REFURBISHMENT CASE STUDY 30

GRAY HOUSE ERROL

REPAIRING A MUDWALL HOME

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

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HISTORIC ENVIRONMENT SCOTLAND REFURBISHMENT CASE STUDY 30

GRAY HOUSE, ERROL

REPAIRING A MUDWALL HOME

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1. INTRODUCTION

This Refurbishment Case Study describes works undertaken in 2017 to repair the walls of a two-storey house in the Perthshire town of Errol.

The building is Category C Listed and located within the Errol Conservation Area, which has a concentration of traditional mudwall buildings. Gray House was identified as possibly being mudwall construction during a rapid survey undertaken in 2012 as part of the Tay Landscape Partnership (TLP), a landscape heritage project funded by the Heritage Lottery Fund, Historic Environment Scotland and the Gannochy Trust.

In 2015, the house owner confirmed the building was mudwall and, concerned about its condition, sought advice on the appropriate way of repairing it. Advice was provided by specialist practice Arc Architects through the TLP, who subsequently provided a grant to support the programme of repairs. The wider works included repairs and replacement of windows and doors, but this study focuses on the repairs to the earth walls.

The repairs were informed by twenty years of research by the author into the conservation of traditional earth buildings in Scotland, and in particular the repair of the Logie and Cottown Schoolhouses. Those buildings were derelict and unoccupied, Category A Listed, single-storey structures in rural locations owned by the National Trust for Scotland. The Gray House project was the first repair of a domestic mudwall house, undertaken on a modest budget while the owner remained in residence.

2. BUILDING LOCATION AND HISTORY

Gray House is located on School Wynd in Errol, the main town in the broad expanse of the Carse of Gowrie, on the north side of the River Tay between Perth and Dundee. It is an area dominated by clay subsoils. The town grew significantly following drainage and agricultural improvements in the 18th and 19th centuries, with many buildings constructed using the local clay earth.

Figure 1: Gray House prior to the works.

By the 20th century these traditions had died out and knowledge of earth materials and techniques faded. Mudwall buildings were frequently coated with cement renders, altered or demolished. This period also saw the loss of other traditional features, including thatched roofs, windows and doors.

Gray House is a good example of this process of alteration and modernisation. Historic maps show that the building had been semi-detached, with a matching building abutting to the south which was demolished during the 20th century. The entrance to the missing house is still visible in the cobbled pavement. Meanwhile, the neighbouring buildings to the north had been extended to abut Gray House at the ground floor.

This change meant that what had been a mutual party wall between houses became the exposed south gable of Gray House. It was also revealed during the works that Gray House had previous incarnations, with evidence of it being raised in height. Door and window openings showed evidence of alteration, and it is likely that the building was subdivided at an earlier time. In the attic, below the Welsh slate roof, remnants of a broom thatch were found, and at ground level a concrete floor had partly replaced a suspended timber floor. These changes are typical of the undocumented alterations that buildings of this type have undergone, but which only become apparent once works are under way.

3. MUDWALL CONSTRUCTION

Mudwall is a traditional form of solid wall construction, where clay subsoil is mixed with straw and sometimes sand. Laid in layers, approximately 200mm high, while still damp, the faces are beaten and trimmed to shape and the wall becomes hard as it dries. The walls are typically 500 - 600mm thick, and one or two storeys in height (Figure 2).

Figure 2: Mudwall being built in the traditional manner.

The mudwall is built off a masonry plinth, typically rubble with clay mortar. These footings can vary in height and depth from shallow and short, to well-sunk and rising to 500mm. In some cases the walls are faced with brick or stone, but it is more typical to have a lime harl; in other cases the mudwall was simply limewashed or left exposed.

In domestic buildings mudwall was typically plastered internally on the hard, often with a clay base coat and lime top coat. Agricultural buildings, however, were left unfinished. Later buildings have lath and plaster linings.

The quality and durability of mudwall varies according to the local subsoil, with the particle size grading the key factor. The mudwall tradition is described in more detail in *Historic Scotland Technical Advice Note 6: Earth Structures and Construction in Scotland.*

4. ASSESSING THE CONDITION OF THE WALLS

The building was visually surveyed in 2016 and a range of characteristic features and defects were identified (Figure 3).

Figure 3: Cracks in the cement render

Wall surface: The surface of the street-facing wall showed a characteristic bulge at its base, indicating a base course of rubble masonry. The wall surface above this sloped inward, apart from the south gable which was vertical, though not aligned with the chimney head which was inset from the wall. The rear elevation had a varied surface, though the reason for this was not apparent. Staining of the surface indicated that the rhones were not working properly and were discharging rainwater onto the face of the building.

Cracks: Numerous cracks were apparent in the external cement render (Figure 3), generally associated with window and door openings, and corners. There were a number of possible explanations including failed lintels, movement of the walls and shrinkage of the inflexible cement render.

Boss render: By tapping the cement, it was clear that in places there was air between the cement render and solid wall. This could be due to moisture, differential movement and failure of mechanical bond.

Internal assessment: Examining the wallhead in the attic space confirmed that the walls were earth construction and that the roof had previously been thatched. Inside, the building smelled damp, indicating a high moisture content and lack of vapour permeability. There was no sign of internal cracking, but any movement in the walls was likely to be concealed behind the modern plasterboard linings.

5. RISK ASSESSMENT

This survey confirmed that repairs were needed, but the extent and nature of the works that would be required remained unclear, as the true condition of the walls was effectively concealed by the cement render. There was concern that the building's condition presented a risk to the occupants and public.

Cracking and boss render could indicate concealed structural movement; failing lintels could allow a section of wall to collapse, and cracked and boss render could detach from the wall and fall onto the street. In the worst case scenario, failing rhones could have discharged rainwater behind the render over a prolonged period, leading to a build-up of moisture within the mudwall. This could reach a plastic state and cause catastrophic failure.

In order to inform the works and quantify the risk, a series of holes were cut in the cement render with an angle grinder to inspect the wall beneath. This revealed that the windows had timber lintels which were rotten and failing (Figure 4). The walls were mainly mudwall with a stone plinth, but there were also areas of brick around the windows and a stone lintel over the door. The cement render was very dense, up to 25mm thick and not loose. The walls were damp but not near a plastic state.

Figure 4: Inspection hole revealing a decayed timber lintel.

From this assessment, it was deemed prudent to leave the cement render in place over the winter until the repairs could be brought to site. There was a concern that, while there might be advantages in removing the render immediately in order to let the walls dry out, this could not be safely done without a full scaffold and might lead to other urgent work being required. On balance, it was felt that the rigid cement coating was helping to keep things in place, and that there was less risk of significant further deterioration through not intervening than there was by initiating a process that was not yet prepared for completion.

6. THE REPAIR STRATEGY

The owner wished to undertake a faithful repair using appropriate materials to return the historic fabric to good condition and restore its traditional appearance. This aim was supported by the local authority's Conservation Officer and TLP grant funders.

It was known that the building had been altered significantly and contained a range of materials. It was not clear what an 'original' condition might have been or quite how far from this the building had strayed. A pragmatic response was called for, utilising experience from previous mudwall repairs, but open to the individuality of the building. Other guiding considerations included:

- Ensuring the safety of the historic building, its resident and the passing public.
- Works had to be done from the external face only, if possible, as the owner would be in residence throughout the repairs.
- There was a finite budget available, with the scaffolding hire period a significant cost and uncertainty over the condition of the building creating a risk of increased cost.

The guiding conservation principles were to retain as much of the original mudwall fabric as possible and for the repairs to focus on achieving external walls that would be resilient in the long term. The mudwall had been assessed as the aspect of the building with the greatest significance, and therefore was to be given priority by the funding organisations in supporting the repair of the building. The budget would focus on these aims, and therefore previous alterations would not be reversed unless they conflicted with upholding these aims.

Once the walls were brought to a sound condition, the second priority would be achieving a unifying, traditional external finish over variable substrates that would be durable in the long term, protect the mudwall, and avoid cracking due to differential movement and loss of bond to the substrate.

7. SEQUENCING THE WORKS

The works were managed to control cost within a finite budget, while also addressing uncertainty over the exact extent of the works that could only be known once the cement render was removed.

Consideration was given to undertaking the work in two phases, prioritising the street façade and north gable, which were in worst condition and presented most risk, and repairing the other walls the following year if the budget allowed. This option was rejected due to the significant increase of scaffolding and other costs that would result, and the confidence gained from the test removal of cement render.

A provisional programme was developed whereby in the spring the cement render was removed and temporary support to any vulnerable areas was provided. The walls would be allowed to dry out, before being repaired in the summer. A clay and lime harl coating could then be applied in several coats in the autumn, allowing for curing and limewashing before winter. The repairs to the window and rainwater goods would be coordinated around this programme.

Sequencing the works to reflect the seasonal climatic conditions was important, as was allowing for periods of planned inactivity to accommodate variations in the works. Although the nature of the completed works was somewhat different than planned, the contractor successfully completed them within an overall period of 16 weeks.

8. CONTROLLING COSTS

The limited budget meant that the works had to be organised on a provisional scheme of works which allowed costs to be clear and grants awarded. This permitted control of the likely variations in the nature of the works.

A scheme of works was prepared, based on the experience of the architects, and tendered to two contractors who had the specialist experience necessary to undertake the works successfully. This price, including a 10% contingency, formed the basis of the grant award.

On site, necessary changes in the work due to the condition of the building resulted in variations in expenditure, which were contained within the contingency allowance. The client added some additional work which took the overall cost slightly above the original project budget, with the final net works costing around £35,000.

9. SELECTING A CONTRACTOR

The works required a specialist contractor with experience of the technical aspects of repairing earth materials and achieving successful lime finishes. This was especially important given the complex physical condition of the building and the need to control site moisture conditions, manage variations in the works, and adhere to cost and programme. An inexperienced contractor would have brought an additional high level of risk to the project.

There are very few contractors who have experience in this field, which restricts the competitive tendering process. The works were tendered to two companies, one of which withdrew due to other commitments. Following a tender report by a quantity surveyor confirming the price was competitive, the single tender was accepted by the funders and client.

The contractor was Alison Davie Construction, who were supported by earth materials specialists Rebearth. This contractor also managed the scaffold and rainwater goods, but the window and door repairs had a different contractor, who was managed directly by the client.

10. SOURCING CLAY MATERIALS

A range of materials had to be sourced for the project, the key one being clay which cannot be supplied from conventional industry sources. In this case, those involved in conducting the works had previous knowledge of the clay available in the area from working on other projects. Clay earth was needed to repair the walls, and could be used in a number of ways:

- As blocks, pre-dried, to undertake masonry repairs of large areas.
- As mortar, with sand, to repair cracks, bed lintels, blocks, etc.
- As slip to consolidate degraded mudwall.
- As daub to consolidate the mudwall surface and build out the wall face.
- As a composite clay/lime base coat to buffer movement between the clay base and lime harl.

The key factor in the technical performance of clay materials is particle grading size. The location of different clay sub-soils in the local area was confirmed by soil maps. Two had previously been used in conservation projects; the chosen one was better graded and performed well in a recent project to repair the nearby Flatfield Barn.

It can often be challenging to obtain local clay soils, but this soil was readily available, as it was being dug by a local farmer to build a new mudwall building in Errol. The clay earth was a Stirling series soil classification, a silty clay loam, non-calcareous gley of estuarine raised beach origin. It was sourced at a depth of about 1m, approximately 2km to the east of Gray House.

11. REMOVING THE CEMENT RENDER

The cement render was a dense layer about 25mm thick. It was removed with a variety of tools including hammers and chisels, angle grinders to cut it into sections, and mechanical breakers (Figure 5). Its removal proved more difficult and time consuming than had been anticipated.

Figure 5: Removing the cement render.

As the work progressed, it became apparent that although the cement layer had largely separated from the clay walling, it had remained firmly bonded in some places to the stone and brick wherever these occurred in the wall face.

The builders who applied the cement had clearly been concerned about it bonding. They had prepared the wall by nailing several hundred nails and hooks into the wall and applying a layer of galvanised chicken wire mesh on the north gable (Figure 6). The nails had largely corroded and were left in the wall as the cement was removed. The mesh proved a significant impediment to removing the cement, preventing it from being broken up. This problem had not been identified in the test sections that were removed, as the angle grinder had cut through the mesh.


Figure 6: The cement render was reinforced with chicken wire.

The cement on the south gable wall was easier to remove, with the exception of the area of stone rubble and some of the plinths. As the render was removed, it become evident that the south gable had a face of cement block built in front of the mudwall, which had been exposed when the neighbouring building was demolished.

Most of the windows were revealed to have margins of brick, suggesting they were later alterations, and the cement was strongly bonded to these. This slender brickwork was only weakly linked to the neighbouring mudwall, and the lintels above were significantly decayed. A careful cut around the edge of the brick margins allowed the cement to be kept temporarily, and when the walls had been repaired, the cement was carefully removed.

12. REPAIRING THE WALLS

Removing the cement revealed walls with signs of multiple alterations, abutting structures, decay and repairs. This left a complex range of materials and created conservation challenges to achieve an effective repair.

The priority was the stability of the structure. When the cement was removed, the mudwall was clearly damp from moisture trapped behind the impermeable cement (Figure 7). The surface readily dried out upon exposure to the air, but the core of the wall took longer to stabilise and recover full strength. However, in the meantime, the moisture content of the mudwall was not dangerous and no intervention was required.

Figure 7: The darker area is damp mudwall, which lightened as it dried.

Of higher concern was the condition of the timber lintels that were in a state of extreme decay, a consequence of the same high levels of moisture (Figure 8). Some lintels had completely failed and the wall above was effectively supported by a natural arch spreading the load. However, the arch was not in a stable condition, with the area underneath loose. Therefore, temporary props were fitted until the lintels could be replaced (Figure 9).

Figure 8: Removing the cement revealed rotten timber lintels supporting brick infill on slender brick facings.

Figure 9: Temporary props allowed the lintels to be replaced in concrete and loose fill consolidated.

Several lintels had clearly been inserted with inadequate bearings, only 50mm in some cases, and in these instances the bearing was increased. Some of the upper lintels were in sound condition, where they had been protected from moisture by the eaves. Otherwise, the outer lintels were generally replaced with concrete lintels, which were used to achieve a compatible render bond and avoid shrinkage cracks. The mid and inner lintels were mostly in sound condition with only two requiring replacement, and consequently the inner plasterboard wall linings did not need to be disturbed. Three stone sills also had to be replaced in kind with concrete.

The masonry plinth was repaired using a lime mortar. Cracks had generally formed between the brick window surrounds and infill repairs, and the adjacent mudwall. These were repaired in clay mortar, with stainless steel HeliBars used to tie across the joints (Figure 10). In one location it was necessary to use longer stainless steel dowels set in resin, in order to stitch a crack in the concrete block gable face.
This work was slow and undertaken in stages to progressively build the strength and stability of the wall as the existing mudwall gained resilience and the new earth mortars were allowed to dry.

Figure 10: HeliBar being inserted to tie the corner brickwork to the main mudwall.

The mortar was made by soaking the dug earth for several days until it became soft and then mixing it with sharp sand to form a consistent mortar. Once mixed and protected from drying, one batch of mortar could be used throughout the job. The mortar was used in a plastic state – wet enough to mean it was easy to fit into all the irregular shapes of the wall, but dry enough to minimise shrinkage on drying (Figure 11).

Figure 11: Clay being mixed with sand and straw by foot on site.

In one location, it was necessary to repair the wall using earth blocks. This was above the flashing to a neighbouring abutting roof, where there had been exceptional decay as moisture accumulated above the lead flashing and behind the cement render. The programme and budget did not allow for blocks to be made using local clay, so commercially available cob blocks were used. These were a poor visual match, but would not be seen on completion.

13. NEW HARL FINISH

There was considerable discussion among the team, based on previous experience, about the best way to achieve a good bond to the variable surfaces that would be resilient in the long term and reinstate an appropriate appearance.

The repaired wall was structurally sound, but presented a highly variable surface on which to apply finishes (Figure 12). The mudwall face dried to become quite resilient, but had decayed back to quite a range of distances from the wall face. However, the mudwall surface was stable and had a significant stone content and relatively low levels of silt, which created a good basis from which to work.

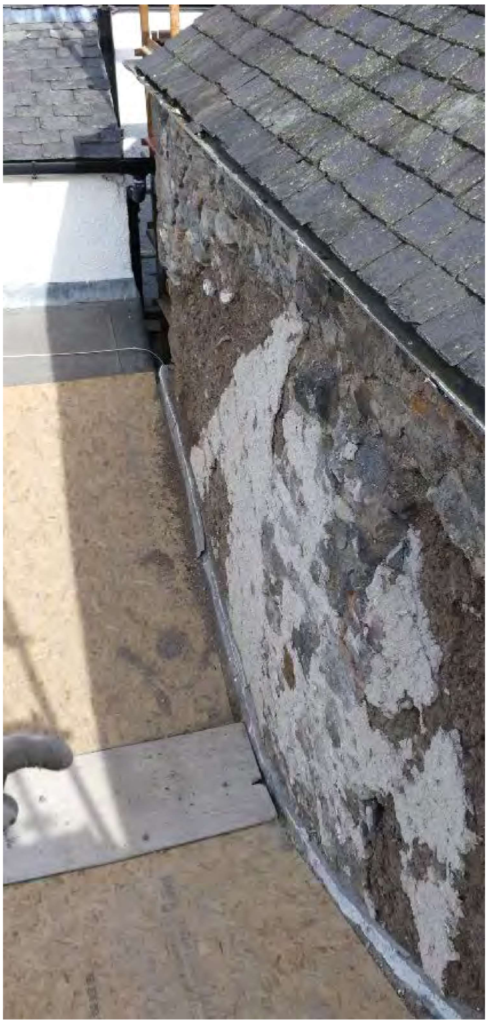

Figure 12: The surface included earth, stone, brick and areas of lime plaster or harl. Here the lime plaster is thought to be the internal plaster for an abutting pitched roof building, which was subsequently demolished.

The first task was to remove all the rusted nails and hooks by hand from the mudwall surface (Figure 13), which the owner volunteered to undertake. If these had been left their corrosion could have detrimentally affected the new finish. Next, the mudwall surface was prepared by dampening with a water spray before brushing on a coat of clay slip (Figure 14). Then, thin layers of daub were applied by hand and pressed into the wall. The daub was mixed by foot using 2 parts clay: 1 part sharp sand: 1.5 parts chopped straw. The high straw content helped unify the surface and control shrinkage. The desired surface was not flat, but undulated following the underlying form of the building to present a weathering surface, an effect achieved by locally building out the surface up to 100mm.

Figure 13: Some of the numerous rusted nails that had to be removed.

Figure 14: The mudwall was dampened before applying a clay slip.
This picture shows the horizontal lift lines.

Imitating the earlier nails, fragments of slate were hammered into the clay daub at about 200mm centres (Figure 15). This left 5-10mm protruding to enhance the mechanical key for the subsequent lime harl.

Figure 15: Slate hammered into the daub, with strings used to set a face line.

The first coat of lime harl was applied only to the mudwall, in a thin coat about 5mm thick. This mix was 1 part quicklime: 1 part NHL5: 4 parts sand, with the sand sourced from Angle Park. A pricking-up coat of sand/lime slurry was applied to the concrete block and brickwork. The second harl coat was applied over the whole building, trowelled on approximately 8mm thick to give smooth undulations on the uneven background. This mix was 2 parts quicklime: 1 part NHL5: 6 parts sand, with the sand sourced from Loch Leven. As an additional measure to counter cracking, directional square plastic mesh was embedded in this coat across the junctions between different background materials, windows and door openings (Figure 16).

Figure 16: Plastic mesh reinforcement across substrate junctions to prevent cracking of the lime harl.

Figure 17: The harling was completed around the scaffold without visible lift lines.

A third lime coat of the second mix was sprayed on to give an even texture and lightly pressed back. After the harl had cured, seven coats of limewash were applied to the whole building. The limewash was tinted with earth mineral pigments, which were selected based on a sample of original lime harl and limewash preserved beneath the cement render (Figures 18 and 19). The window margins were slightly raised, pressed smooth and finished with a darker wash. The finished works can be seen in Figure 20.

Figure 18: One fragment of original lime harl with limewash was found beneath the cement render.

Figure 19: Fragment used to assess samples of limewash colour.

Figure 20: Gray House after the completion of works.

14. MANAGING MOISTURE

Great care was taken during harling to ensure optimal drying and curing. Weather conditions included very hot and dry spells, interspersed with periods of persistent rain. Rainwater goods were removed to enable a complete coat to be applied and, when necessitated by the weather, temporary pipes and plastic sheeting were used to avoid rainwater running down the wall face.

The original thatch roof would have protected the walls better than the subsequent slate roof. Thatch disperses rainwater evenly and clear of the wall, while cast iron rhones gather water close to the wallhead. This creates a risk of local deluge as joints leak, iron corrodes, or the pipes become choked. The plastic rhones and broken downpipes were replaced with cast iron to ensure proper rainwater discharge away from the walls.

This was part of a consistent focus on managing moisture, a key component of any earth construction project. Dampness caused by the cement render trapping moisture had weakened the wall and the render's removal allowed the wall to dry and gain strength. But the surface had to be dampened to create a good bond for the finishes, the curing of which was controlled both by spraying and by limiting exposure to sunshine and air movement through covering with layers of hessian and tarpaulin.

While the preparation of the variable substrate enabled an effective bond for the lime harl, the reduction of moisture in the lower section of the wall was slowed due to the dampening of the wall required during the works, the proximity of the pavement and the inner concrete slab. This leaves the area vulnerable to frost and road splash damage, especially during the first winter.

Throughout the project, the owner was very engaged and developed a good technical understanding of his home's traditional construction. Interest and understanding of this sort helps safeguard the building in the long term by avoiding risks of moisture-related damage.

15. CONCLUSIONS

An expert understanding of weathering and decay of earth materials is critical in assessing the condition of traditional earth buildings and quantifying the level of risk they face, thereby informing an appropriate programme of repairs. Sourcing appropriate local earth for use in repairs can be challenging and must be addressed well in advance of site works. An understanding of how moisture affects traditional buildings is also key to removing the problem, achieving good quality repair and subsequently maintaining the building in the long term. Therefore, specialist skills are required to successfully execute this type of project and there are very few contractors who have the relevant experience. This inhibits competitive tendering, but does not preclude value for money.

The cost of the repairs was significant, but made affordable to the owner with the assistance of grant support. The Tay Landscape Partnership provided specialist technical guidance to the owner at an early stage, which was instrumental in developing an appropriate scheme of repairs. The works, budget and programme were all successfully managed through close teamwork between experienced contractors, architects and a conservation-minded client.

This project presented a range of complex technical and management challenges. This is typical for a building of this type when incompatible materials have been used. It demonstrated, however, that it is possible to meet these challenges and deliver good-quality, traditional repairs to mudwall buildings, and safeguard their heritage and financial value, all whilst minimising cost and inconvenience to domestic property owners. Successful projects such as this can promote good practice in areas with concentrations of traditional buildings.

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