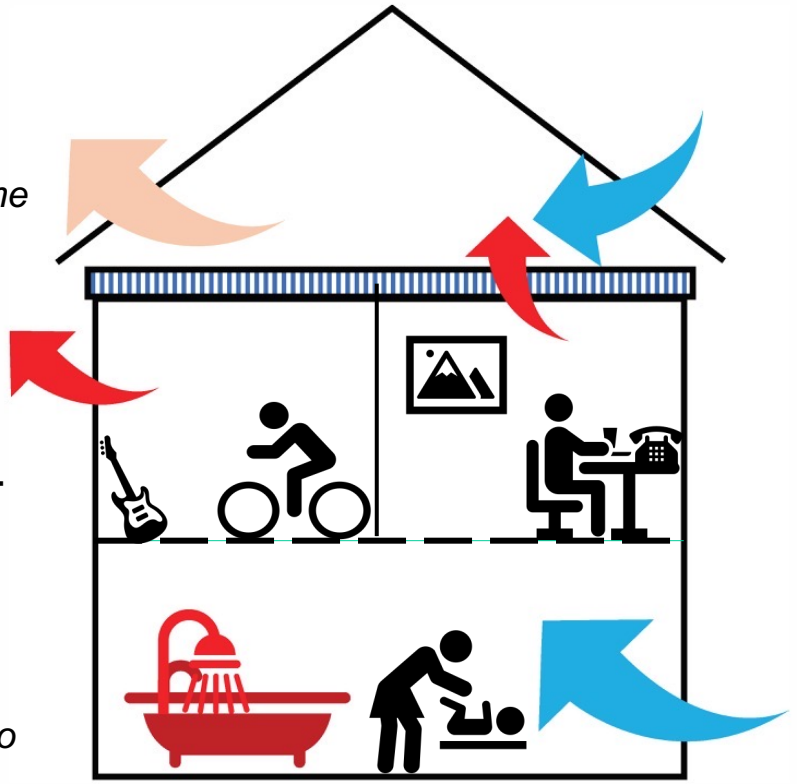
- Designed natural and mechanical extract. **Flues**.
- Dilution by outside air, *the more air and the warmer indoors, the more will be removed.*
- Absorption into building fabric. Condensation.

MOISTURE AND HEAT PASSING FROM HOUSE TO LOFT

- Air passing through holes, cracks, bypasses.
- Water vapour diffusing through the ceiling.
- Amount of insulation, *but effect on cold roofs is small*

MOISTURE REMOVAL FROM THE LOFT

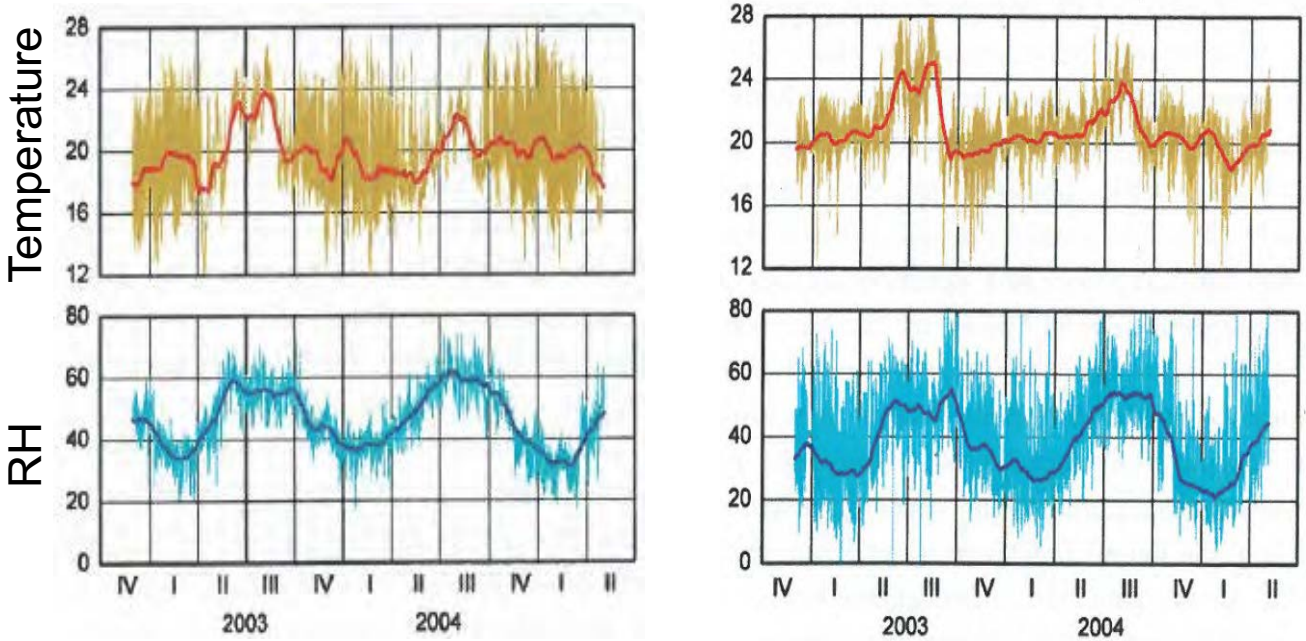
- Largely by dilution by outside air, *but this removes heat too*
- **So conditions may be on a knife-edge.**



Stabilisation by absorbent materials can help
e.g. timber, lime plaster, porous brick and stone

Traditional brick house
with masonry stove

Newer concrete house
with central heating



<< Data shown by quarter from October 2002 to June 2005. The peaks represent the summers.

<< *Fluctuations in RH (Relative Humidity) and condensation risk grow in the newer house.*

Even modern paints can reduce beneficial stabilising effects.

SOURCE: Fraunhofer Institute, Germany via Thomas Gärtner

Q1. *Why does extra insulation lead to condensation problems in some roofs but not others?*

IT DEPENDS VERY MUCH ON THE CONTEXT:

Insulation reduces loft temperatures only very slightly … **BUT**
There is a **delicate balance** between wetting and drying in "cold" lofts*, *where winter relative humidities are often close to saturation …* **AND**

Did only the insulation change? Often other things do too, typically:

- **Less indoor ventilation:** *new windows, draughtproofing, changes from open-flued heating to balanced-flue or electric heating.*
- **More moisture from occupancy:** *More people, more wet things …*
- **New holes in ceilings:** *for pipes, ducts, cables, recessed lights …*
- **Less roofspace ventilation by outside air**, in particular with *new underlays and thicker insulation that blocks air paths at the eaves.*

* SEE FOR EXAMPLE: B Bordass, Slides to Historic England Traditional Roofs conference, Church House, 3 March 2020

Q2. What effects do underlays, air + vapour control layers and ventilation have on roof environments?

UNDERLAYS can severely reduce loft ventilation by outside air … **SO**

- *Either extra ventilation needs to be provided… **AND/OR***
- *The ceilings need to be more airtight, possibly vapour-tight too… **AND***
- *Properties of modern underlays may make subtle differences.*

AIR AND VAPOUR CONTROL LAYERS (AVCLs)

- Not present traditionally … **BUT** *Wet plaster is reasonably airtight.*
- Air movement from house to roof normally carries the most vapour.
- AVCLs are essential in some modern construction – *particularly unventilated roofs - if fitted, AVCLs need to be really well-sealed.*
- AVCLs may cause problems by concentrating ingressed water.

VENTILATION usually needs to get moisture out of roofs much faster than it can get in, *though there are some exceptions (see footnote).*

FOR EXCEPTIONS SEE : B Bordass, *English Heritage Research Transactions,* Volume 1, *Metals* (April 1998), p 21-72.

Q3. *How can the risks of condensation and moisture accumulation be minimised?*

- MAINTAIN THE ROOF PROPERLY, to minimise water ingress.
- STOP THE AIR GETTING TOO DAMP INDOORS, *so ventilate sufficiently and* ***extract moisture at source*** *from bathrooms etc..*
- VENTILATE THE LOFT SUFFICIENTLY – *How much outside air depends critically on the air and vapour tightness of the ceiling.*
- THE MORE INSULATED AND AIRTIGHT YOU MAKE THE HOUSE, *the* ***more air and vapour tight the ceiling should be.***
- HIGH OCCUPANCY CAN HAVE A BIG EFFECT: *landlords must be cautious as occupants won't "own" any resulting problems.*
- TRY TO SPOT EMERGING ISSUES: *e.g. with occasional inspections or installing cheap, simple monitoring arrangements.*

AND TO COME …

A 2021 version of BS 5250, Management of Moisture in Buildings *is expected to take a broader view than previous editions, with alternative approaches 1). Prescription, 2). Modelling, 3). Principles + Experience.*

To complement Approach 3), Historic England is considering:

- Publications on roof performance, *including this four roofs study.*
- Guidance on estimating loft ventilation rates, *including a short extension to the air pressure tests used for regulatory compliance.*
- A possible “triage” system *to help professionals identify and manage risks that may arise in energy retrofits and work to roofs.*

Thank you

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