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Cornwall Council - skills training and energy saving initiatives

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Abstract – *Traditional buildings are complex and work in different ways to new buildings. They are often hard to heat but need to be upgraded with 'breathable' as opposed to 'air tight' solutions. Well intentioned alterations to improve energy efficiency often harm original historic fabric and create unhealthy living environments for occupants. Perceived difficulties in upgrading older buildings lead many developers to prefer demolition and new build to conversion.*

Cornwall Council has been using externally sourced funding to authentically repair traditional buildings in its historic towns and show how they can be sustainably repaired and upgraded without damaging their character and with health benefits to occupants.

This paper will briefly describe how this has been achieved through:

- *Traditional skills training and energy monitoring programs*
- *Production of web based energy saving guidance*
- *Embodied energy and life cycle comparisons of converting local historic buildings as opposed to demolishing and building new.*

Keywords – Retrofitting; skills training; coordinated local approach

1. INTRODUCTION

Cornwall is a remote county in South West England. Over the last 16 years Cornwall Council has successfully sourced national heritage led regeneration funding and implemented traditional repair schemes in its historic towns. These were mainly though Heritage Lottery funded Townscape Heritage Initiatives (THI's), four year multi funded grant schemes with partnership funds over £1 million pounds [1]. Grants of up to 75% were offered to around 30 buildings on each scheme for quality traditional repairs using local materials, reinstating missing architectural detailing and bringing vacant buildings back in to use.

12 heritage led regeneration schemes have been successfully implemented in Cornwall between 1998 and 2013. In addition Camborne, Roskear and Tuckingmill THI finishes in June 2016 and a new scheme in the historic market town of St Austell will start in 2017. Completed schemes have created £25 million pounds of investment (including £8.2 million private investment) in the historic towns through a combined Cornwall Council contribution of £1.7 million. The later schemes have progressed

pioneering traditional skills and monitored energy saving measures which have benefited the local construction skills base and influenced local retrofitting proposals.

2. TRADITIONAL SKILLS TRAINING AND ENERGY MONITORING

Traditional buildings in Cornwall were robustly built with locally sourced stone and slate to withstand extreme local weather conditions. This produced a distinctive local character which is now under threat. There is a long standing shortage of specifiers and installers who understand traditional buildings and traditional building skills are rarely taught in colleges. Local contractors often prefer to replace rather than repair original building fabric and to demolish and build new rather than convert.

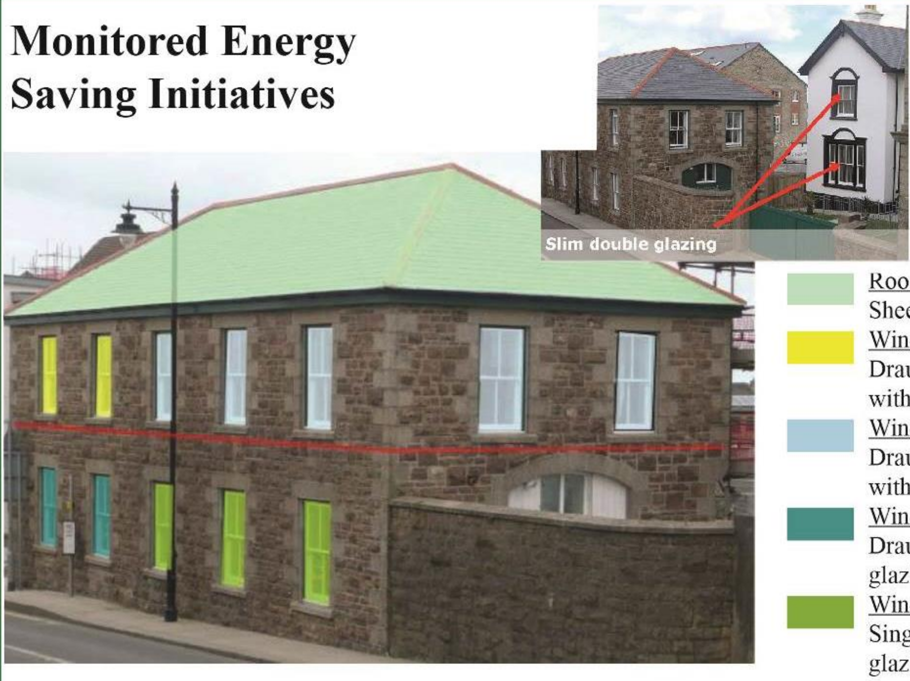
Traditional buildings with solid wall construction make up 25% of the UK building stock. Upgrading them to reduce energy consumption and carbon emissions is a generally accepted principle. Retrofitting schemes, however, often use external non permeable ‘air tight’ insulation that prevents solid walls from ‘breathing’. This can cause water ingress, condensation and mould growth as well as obscuring original materials and details. Creating sealed environments is potentially damaging to occupants health and there is a need to balance insulation and ventilation. Tenant interviews on THI funded schemes revealed windows were rarely opened, a concern as Cornwall is a radon affected area.

To address these issues a THI in the Cornish settlements of Camborne, Roskear and Tuckingmill [2] has funded and promoted high quality traditional repairs, organised training days for local contractors and Architects and given local college students work experience traditionally repairing historic buildings funded by the THI (Fig.1).

Sympathetic ways of upgrading traditional construction have been installed on THI funded buildings. Performance of products used have been monitored by local Renewable Energy and Carbon Management students as part of their coursework. So far monitoring has taken place on upgraded original timber single glazed windows (Fig.2) and natural breathable internal insultion (Fig.3). Results have been added to an ‘Improving Energy Efficiency in Cornish Historic Buildings’ guide [2]. This web based guidance produced by Cornwall Council illustrates local examples of good practice, provides updated costs and lifespans of products and includes web links to enable further research. The guide has been formally endorsed by Cornwall Council and links to wider local policy and guidance. It is used early in the planning process and before Building Regulation applications to influence the quality of local retrofit schemes. The guidance concluded that retrofitting historic buildings required a ‘whole building’ approach taking on board location, construction, condition, effectiveness of building services, heritage value, significance and occupant behaviour.

Figure 1. THI funded timber repair training day, Rosewarne House. The top and bottom photos on the right show a discreet trickle ventilation detail for timber sash windows produced with local carpenters as part of training days. This provides health benefits by providing secure ventilation without damaging the character of the window.

Monitored Energy Saving Initiatives



Roof:
Sheepswool insulation

Windows:
Draught proofed single glazing with internal shutters (2 windows)

Windows:
Draught proofed single glazing with thermal shutters (5 windows)

Windows:
Draught proofed single glazing (2 windows)

Windows:
Single glazing with secondary glazing (3 windows)

Doors:
Draught proofing. Insultatd ground floor door

First Floor:
Insultation between timber joists inserted from above floor

Two adjoining historic buildings at the former Holman's Engineering works, Camborne were converted to residential accommodation. Both buildings were divided into units and subtly different methods of improving the thermal and noise performance of traditional windows were installed. This provided a visual comparison of the measures and meant that the performance of each measure could be compared to one another.

Figure 2. Example from 'Improving Energy Efficiency in Cornish Historic Buildings' guide, showing how timber single glazed sash windows can be upgraded without altering their character by installing draughtproofing, secondary glazing, internal timber shutters and slim double glazing. Monitoring showed that all of these methods effectively reduced heat loss, reducing energy bills by 15% and £100 a year for occupants as well as providing good noise protection. The building was not listed and without grant aid unsympathetic pvc windows could have been installed which would have damaged character.

The aim of these initiatives is to show that repairing rather than replacing original fabric retains original character and costs less. Good, regular repairs help the performance of traditionally built buildings which can then be upgraded in ways that do not damage their character. THI funded schemes provide easily accessible reference points for local developers, contractors and Architects to see how this has been achieved while the web based guidance provide a basis for discussion and negotiation through feedback on performance, cost and lifespan of products used.

These initiatives so far have provided 24 training events for 534 local builders, professional agents and college students, 'live' training opportunities for over 100 local college students, good practice monitored energy saving methods to 40 building units and led to inclusion of traditional building repair skills, sympathetic retrofitting details and energy monitoring as part of local college construction and renewable energy courses [2].

3. MONITORING OF ROSEWARNE HOUSE STABLE BLOCK CONVERSION

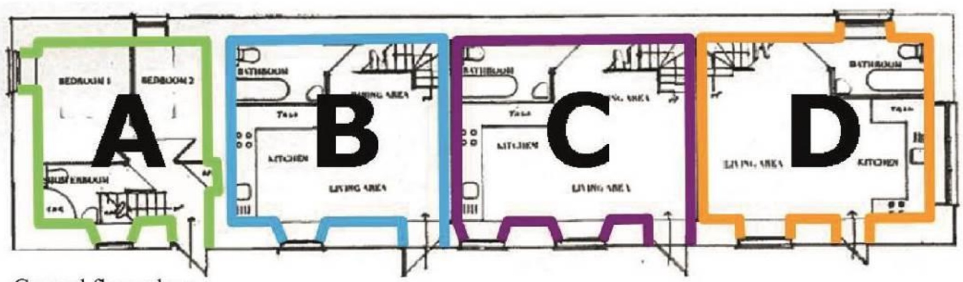
3.1 Introduction

A stable block with solid local stone walls at the rear of a grade 2* listed building is being converted to four separate cottages (Fig.3). Cottage A is being upgraded conventionally with internal non permeable Celotex PUR closed cell dry lining. The other three cottages are being internally insulated with different types of natural breathable insulation. Cottage B is being insulated with woodfibre board and clay plaster, Cottage C with ecoCork plaster and Cottage D with Cork board. 60mm insulation was fixed to internal walls and 20mm to window reveals to counter cold bridging. Monitoring will compare products analysing:

- Whether breathable internal insulation effectively increases thermal performance of solid walls, reduces damp problems and maintains good air quality.
- The relative life cycle impact of retrofitting historic buildings compared to demolishing and building new. A retrofitted building's thermal performance will usually be worse than that of a new building leading to higher in use energy and emissions. The analysis looks to what extent this is mitigated by the lower embodied energy and carbon of the retrofit and how this is affected by choice of materials.

Heat Flow measurements to date compare Cottage A with Cottage D (with normalised floor areas) and provide estimates of the embodied in use and overall energy and carbon of the conversion compared to a similar sized new building built in masonry/ cement construction.

Stable Block during conversion | Cork Board Cottage D | Section through Stable Block



Ground floor plans

	Conventional Celotex:	non permeable rigid polyisocyanurat (PIR) foam insulation http://www.celotex.co.uk
	Woodfibre board:	natural softwood made from timber offcuts from local sawmills https://mikewye.co.uk/product-category/natural-insulation/pavatex-wood-fibre-insulation-systems/fibre-insulation-boards/
	Clay plaster:	hygroscopic natural plaster which can reduce mould and transmission of airbourne bacteria and viruses http://clay-works.com/specifications/specfications-overview/#
	Secil ecoCORK plaster:	breathable lightweight lime render with natural cork aggregates https://www.mikewye.co.uk/wall-insulation/#ecoCORK int
	Cork board:	vapour permeable insulation with good acoustic properties made from natural and renewable cork https://www.mikewye.co.uk/wall-insulation/#Cork EWI
	Woodwool board:	rigid roof boards made from wood pulp https://www.mikewye.co.uk/product/pavatherm-thermal-board

Key to internal insulation trialled

Figure 3. Monitored internal insulation, Stable Block, Rosewarne House. Thermal monitoring uses Hukseflux heat flux plates, thermocouple temperature sensors and Enviromon data logges [3]. Air Quality monitoring uses EVM-7 all in one environmental monitors [4].

3.2 Monitoring

The 600 mm thick stable block walls have granite facing stones with a central core of stone, earth and air voids making an accurate thermal resistance estimate difficult. Presuming the stone is granite and the earth/stone core ratio range is 20/80 to 80/20 then a steady state U-value calculation would estimate the R value of the stone wall to be 0.37 to 0.65 W^{-1} K m^2, giving a U-value of 1.5 to 2.7 W K^{-1} m^{-2}. Steady state calculations for finished walls after adding insulation give U values of 0.31 – 0.34 for Cottage A, and 0.74 to 0.94 for Cottage D.

Heat flux measurements were carried out over several days in a same manner to other research [5,6], using thermistors pressed to the interior and exterior surfaces to measure temperatures T_{in} and T_{out}, together with a Hukseflux HP5 heat plate [3] on the interior wall surface to measure the heat flux Q. The data were analysed in the manner of Biddulph and co-workers [6]. By modelling walls as two thermal resistances R_1 and R_2, linked to an internal wall heat capacity C, with the initial temperature of the wall interior parametrised as $T_{\mathrm{m,init}}$. A maximum likelihood estimation, using the mle() function in R was used to find the best fit values of these parameters. Temperature measurement plots and real and modelled heat flow measurements are shown in Figure 4.

Results show Cottage D walls have a thermal resistance of 2.65 W^{-1} K m^2, and a U-value of 0.39 W K^{-1} m^{-2}, while those of Cottage A are 2.96 W^{-1} K m^2 and 0.34 W K^{-1} m^{-2}. A bare wall U value measurement of Cottage A before insulation was 1.3 W K^{-1} m^{-2}. This reduced U value difference impacts on the relative life-cycle impacts of the two type of construction. An estimate of embodied and in use carbon and energy use (including demolition and disposal) was made comparing the cottage conversion to a similar sized new building using a process LCA with data from the Bath Inventory of Carbon and Energy [7] and a simplified building physics model [8] based on SAP. It was assumed, following Moncaster and Symons [9],that the demolition life cycle part included in the total for the new build accounts for 21% of embodied carbon and 5% of embodied energy. Results are summarised in Figure 5.

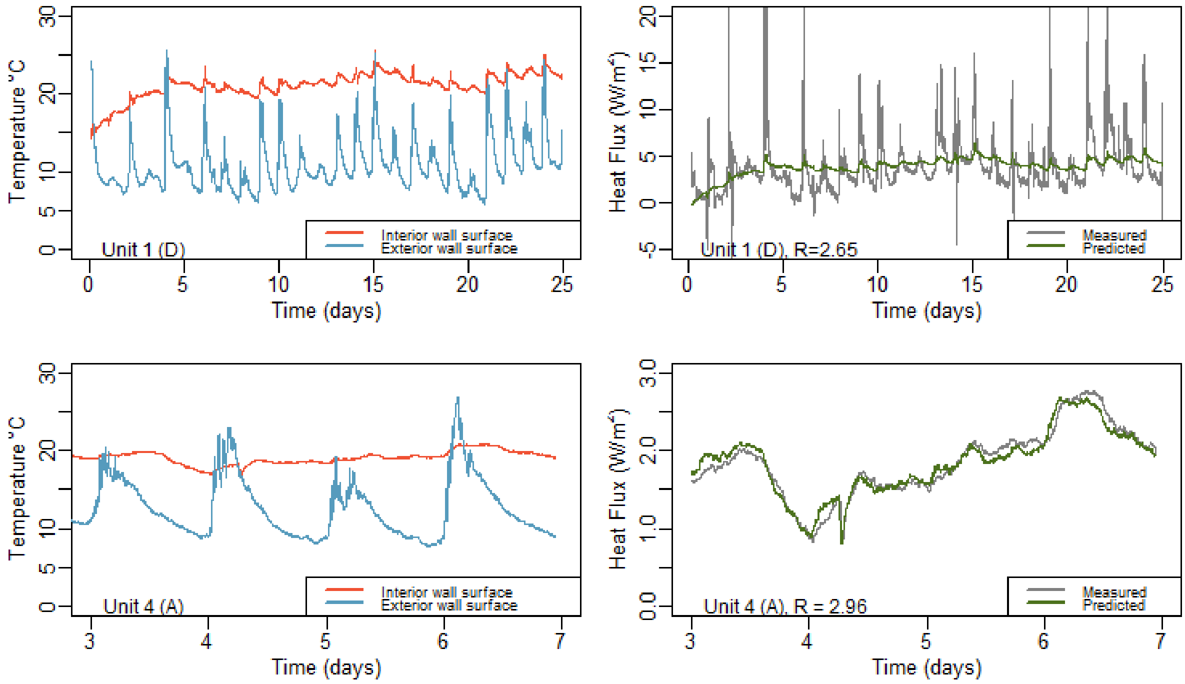


Figure 4. Left panels show interior and exterior wall surface temperatures of the two retrofitted cottages. Right panels show modelled (green) and measured (grey) heat fluxes through the walls of these units

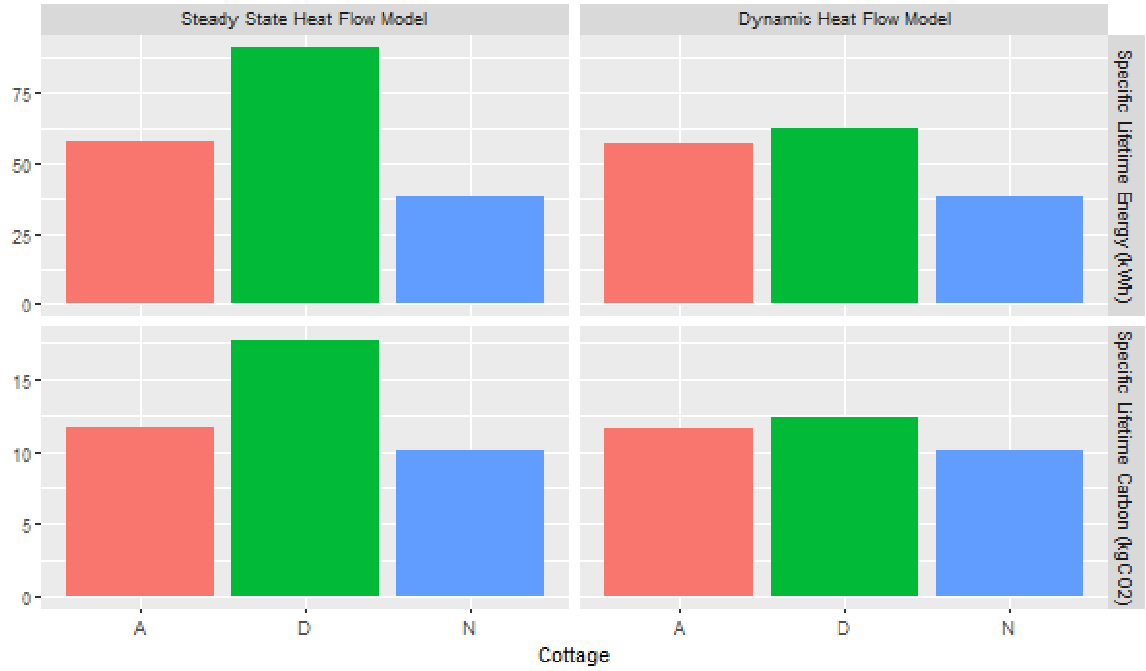


Figure 5. Summary of the specific lifetime (50 year) energy and carbon of the two retrofitted units (A nd D) and of a conventional new-build (N) of the same size, under steady-state and dynamic heat flow models.

4. CONCLUSION

- The dynamic nature of heat flow through the thick solid walls shows that lifetime carbon emissions of the retrofitted cottages are comparable to those of the new build, even for cottage D where a less thermally insulating cork layer was used. Using this dynamic treatment significantly reduces lifetime emissions assumptions.
- Further, the natural product retrofit has scope to achieve lower emissions than either the modern material or new build options if space and water heating were switched to an electrical form, as the carbon intensity of electricity in coming decades is expected to reduce.
- U values of solid walls, used for SAP energy performance calculations and Building Regulations are often lower than anticipated making energy efficiency calculations of solid walls inaccurate. Breathable insulation is essential to a solid walled buildings long term survival and all breathable internal insulation monitored worked effectively.
- Cork boards and plasters used in Cottage D, as well as all roofing slates were imported from Portugal and Spain. Carbon intensities supplied by DEFRA[10] show that the additional transport emissions due to this distance of travel are less than 1% of the lifetime building emissions, and thus not a major consideration.
- Monitoring is not fully complete with full analysis of thermal and air quality results expected in July. A final summary will be available for the conference in October.

5. REFERENCES

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