Refurbishment Case Study 5

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The Pleasance, Edinburgh

Insulation of coom ceiling, attic space & lightwell

2nd edition

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Insulation of coom ceiling, attic space & lightwell

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CASTLE ROCK EDINVAR HOUSING ASSOCIATION

Edinburgh Napier UNIVERSITY

1. Introduction

This is the fifth project in the *Refurbishment Case Study* series and follows the theme of thermal upgrades to traditionally built properties in Scotland. This project focuses on the insulation of a coom ceiling within a mansard roof, which is the sloping wall in a habitable room that is wholly or partially within the roof space. These areas have previously been difficult to insulate without stripping out internal linings, often leading to loss of historic fabric, disruptive building work, and the expense of new materials and labour. The insulation work also extended to the dormer roofs and cheeks.

This project sought to demonstrate that effective thermal upgrades are possible for coom ceilings and dormers without excessive cost and disruption for the owner or extensive removal and damage to the fabric. For the project to be successful, it was considered essential to use 'vapour-open' materials that allow the free transmission of water vapour through the building envelope. This is particularly important for roof spaces and coom ceilings, as any build up of moisture behind the internal linings could lead to degradation of the timber roof elements.

The works are described in terms of the interventions to individual fabric elements, following the outline hierarchy of interventions, set out in the Historic Scotland Short Guide *Fabric Improvements for Energy Efficiency in Traditional Buildings*.

2. The site

The subject of the upgrade trial is a mid-terrace attic floor apartment within a late 18th century tenement building, consisting of two stories plus an attic (Fig.1). The property is owned and managed by Castle Rock Edinvar Housing Association and is Category 'B' listed.

Fig. 1. Front elevation of The Pleasance, Edinburgh

The building is constructed of coursed pale pink sandstone rubble walls with ashlar dressings. It has a mansard roof, which is a later addition, with lead roofed dormer windows at the front and back. The property sits on the main street of a built up residential area with no unusual exposure issues or vulnerability to extreme weather.

Roof

The mansard roof is constructed of Scots slate laid on a bituminous under-slate felt, over 16 mm timber sarking. While there was nominal gaps between the sarking boards, there was no ventilation provision at the eaves, ridge, or at the junction between the pitched roof and mono-pitches due to the under-slate felt, and existing roof ventilation was modest at best. The upper-pitched roof is supported on primary beams, running side to side from load-bearing cross walls. The roof space is accessed from a hatch in the ceiling within the common stair. The roof had been insulated with old glass fibre insulation laid between truss ties, approximately 50 mm thick, with 100 mm thick modern mineral wool insulation laid over the top.

Within the attic space there are two light wells from the roof line down to ceiling level, one of which remains in use providing natural daylight into the hall below; the other redundant and closed off. The shafts are lined with lime plaster on timber lath nailed directly on to timber framing, with some areas of plaster replaced with plasterboard (Fig. 2). The inside faces of the light wells are finished in a textured coating. The functioning light shafts were insulated on the attic side with 100 mm glass fibre insulation, held in place with nylon bands (Fig. 3).

Fig. 2. Un-insulated lightwell within the attic space. Image by Adam Dudley Architects

Fig. 3. Old glass fibre insulation to lightwell. Image by Adam Dudley Architects

Internal linings

The ceiling is lined with approximately 20 mm lime plaster on timber lath, nailed directly to the underside of ceiling ties, and to the face of rafters forming the coom ceiling. The ceiling linings are generally painted with emulsion directly on to the plaster, apart from in the kitchen and hallway where the ceiling is finished in a textured applied coating, and painted with emulsion. The coom has 20 mm lime plaster on timber lath, nailed directly onto timber struts. The wall linings were generally finished with lining paper and painted with emulsion, apart from in the kitchen where the walls were finished in a textured coating and painted with emulsion (Fig. 4), and in the living room, which was wallpapered.

Fig. 4. Mansard roof in the kitchen with finish to walls

Dormers

The property has two dormers to the front and rear with single glazed, timber sash and case windows. The windows have single glazed, aluminum framed secondary glazing throughout, with no trickle ventilation provision. This appears to work effectively for heat and acoustic insulation, with no condensation issues. The dormers have lead-clad flat roofs (Fig. 5), except one of the rear dormers which has a slated mono-pitch roof (Fig. 6). There is no ventilation provision.

The dormer cheeks are lead clad, with the lead laid directly on to 16 mm timber sarking. The dormer cheeks are lined internally in approximately 20 mm of lime plaster on timber lath, nailed directly to timber uprights. The dormer cheeks and ceiling linings are finished with lining paper painted with emulsion (Fig. 7 and Fig. 8), apart from in the kitchen where the walls are finished in a textured applied coating.

Fig. 5. Lead flat roofed dormer. Image by Adam Dudley Architects

Fig. 6. Pitched roof dormer. Image by Adam Dudley Architects

Fig. 7. Dormer cheeks in the living room, showing the existing aluminium-framed secondary glazing

Fig. 8. The dormer in the bedroom

3. Pre-intervention thermal performance

The thermal performance of the unimproved elements was measured prior to the works by Edinburgh Napier University to provide in situ U-value measurements of the mansard roof and the ceiling, using the standard heat flux plate and associated equipment (Fig. 9). This allowed a baseline pre-intervention figure to be calculated, from which could be measured the effectiveness of the upgrade works and any effect on the fabric (Table 1). The relative humidity (RH) within the void behind the lath and plaster of the coom ceiling was also tested. The techniques for measurement and analysis are described in *Historic Scotland Technical Paper 10* and *Historic Scotland Technical Paper 17*.

Fig. 9. U-value and humidity monitoring equipment whilst in place on coom ceiling, dormer and dormer roof

Building element	U-value (W/m^{2}K)*	Notes
Coom ceiling	1.5	Slate and sarking, 120 mm void, lath and plaster lining
Dormer roof	1.5	Lead on sarking with lath and plaster lining
Dormer cheek	0.9	Lead on sarking with lath and plaster lining

Table 1. Pre-intervention U-values

*Measurement taken December 2011–the average internal temperature during testing period was 19°C and the average internal RH 58%

4. Delivery of the work

The work was designed and specified by a local architect under instruction from Historic Scotland, and delivered on site by an insulation installer. The work was scheduled to be completed within a week, however this overran due to delays in delivery of materials, and mechanical issues with the pump used to blow in the bonded bead. The work was carried out with the tenant in residence. There were limited downtakings, consisting of the removal of the linings from the dormer cheeks in two of the rooms, in order to identify the building construction and inform the proposed works. The existing mineral wool insulation from the roof space was also removed.

Inspections

A section of laminate flooring at the base of the dwarf wall framing in the living room at the front was carefully removed and set aside, and two floorboards lifted, exposing sound deafening fill up to the top of the floor joists, indicating that there were no open routes which the blown insulation might migrate along the floor between the joists. In order to confirm that there were no other open routes for the insulation to escape, an inspection panel was carefully cut through the face of the lath and plaster to the dwarf wall framing.

5. Improvements to the roof light

The existing roof light was removed and replaced with a double glazed roof light (Fig. 10) with a motorised opening mechanism (Fig. 11). This was to allow cooling of the building during the summer months and controlled ventilation throughout the year. As the building fronts onto a busy road, and the rear faces the Pleasance Courtyard (a principal Edinburgh Fringe venue), noise pollution was an issue, so providing ventilation without opening the front and rear windows improved the internal conditions.

Fig. 10. New double glazed mechanized roof light

Fig. 11. The tenant can easily operate the roof light

6. Improvements to roof space

All existing insulation was removed from between the truss ties and from the light shaft walls (Fig. 12). Following the removal of all debris, 180 mm sheep's wool insulation was laid between the truss ties, and 100 mm insulation above, across the ties, overlapping with the bonded bead which filled the coom, to provide a completely insulated envelope (Fig. 13 and Fig. 14). Sheep's wool insulation, 180 mm in thickness, was installed between the timber uprights to the roof light shafts, wrapped at the corners, and secured with nylon banding (Fig. 15). The cold-water tanks and copper pipework were all also insulated using proprietary materials and installation methods.

Fig. 12. Existing roof insulation was removed. Image by Adam Dudley Architects

Fig. 13. Blown bead showing at the top of the filled cavity. Image by Adam Dudley Architects

Fig. 14. The blown bead and the sheep's wool overlap to provide a fully insulated roof. Image by Adam Dudley Architects

Fig. 15. Light well, insulated with sheep's wool. Image by Adam Dudley Architects

7. Improvements to coom ceiling

Holes were drilled through the lath and plaster at the top of the sloping walls, directly below the roof truss beams between every rafter, and below each windowsill between every upright. Polystyrene bead insulation was blown in through these holes, where they filled the voids at the eaves, behind the dwarf wall partitions, and between the lath and plaster and the underside of the sarking of the coom ceiling (Figs. 16 -19). This bead product was coated on entry with a PVA glue that, once in place, holds the beads together in a solid open-celled matrix.

Fig. 16. Bonded polystyrene bead being pumped into the void

Fig. 17. The polystyrene bead insulation is pumped through holes approximately 30 mm in diameter

Fig. 18. Drill holes in the bedroom. Image by Adam Dudley Architects

Fig. 19. Drill holes. Image by Adam Dudley Architects

During the installation, some bead escaped through small gaps between the wall head and the bottom edge of the sarking. With the scaffolding in place, these gaps were plugged with sheep's wool packing.

8. Improvements to dormers

To establish the construction detailing, the linings to the dormer cheeks in the rear bedroom dormer and kitchen were removed, leaving the original lath and plaster linings, to the living room and other rear bedroom, in place. Using the information obtained through the opening-up works, 22 mm diameter holes were drilled through the lath and plaster at the head of the dormer cheeks in the living room and rear bedroom, each side of the central upright, and blown bead insulation was installed (Fig. 20).

Fig. 20. Dormer cheek, drilled prior to injection of the bead. Image by Adam Dudley Architects

Where the cheek linings had been removed, rigid wood fibre insulation was fitted tightly between the timber framing each side of the central upright, and the cheeks were reinstated with 12.5 mm plasterboard screwed to existing timbers. These were then finished with a 3 mm plaster skim coat. As the location of the roof timbers over the dormer ceilings could be accurately identified, 22 mm diameter holes were drilled into the voids between these, and blown bead insulation was installed.

9. Redecoration

All drill holes through the lath and plaster were filled with expanding foam filler, to provide a ’backing’ for flush filling. The filler to the holes in the kitchen linings were given a textured finish, to match the existing and the entire coom ceiling and dormer linings in the kitchen and rear bedrooms were painted with emulsion to match the adjacent walls. The existing wallpaper to the external coom and dormer linings was stripped back to the plaster. The plaster was filled, rubbed down, prepared and papered with 120 gauge lining paper, and painted with three coats of clay-based paint (Fig. 21).

Fig. 21. Completed bedroom. Image by Adam Dudley Architects

10. Post-intervention thermal performance

Following the works, measurements were taken to assess the thermal improvements made by the interventions (Table 2).

Building element	Pre-intervention U-value (W/m^{2}K)	Post-intervention U-value (W/m^{2}K)*	Notes
Coom ceiling	1.5	0.4	Blown polystyrene bead behind lath & plaster
Dormer roof	1.5	0.5	Blown polystyrene bead
Dormer cheek	0.9	-	Not insulated

Table 2. Thermal monitoring results

*The post-intervention U-value readings were taken in March 2012. During this period the average internal temperature was 18°C and the external temperature varied between 3°C and 10°C

11. Humidity readings

The relative humidity within the unventilated cavity, between the roof sarking and the internal linings, had been measured before the works were undertaken and showed that the voids in the roof were dry and appeared to be well ventilated, although this seemed to be more fortuitous than by design.

Following the installation of insulation within the coom ceiling, humidity sensors were re-instated within the filled cavity. Initial humidity readings, taken over a period of three months between February and April, showed that the relative humidity was lower than expected, and at times temperatures within the voids were higher than the room temperature. This is almost definitely due to solar gain on the slates, which even in overcast conditions with low sun provided a significant heating effect.

12. Condensation risk

The insulation of the coom ceiling was experimental; filling the void behind roof linings without leaving a ventilation gap is not normally advisable, due to the risk of condensation forming on the underside of the sarking or rafters and leading to timber decay. Such an outcome could be potentially serious, as rot or insect infestation caused by elevated moisture levels can lead to damage and expensive repairs. For this reason, the choice of insulation material was critical. Bonded polystyrene bead insulation consists of small beads of polystyrene held loosely together with PVA glue. This creates an ‘open cell’ material which allows air to move through and moisture to dissipate. As the permeability of the material is high, and there is little risk of liquid water being trapped within or behind the insulation in the event of a leak, it is assumed that the risk of moisture build-up is low, as moisture should be dissipated through the insulation and building fabric before it reaches levels which could be damaging. This does assume a degree of ventilation through the roof (i.e. between the sarking and slates) and through the internal linings.

The property at The Pleasance has bitumen under-slate felt between the sarking and the slate, probably dating from the 1960’s or 1970’s, and as such it is not well ventilated. However, the internal linings of lath and lime plaster are vapour permeable and will allow a degree of moisture dissipation in the event of an incident. To allow proper oversight of this intervention, the filled cavity in the coom will be monitored over at least a year to track changes in interstitial moisture levels as the internal and external conditions change. Edinburgh Napier University is in the process of conducting this monitoring work, which is reported on in *Technical Paper 17.*

13. Water damage

Following completion of the work at The Pleasance, an incident occurred which caused water damage to the insulated areas. This came about due to an overflow pipe from the water tank in the loft becoming damaged during the refurbishment works. When the tank subsequently overflowed, the water was released into the roof space rather than being discharged out of the building at roof level. The overflow was of sufficient quantity to percolate through the insulation and into the internal linings of the coom and flat ceilings, causing localised damage (Fig. 22).

Fig. 22. Water damage to the coom ceiling from damaged pipe in the water tank

It should be emphasised that water ingress itself does not always cause extensive damage; it is usually the added weight that causes plaster to fall. Timber is not always damaged by water, although smaller sections can distort if only wet for a short period of time. It is prolonged saturation, or prolonged levels of high humidity that cause decay. In properly ventilated roof structures water should be able to dissipate freely. In this case the damage was exacerbated by the fact that the situation was not fully addressed for some time and drying of the plaster was inhibited by surface finishes that did not allow the free movement of water vapour. However, when the areas were fully uncovered, it was observed that the bonded bead remained largely unaffected although the bonding agent in the beads (a water-based glue) had partially broken down and the beads were effectively loose (Fig. 23).

Figure. 23. Bonded bead following the water damage

The fabric did however effectively dry out, and the presence of the bonded bead did not prevent timely drying. Humidity monitors have been installed to monitor the relative humidity at the depth of the sarking and just behind the internal lining. Results from this monitoring will show how quickly and effectively the wall is drying out to appropriate levels.

14. Conclusion

The work at The Pleasance has shown that areas commonly thought of as ‘difficult’ can be insulated with minimal intervention, using inexpensive materials and techniques. The technical reservations regarding the filling of previously open cavities beneath roofs are still open to question. Longer term monitoring and assessment of the relative humidity within the walls and the filled cavity will be required to resolve the technical issues more confidently. This is particularly true for the area affected by the water leak. The true success of this type of intervention will therefore not be known for some time. However, the immediate gains are evident in the improvement of the U-values of the insulated elements, particularly the coom ceiling and dormer. Feedback from the occupants on their thermal comfort and energy bills over the coming winter will be the other key outcomes.

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