Responsible Retrofit Series

Case Study

RHA

STBA
SUSTAINABLE TRADITIONAL BUILDINGS ALLIANCE

Whole House Retrofit Ton Pentre

The property

Location	Ton Pentre, South Wales
Type of property	2-storey mid-terraced, pre-1919
Owner & co-funder	RHA
Project managers	STBA & RHA
Main contractor	PBM Wales
Key measures	Repairs, IWI, Lime render, PV, Battery storage, Ventilation, Monitoring
Co-funder	Department for Business, Energy & Industrial Strategy: Thermal Efficiency Innovation Fund

The STBA worked in partnership with RHA (formerly known as Rhondda Housing Association) to carry out a Whole House retrofit at a void 2-bed mid terrace pre-1919 dwelling in Ton Pentre in the South Wales valleys. The project was co-funded by the Housing Association and the BEIS Thermal Efficiency Innovation Fund (TEIF). The project commenced in 2021 and was completed in 2022, with technical monitoring continuing for three years.

Aims of the project

- Test out the Whole House approach to retrofit
- Test out the STBA retrofit survey template

Subsidiary targets were agreed between RHA and STBA:

- EPC 'A' rating in line with projected Welsh Government targets
- U-values: 0.7W/m^{2}K for the rear wall, in line with Building Regulations AD Part L
- Over 50% use of self-generated electricity
- Good Internal Air Quality and comfortable internal environment (IAQ) measured through:
  – Relative Humidity (between 40-60%)
  – Temperatures (between 18-24^{0}C)
- Positive feedback from tenant

Key conclusions

- An aerogel based IWI system with an external air lime render has yielded a U-value of 0.53W/m^{2}K, well within the limiting value in Building Regulations Part L1B.
- This stone property reached EPC A92 whilst maintaining moisture open fabric.
- The property needs to be void for this kind of work to be considered.
- A high quality Whole House survey is essential for developing a balanced strategy to optimise energy, ventilation, health and heritage.

Existing construction

Wall construction	Rear: Solid stone (490mm) laid in lime mortar. Rendered with cement render Front: Cement block / cavity (earlier replacement). Uninsulated, Rendered with cement render
Floor construction	Solid concrete (replacement), uninsulated
Walls and windows	Modern uPVC doors and double glazed windows
Roof	Pitched, loft fully insulated
Heating	Gas central heating, installed 2020
Start EPC rating	C (70)

The property is a typical late Victorian two-up, two-down mid-terrace in social ownership. It had previously been extensively altered, some efficiency upgrades installed, and substantial repairs were required prior to retrofit.

Reveals exposed prior to repair and IWI

Retrofit assessment methodology

The dwelling was assessed prior to retrofit using the STBA survey tool, based on the Whole House Approach adopted by PAS2035. The survey tool gathers information on all aspects of the building:

- Context
- Age and Built form
- Condition
- Significance
- Building fabric
- Heating systems
- Ventilation
- Occupation

The survey revealed that the front west facing elevation was a replacement cavity wall made from concrete blocks, with the outer leaf laid flat and inner leaf on edge, with a 100mm cavity, thus resembling the typical width of a solid wall.

The Retrofit Assessment was then reviewed by STBA and shared with RHA.

The decision-making process

In discussions between STBA and RHA, and bearing in mind the aims of the project outlined above, the following factors were taken into account when considering individual retrofit measures, within a Whole House context:

- External walls – existing render to front elevation was retained as the underlying replacement cavity wall was no longer vapour open. Render on rear elevation was replaced to reinstate drying, but with no impact on heritage. Installing IWI also had no impact on heritage
- Floor – it was decided not to insulate the floor due to cost and the disruption to fixtures & fittings
- Windows – the existing windows were less than 5 years old so no upgrade was proposed – avoiding a wasted asset as the embodied energy of the existing windows will not have been repaid
- Roof – the attic already had 275mm of mineral wool – in line with best practice, but the coomb ceiling required attention in order to prevent a thermal bridge once the walls were insulated
- Ventilation – as air tightness and insulation measures would reduce natural ventilation/air leakage, relative humidity-controlled extract ventilation would be required
- Heat source – the recently installed gas boiler was retained. A heat pump would have been possible for the house but not possible within the project due to capital costs. It would have also increased the running cost for the tenants, which was unacceptable, and adversely affected the EPC rating
- PhotoVoltaic generation – independent renewable energy boosts the EPC rating and, when combined with the battery storage, would help reduce any fuel poverty risk for the tenant

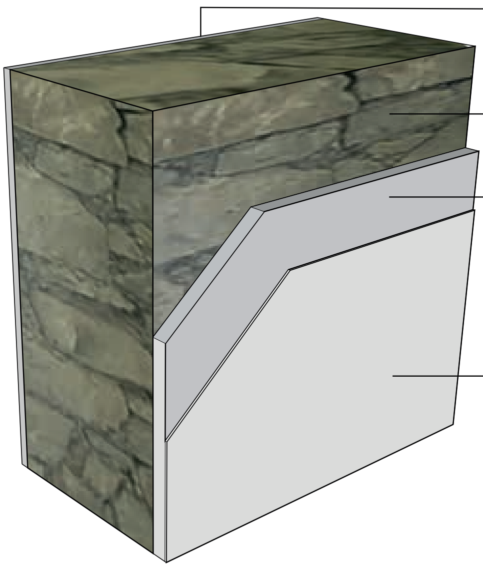
The final retrofit plan for property was agreed by both parties.

The internal wall insulation required extensive enabling works including:
- Removal of existing plaster on external walls and the render on the rear elevation
- Creating fold-backs along party walls (including temporary removal of the stairwell)
- Exposing the inter-floor zone by the removal of ceilings
- Removal of the kitchen units

Other refurbishment/enabling requirements included:
- Installation of a raised platform in the loft for safe access/maintenance for the solar inverter and battery
- Installation of a fire alarm in the loft
- A new surface water drain to the rear of the property to keep the wall dry

Summary of retrofit measures

Repairs	Roof repairs, new guttering, new kitchen, removal of cement render from rear elevation
Exterior wall surfaces	Front elevation: cement render retained Rear elevation: 15 – 25mm Air lime with porous aggregate render – diffusion lime render – with limewash finish
Internal wall insulation	Front elevation: 40mm NHL lime, cork and clay plaster with lime plaster top coat Rear elevation: 40mm NHL lime with aerogel aggregate plaster with lime plaster top coat
Coomb (sloping) ceiling above wall plate, below loft	Hybrid method of insulation boards and NHL lime with aerogel aggregate plaster
Ventilation	Constant RH controlled extract ventilation from wet rooms
PV	2.6kWp PV array, 5.2kWh battery, with monitoring



Rear elevation: Wall build-up

Innovation in solid wall insulation

The approach to the insulation of the solid walls is highly innovative. The intention was to provide long-term moisture control via the external render and thermal performance of the new aerogel lime plaster IWI plaster. In the west facing wall, WUFI modelling showed that there would be a low moisture risk. Our target U-value was 0.70W/m^{2}K but the system achieved 0.53W/m^{2}K, a 24% improvement.

Different methods of application of the render and plaster were explored to assess potential for use in larger scale roll-out. The ‘dubbing out’ process, to level off the surface, was applied by ‘harling’ – i.e. manually throwing the render on. The scratch and finished coats were applied either by an Airline render sprayer (a small hand held render hopper and a compressed air pump) or an industrial render pump. Pumping would be more suitable for multiple dwelling projects, while the sprayers are cheap and useable for small one-off projects. The internal insulated plaster was applied by hand using a conventional hawk and trowel. The feedback from the contractors was that all of the insulated plaster and render was within their skill set, but that the specialist knowledge of each product was vital to its successful application.

External wall dubbed out by harling prior to pumped application of render ©Peter Draper

Monitoring strategy

Independent interstitial thermodynamic monitoring has been embedded into the rear wall for a three-year period. Temperature and moisture levels are being recorded at different depths. The first-year report can be found at: https://sdfoundation.org.uk/future-visions. RHA also installed the Welsh Government required monitoring system that records IAQ, energy consumption and temperatures. Independent room monitors for RH and temperature were also installed and these results are shown in Appendix 1.

The PV system (array and battery) has inbuilt monitoring and/reporting, and the results are shown in Appendix 2. An rdSAP assessment was made using latest independent in-situ measured U-value data (0.53W/m^{2}K).

Monitoring included seeking feedback from the new tenant, who commented: "everything is ok in the property; it's warm and the electricity is pretty cheap."

Finished render with limewash sacrificial layer ©Peter Draper

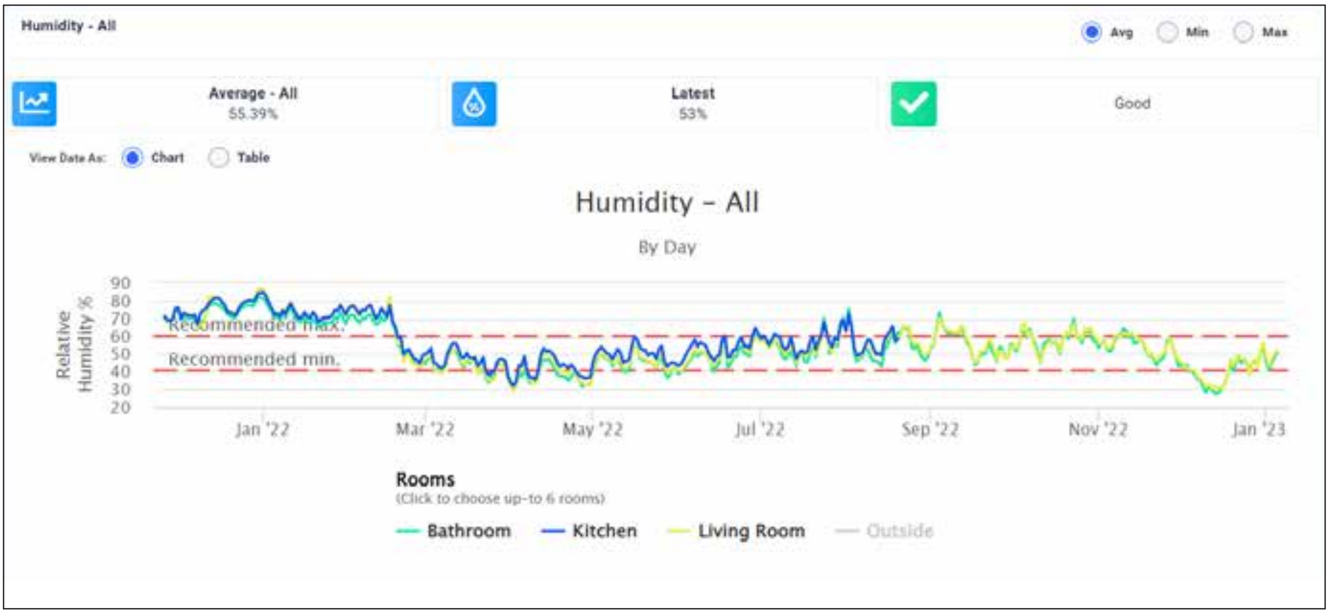
Finished kitchen units on external and party walls ©Peter Draper

Key technical results

- Preliminary EPC rating of A92
- U-value of 0.53W/m^{2}K for rear wall – see first annual Monitoring Report
- RH steady state ranging between 40-50% RH – see Appendix 1
- Temperatures steady state around 20^{0}C – see Appendix 1
- Over 90% use of self-generated electricity – see Appendix 2

APPENDIX 1

Monitoring shows IAQ metrics within 'ideal/safe' bounds with RH between 40-60% in all rooms.



Monitoring shows IAQ metrics within 'ideal/safe' bounds with temperatures between 18 and 24⁰ C in all rooms.

APPENDIX 2

Inbuilt PV and battery monitoring shows a self-consumption rate of over 94%. (ie, electricity produced and used by the tenant, either directly whilst producing, or via stored energy via the battery.) The consumption figures also show that of the 2,665 kWh used to date, 1,415 kWh was self-generated. This represents a saving of over 50% on energy costs for the tenant.

The image below shows the flow of energy within the system that illustrates the comparative roles of the battery and the PV array. With the tenants largely at home using the PV generated power during the day.