

Minimal Intervention and Regular Repair

This paper deals with the conservative repair of old fabric on or near the surface of historic buildings, the first three case studies being external wall surfaces, the fourth being a floor. They illustrate a wide range of materials and techniques used on a range of substrates. However they all have in common mortar mixes bound only by non-hydraulic lime, and only traditional building techniques were used.

In all four examples a balance had to be made between the desire to preserve the maximum amount of authentic fabric, together with the beautiful effect that weathering and sundry wear has had upon it, and the desire to do a thoroughly effective, and traditionally workmanlike job in prolonging its useful life, and therefore eliminating as far as is practicable the need to return in a few years to do more work.

The extreme solution to the first desire is to do nothing. Sometimes this is an honourable decision. However, normally the solution is to cause minimum intervention by executing only the smallest and most urgent repairs, and to aim to change the appearance of the building as little as possible. One should be aware that this approach means that further work will be required, sooner than later, as the fabric will always be somewhat vulnerable. If the repair cycle is diminished in this way it is especially important to evolve a 'concept of maintenance'. This is only feasible if there is a guarantee of future sympathy for a programme of frequent inspections and repairs, and of a continuity of appropriate repairers and repair materials.

The extreme solution to the second desire is to improve the functioning of the old fabric as much as possible, strengthening its fragility by reinstating all its missing parts including its original upper layer(s). Thus, repair by the full addition of like materials, albeit the most carefully chosen ones, becomes a restoration of the original builders' intended surface, with the attendant risk of conjecture: at what level was that surface, exactly where was it, exactly how was it, and when? Also, in this worthy desire to add new fabric to support, nourish and protect the semi-decayed fabric, the existing appearance of the building has been sacrificed. Some of that warm feeling of ancientness will have been lost to the viewer, as the building enters this new phase in its repair cycle. Eventually it might be regained. We can have faith that, if the new materials have been thoughtfully chosen to be fully compatible with, and even slightly softer than, the existing materials, they will all weather in harmony with each other so that in the fullness of time another patina will have developed.

In finding solutions to either of these two often conflicting desires outlined above, it is always necessary to understand how the building is constructed, and surfaced. For example it is vital to accept that all old buildings are vapour permeable. Vernacular and pre-industrial period buildings such as those in these studies are often soft-built, and 'low tech'; with their feet in damp ground they draw up moisture (and salts in solution), which should be allowed to evaporate freely from their soft permeable skins. With basic maintenance over the centuries it

seems that soft-built structures are paradoxically more *durable* than many modern hard – *durus* in Latin – brittle materials and assemblages that cannot breathe, or accommodate ground or thermal movements.

So before making a plan of action it is important to analyse how and why the materials in an old building have worked so well together; also to see how the fabric has settled over the years into a unit. Often the most sympathetic and effective treatment is to respect the integrity of this unit, weakened though it is, and to stitch the fabric together as one mends holes in a woollen sock. Each patch maybe flimsy, but the cumulative effect of many tenuous connections of new soft material to the existing fabric is an overall gaining of strength.

Finally, it is worth remembering that every building is unique, even though it might sometimes be closely related to its neighbours and contemporaries. So every case should be taken on its own merits and the specification should be tailor-made for it.

Fig. 1. First case study: Church House Gazebo. Preparation for lime mortar consolidation and lime roughcast render. Loose material was associated with settlement in the structure.



All this observation and thinking takes time, and a growing commitment, which continues as one becomes more intimate with the building during the physical work of repairing. Even in these four modest sized projects interest in the work was enhanced by each building gradually revealing its secrets. Dogmatic rules and methodologies have little place here; more relevant is an open-mindedness. Decisions should be flexible and governed by a sensitivity to the building and its needs, its architectural style, period, status and its final appearance on completion of the repair work.

Careful judgement is needed at all stages, especially at the outset of the repair process, of how much decayed fabric is to be removed. The greater the intervention, the greater the loss of authenticity – and the greater the cost of the work – but the more long lasting will be the repair.

Furthermore many decisions will inevitably be taken subjectively. For instance, what is authenticity? One might retain all the existing fabric, with its repairs of different periods. Alternatively one might allow oneself to discriminate against modern repairs that are not part of the long tradition of wholesome building, i.e. those which are not of soft 'low tech', or hand made materials – indeed those which are ethically or aesthetically unacceptable in some way.

There is no substitute for personal experience derived from a close involvement with old buildings. In the case of these four studies a strictly scientific input was not thought relevant or necessary. Instead, an empirical approach was taken. Rediscovering time-honoured methods and materials, and working in the spirit of the original craftsmen provides an almost innate understanding of traditional building culture that has largely been lost today. This is not surprising, because for much of the twentieth century (and the nineteenth century) there has been a confident belief in contemporary technology. There has been an almost moral obligation that we must solve ancient problems in novel ways, and experiment with modern materials and techniques, often with the aim of cutting costs by saving labour on the job. In new building, 'first cost' has been a main consideration with little thought of future maintenance costs. But the hope of recent times has been that we can enable our building stock to be maintenance-free, even to be given the elixir of life.

Two more tenets of good conservation that were followed where practicable in these studies are first, that repairs should be reversible, in that they can be removed for any reason without damaging the original fabric. The softer range of lime mortars facilitates this. Second, repairs are generally additive, in that minimal old fabric is removed in order to effect the repair, but some might be covered up by new material.

Workmanship must always be competent, conscientious, neat and conforming to the quality of the 'old work'. One must aim to do the best for the building within any campaign of repair work, however short. Sometimes on large scale repair projects today although there is an impressive input of human endeavour at an early stage – project management, conservation philosophy, archaeological recording, scientific analysis and advice on health and safety – the quality of the craftsmanship is disappointing. More funding, time, and thought could have been given to the actual repair work on the fabric. The importance of highly motivated, skilled and careful operators should never be overlooked. Likewise it should never be taken for granted that all those who handle old fabric will pay the respect that it deserves.

All four studies were small scale, taking between five and twenty days to complete and involving only two operators, although various opinions were sought before and during the work. They can be regarded as pilot projects, in which no compromise was allowed. Each job was given all the time and materials that it demanded. In each case the final amount of work done on the building exceeded the estimated amount, but the consequent loss of income was accepted. The main objectives were to do the best for the building, and to record the process with a view to returning at intervals in the future to monitor the effectiveness of the repairs.

None of these studies involved the use of the hydraulic range of limes. (Portland cement was not used either.) Experience with non-hydraulic lime made from high calcium limestone and matured as a putty, and a confidence in its use on site was sufficient to make the repairs work successfully in each situation.

During the 'Lime Revival' over the past twenty years in Britain much knowledge has been regained about working with non-hydraulic lime. It is suitable for most soft repairs: workability is good and mixes can be stored for further use. However it does have limitations: it is white, it shrinks in use, it hardens slowly and from the surface inwards, it can remain unfixed in situ, and it may be too soft. In the last few years we have been moving forward, experimenting with hydraulic limes, realising that there was a great diversity in the past, and that once again we should have available a whole palette of limes, each of which should be considered at the outset of a repair project. In retrospect hydraulic lime mixes would have been considered in the third and fourth case studies to produce a more robust result. But so far these repairs are performing satisfactorily. There is still a lot we do not know about hydraulic limes. For instance, how high is their long term acquisition of strength? However hard they might become their properties are closely related within the family of limes and are quite different from those of Portland cement. There is no technical 'quick fix' in repairing with any lime. However there is the satisfaction of using a material which has beauty, character and pedigree to look after old buildings in the best way.

The first study is of conservative repairs to the lime roughcast render original to an early eighteenth century garden building situated adjacent to Church House in Lechlade, Gloucestershire. This is the most sophisticated of five gazebos of similar form in the village. It consists of a square room, with fine architectural features matching those in the house. It is entered by a flight of steps, there being a cellar below with a side entrance, and is lit by windows in all four walls including one over the door.

The gazebo is in a stable condition and is much appreciated by its owners. However the damp level in the basement walls has been raised by dense Portland cement repairs to the roughcast low down on each elevation, carried out in the 1960s. Then various repairs have been done to the building over the past decade, as and when required, using lime-based mixes. The owners do not want to restore the exterior surfaces as they admire their mellow grey-coloured patina.

Fig. 2, 3. First case study: Church House Gazebo. Completed lime roughcast render repairs, with coloured limewash.

Fig. 4, 5. First case study: Church House Gazebo. Completed lime roughcast render repairs, with coloured limewash. Detail, showing repairs to fictive quoins against door architrave.

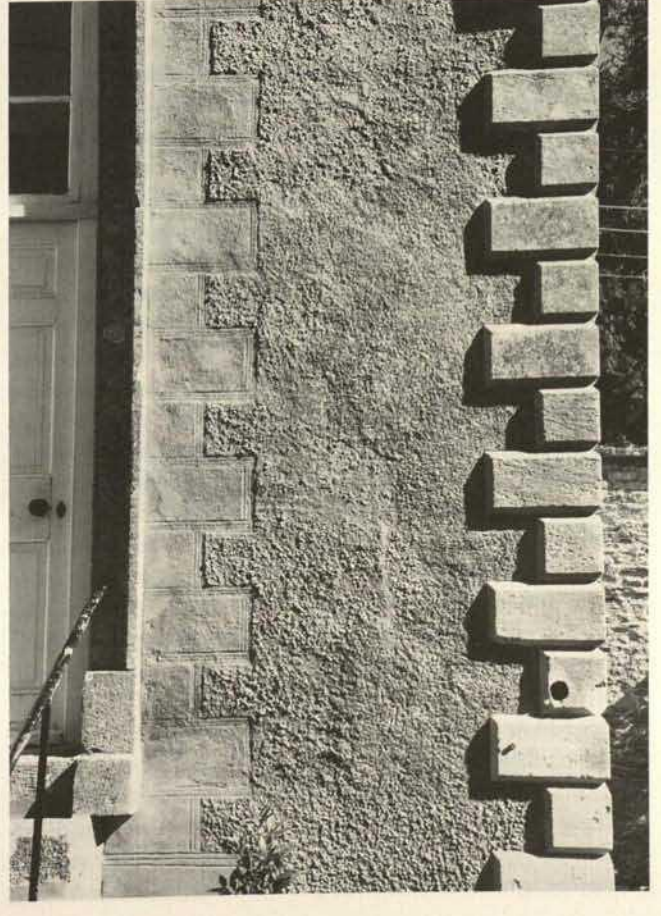
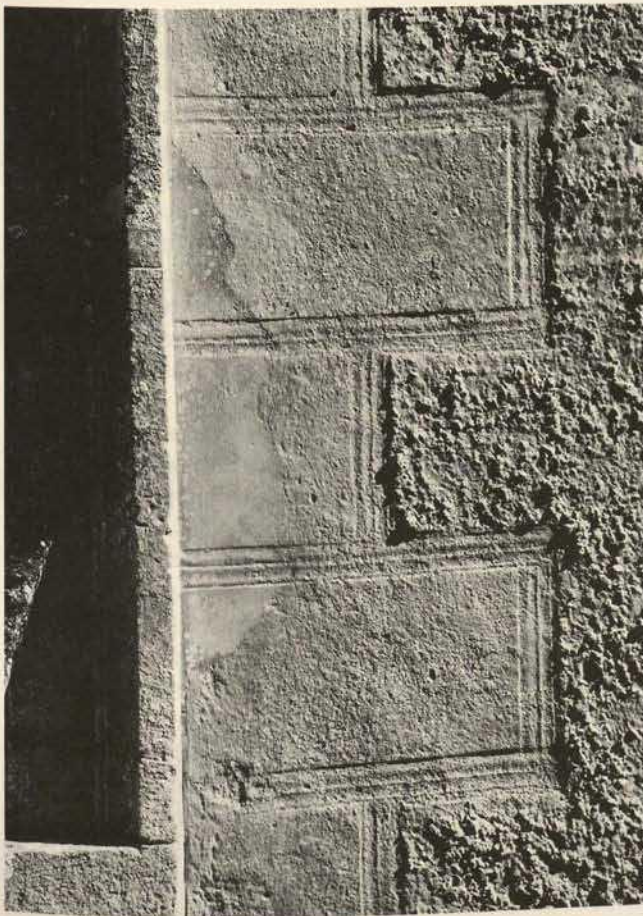
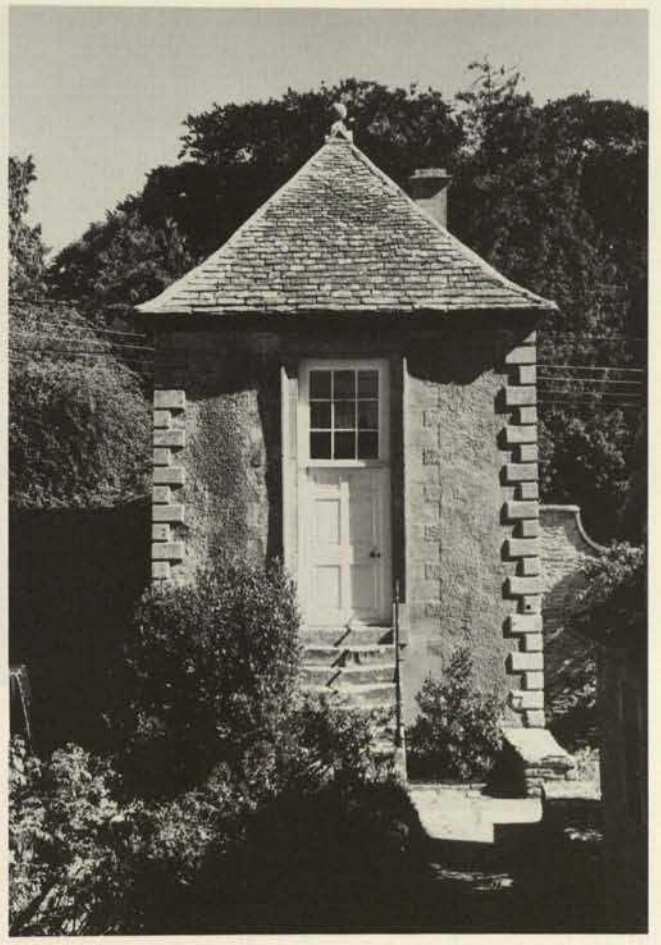




Fig. 6. Second case study: Woolgatherers staircase. The original lime surface before repair work. Note previous repairs with Portland cement on wall to right, and on timber lintel below.

In the summer of 1998 a large plant was removed from against the building and an area of decayed render was revealed. This was the original coating, slowly worn away, and unseen for many years. All it required was consolidation of its loose and missing parts. Thus, holes and cracks were investigated. At first sight one would have expected that only a day's work would be necessary to make good the surface so it would no longer be vulnerable. But in spite of nothing more aggressive than small trowels and spatulas being used to pick out only the loose material, a more extensive pattern of decay was exposed. It related to detachment of the render from its substrate due to the building slowly settling on its foundations. Furthermore some poorer quality stones in the cheaply built rubblework had disintegrated where weather had penetrated through the gaps in the render, so these were removed if structurally unsound. After raking out was completed, the cavities were brushed out and then washed clean.

During this careful process of archaeological excavation one always discovers much about the original method of construction. In this case the temporarily exposed internal face of the high quality freestone door architrave and the quoins clearly showed the sequence of stone laying (and the method of working the stone.) The salient masonry had been erected using a fine lime-rich slurry mortar which had squeezed out of the bed joints. Then it was dented while still soft when the wall of rubblework was laid between the freestone 'piers' using a cheaply made coarse loam mortar. This contrast between expensive (white) mortar used sparingly and common (yellow) mortar used freely is typical of this region and is related to that found in vernacular and pre-industrial period buildings elsewhere. Another discovery behind a failed area of render was a loosely filled up 'putlog hole' used to accommodate a horizontal scaffolding timber during the building's construction. To come upon all this perfectly preserved evidence inside the wall is to read an historical document.

In common with all four case studies lime mortar had been made up in advance of the job and was further blended with different aggregates to make various mixes to suit their context. One of these was used for all deep consolidation, (rather than the

original loam mortar) to give strength to the slightly loose rubblework substrate. The maximum amount of clean, sound stone fragments were tapped into the mortar to provide a core to the repairs, thereby reducing the volume and shrinkage of the mortar. This process was continued in the 'dubbing out' where the surface was levelled up to receive an even coat of roughcast in all the lacunae. This coat is thrown on in the traditional way, at a suitable moisture consistency. Time was allowed to elapse before the addition of the final touches. A visual sensitivity is crucial at this stage. It is possible to blend the repair in with the existing surface so that new and old textures are subtly differentiated. Various brushes were used to achieve an appropriate texture. The decorative feature of the render adjacent to the door architrave was repaired with smooth render. Later, several coats of limewash, pigmented to match the general colour of the existing render, were brushed or flicked onto the damp surface. As soon as the render was ready to receive more limewash various colours were flicked on to harmonize with the patterns of lichen growth. This is *tratteggio* in which the wall is unified when seen from a distance, but near-to the repairs are obvious. Why should old buildings not be considered as being artefacts just as precious as old paintings or sculpture?

The second study is of conservative repairs to an area of lime-washed rubblework original to a seventeenth century wool merchant's house in Cirencester. The work took nine man-days. It was carried out in July 1994 at no cost to the owner. This wall which encloses the main staircase was selected because its surface was almost intact, having been sheltered by the overhanging roof eaves, and having largely escaped the hand of the twentieth century. It survived because it had gone unnoticed. Though once ubiquitous, these authentic surfaces are now rare, because they have been misunderstood and are usually destroyed today.

Here was a true and even surface, following the medieval tradition. The wall construction was the same as that described in the first study, but it had never been rendered. Instead it was flushpointed, almost 'plaster pointed', with a very resilient lightweight lime-rich mortar, (almost pure lime putty), and reinforced with cow hair. Like the mortar used to bed the freestone



Fig. 7. Second case study: Woolgatherers staircase. Completed lime repairs to mortar joints and stones, and five coats of limewash.

quoins and the window it was soft, porous and off-white. The mortar was level with the stones and one could see trowel imprints. One detects that the work, though a little crude, was done with speed and confidence, and it has proved successful. A laminated patina of different coloured coats of limewash survived in the hollows and in the 'rain shadow', but had been worn off the denser and smoother stones. Though not re-limewashed since the nineteenth century this soft and peeling 'skin' was still providing the 'muscle' and 'bone' with a partial containment, and a partial barrier to infection from weather and air pollution.

There were three purposes in doing this project. First, to encourage the house owner to begin a regime of lime-based maintenance to a plan; for instance, repairing one elevation every other year. Although the result was appreciated, the property has received no significant repairs since then. Second, to demonstrate the use of lime products in building repair during a practical training day. Third, to inspire and influence the guardians of the many old buildings of the neighbouring large private estate that have similar wall surfaces. At first this had some impact but in general the estate has reverted to the modern convention of 'scraping' such walls as this. In this process all the lime pointing and the surviving soft lime patinas are removed and the joints are filled with a Portland cement based mix whose darker tone and greyish colour highlights each stone (in accordance with popular taste.) The architectural quality of these façades becomes marred as their surface is masked by the resultant coarse textured treatment. The economic implications are equally significant because the long-term health of the building is jeopardized.

This study serves as an exemplar of traditional maintenance of a genuinely historic wall surface. It demonstrates that the joints and coatings of a wall are as much part of its function and character as are the stones. If the top surface is regularly maintained it will protect its substrate (of flush pointing here) which in turn will protect the structure. Thus if minor decay is not halted it leads to major and costly decay. This wall is weathering well, becoming beautifully mellow over the past four years. In appearance, it resembles the walls our ancestors would have seen.

The work on this wall was similar to that described in the first case study. The minimum of fabric was removed, and only using small blade tools, except for several isolated hard cement fillings which required a hammer and sharp chisels to free them. Slight settlement within the wall had caused cracks to open up and these contained loose material. Detachment of the pointing mortar was also associated with its original shrinkage cracks. The cavities and the surface were carefully brushed down, first dry then wet, care being taken not to let excess moisture penetrate the structure. Only loose flaking layers of limewash were lost in this process.

Mortars similar (but not identical) to those found in situ were used to reinstate the structural integrity of the wall and then build up the surface of the mortar joints so that the new work lay precisely in line with the remaining original mortar surface, not overlapping at any point. Areas of decay in the freestone dressings were removed, and these irregular-shaped lacunae were then built up layer by layer with mortars designed to match the colour and texture of the stone.

There is a modern convention of executing mortar repairs in rectangular-cut lacunae that no doubt derives from a stone masonry tradition. Straight edges and right angles draw attention to the repairs; they are unnatural to the geology and weathering of stones. Furthermore it is more effective to place mortar against a curved profile than into corners. Minimum intervention and great visual subtlety can be achieved by filling only that which has decayed.

A day after the mortaring was complete the whole area was limewashed in a colour related to those of the surviving fragments, using traditional iron oxide earth pigments. As always, after systematic and careful dampening, the limewash was flooded onto the surface and worked into all fissures and granular areas and allowed to partially absorb. It was taken up to the glazing line in the window. Then it was 'burnished' with an empty but damp brush to compact it, in the same way as the mortar has been pressed in to counteract shrinkage cracking. The work was protected from sun and wind. Four more coats of limewash were added, no more than once a day, allowing for carbon-



Fig. 8. Third case study: Broadfield Court. The fourteenth century doorway before repairs. Note decayed surfaces to hoodmould and surrounding rubblework, and Portland cement fillings.

ation to occur. Controlling the moisture under the surface always involves careful attention.

In both these case studies it was accepted from the outset that these lime skins were original to the building (but might have been replenished over the years) and that they should be preserved. They were seen to have as much value and 'cultural significance' as the harder components of each building such as stonework features or roofs of local stone 'tiles'. Furthermore it is often forgotten that these thin lime coverings are 'architectural', and can be traced back to the ancient world. In the seventeenth, eighteenth and early nineteenth centuries the builders of Europe's great houses read treatises on antique building technology and understood the eloquence and significance of these skins. And if some people should doubt their usefulness the proof is there: where they survive intact the substrate is in perfect condition and where they have fallen away there is corresponding decay underneath. The roughcast plaster may only be 10mm thick, the limewash 1mm thick and both may be soft but they continue to function until they eventually fall off their substrate.

By contrast, the third (and fourth) case study did not involve limewash (although it was used to help bond the mortar repairs to their substrate) – nor was there a continuous skin surviving. Instead, only lime mortars were used to repair the fourteenth

Fig. 9. Third case study: Broadfield Court. The range of lime products used on the repairs to the doorway. Note goat hair for reinforcement of mortar for hoodmould.



Fig. 10. Third case study: Broadfield Court. The completed lime repairs. Note the limewashed stones of the hoodmould, and repointed rubblework.

century sandstone doorway and surrounding sandstone rubblework in the north elevation of Broadfield Court at Bodenham, in Herefordshire. The house has a complex building history extending into modern times and there is a current tradition, perhaps a century old, of expressing all its stonework, rough and smooth together, that had to be respected on this job. However, old limewash was found adhering to the doorway masonry when hard cement patches were removed. Early rubblework in this sandstone district was once finished in similar ways to that found in the limestone district where the first two studies are situated. Here it might have been flush pointed and limewashed, or rendered.

The aim of this project was to find ways of arresting the decaying doorway masonry without adversely changing its appearance, or losing original fabric. Commonplace lime mortars if used with mastery and invention (as is often the case in 'old work') were considered to be a desirable alternative to unproven (and expensive) chemical 'preservatives', or to conventional masonry practice. Cutting out and replacing so-called 'failed' stone would have drastically altered the ancient character of the doorway, and would have been expensive. On closer inspection the decay, though active, was only affecting the stone to a maximum depth of 15mm and it was mainly confined to the encircling hoodmould which was of a green coloured soft siltstone. Apart from ancient wear, the gritstone masonry was basically in a stable condition. It was assessed that there were two principal causes leading to the decay of the doorway which posed a serious threat in the future. One was the hoodmould that had become so decayed that it was no longer functioning as a water-shedding feature, with the result that the carved voussoirs and jambs were suffering unnecessarily. The other was the surrounding rubblework of friable weakened stones in a perished mortar exacerbated by a large area of recent repointing in a dense cement mortar, associated with a once-leaking drainpipe.

It was agreed that the ambient conditions within the fabric must be improved. Therefore its functional equilibrium in the immediate area of the doorway was restored so that it could perform efficiently as a rain-absorbing and evaporating surface. It was hoped that this in turn would alleviate stress in the hoodmould, and the masonry below, by reducing direct run-off and avoiding an accumulation of moisture within the wall. It was decided to restore the full architectural form of the hoodmould so that it might once again perform its intended function. The chal-

lenge here was to make ordinary lime mortar adhere to the siltstone, and endure in this stressful location on the façade.

The work was carried out in September 1995 and amounted to twenty man days. Various lime mortars were prepared in advance. Decayed or cementitious material was removed from the doorway and the surrounding rubblework, after which the masonry was cleaned. Joints and voids were filled with the appropriate mortar, and subsequently 'finished' by compacting, then paring away, and brushing and sponging the surface to reveal the aggregates, that is, the full character of each mix. Because they would be exposed to view it was important to counteract the inherent light tone of lime. However the most intricate operation was the consolidation and building up of the hoodmould to its full form. This involved incorporating terra cotta chips, thereby providing a core to counteract shrinkage by halving the thickness of this necessarily plastic mix. It was then limewashed to match the colour of each stone within its length. Lime shelter coats were applied in very localised areas such as the disaggregated ballflower ornamentation. Finally a rotten stone near the base of the right jamb was replaced with a suitable piece of gritstone. A mortar repair was not chosen for this position because it might be too weak, being vulnerable to salt decay, frost and mechanical damage. The immediate environmental conditions were controlled so the work would dry out gradually. Fortunately the autumn was warm and dry. The first frost came seven weeks after completion of the work. The doorway has been inspected every six months since, and is looking well three years later.

The lime-based materials used on this project did not attempt to compete with the existing materials of the original construction, but to complement them. Although lime was the 'archaeologically correct' substance to use, this in itself was a minor consideration. More importantly, the mortars used had similar mechanical and functional properties to those in the original construction – both the mortars themselves and to a certain degree the soft and hard stones. It was intended that the mortars be 'sacrificial' to the stones, accommodating weathering and decay processes and thereby protecting them. The known benefits of repairing with lime-based materials outweighed any perceived notion that sandstone is damaged by the proximity of lime. Beyond this the lime-based materials were intended to be aesthetically pleasing. This work of respecting and honouring the doorway did not follow a dogmatic 'conserve as found' approach, but was nevertheless conservative – rather, a 'repair by addition'.



Fig. 12. Fourth case study: Acton Court. Cross passage floor from west to east after lime mortar repairs. Note the unusual configuration of pennant stone parving.

The fourth case study is of the consolidation of an ancient floor with lime mortars. Here the more strict 'conserve as found' approach was taken. The floor belongs to the cross passage in the centre of the east range of Acton Court at Iron Acton, on the northern outskirts of Bristol. The property was rebuilt by Sir Nicholas Poyntz who was connected to the Royal Court. Architecturally one of the most important surviving houses of its period in England it contains a painted Renaissance frieze and other mid-sixteenth century features, such as the earlier parts of the cross passage floor. For the past ten years Acton Court has been in the guardianship of English Heritage, the state historic buildings service. Incidentally the exterior wall surfaces of dark red irony Pennant sandstone rubblework were originally protected with an off-white roughcast render, the remnants of which have been consolidated on the now repointed walls.

The work was carried out in March 1998 and amounted to twenty man days. The floor measures approximately 4 m x 8 m. The architect's brief was to do as little as possible to safeguard the floor and to preserve its integrity. It was established that the majority of the floor would have very low use in the foreseeable future as the only thoroughfare would be across the west end. Therefore it was agreed that non-hydraulic lime mortars would be adequate for the necessary consolidation work. They would allow the maximum transpiration of moisture from the floor as a whole, and maximum reversibility. This campaign of work

Fig. 11. Fourth case study: Acton Court. Cross passage floor after lime repairs. Note lacunae filled with mortar, and only the larger joints.



should not preclude any future archaeological, or more sophisticated conservation activities. Having thought that non-hydraulic lime would be sufficiently robust, it was then decided that brick dust should be added to give a pozzolanic set. It would also help to darken the tone to the mixes, together with a range of sands, stone dusts, charcoal and coal dust, all of which were found in different concentrations in the various existing bedding mortars. The floor was dry brushed and then gradually wet cleaned. Only water was used, impacted dirt being softened with repeated mist spraying. Care was taken not to let excess water sink into the bedding layers as this would activate salts.

During this process the floor revealed itself as a vivid historical document. It was a map of adjacent areas of at least seven different types (and as many phases?) of paving: four different categories of glazed terra-cotta tiles and three of stone, all contributing to a beautiful patchwork of colour and texture. (There was even a block of coal laid in one corner.) Additional to this pleasing effect was the reticulation of cracks in every paving material due to their inadequate bedding. Undulations, and especially, the sudden breaks in the floor plane due to subsidence or delamination, all made these in situ repairs more difficult.

In this 'holding operation' the mortar was placed adjacent to the components to secure them in place and protect vulnerable edges, and only where absolutely necessary for their survival in situ was it placed under them. The joints between components and only the principal breaks within each component were

Fig. 13. Fourth case study: Acton Court. Cross passage floor on completion of lime repairs. Note area of contrasting mortar to indicate resiting of buried tiles.



filled. The work was constantly reassessed and further filling of secondary breaks was done if it could be justified. It was found that the gradual deposition of dirt in the finer cracks was acting as an effective stabilizing medium and therefore it was left in situ. Shortage of funding and time helped to discipline the extent of the repair activities.

As the work proceeded there emerged a distinct pattern to this rich accumulation of repairs. The oldest flooring was adjacent to the long side walls. By contrast the areas that had received most wear had been replaced most frequently, so the most recent area was down the longitudinal axis of the floor. This included crude patches of mid-twentieth century concrete. These were removed where possible, on the grounds that they were physically and visually obtrusive, lying proud of the surrounding paving. The concrete was also preventing the floor from performing its function as an evenly evaporating surface.

It was decided not to 'confuse history' by restoring the missing paving with similar materials. Two exceptions were made in front of two door thresholds, areas which would always receive more traffic. Instead, all the other lacunae, both those existing and those caused by the removal of concrete, were packed with a composite repair material consisting of layers of low fired tile and lime/brick dust mortar, bulked out with clean permeable stone if the depth exceeded 50mm (being the approximate thickness of the larger flooring components.) The deepest of these areas remained damp and workable for ten days. During this time and subsequently, they were absorbing soluble salts from the ground and the adjacent floor, which were later to effloresce. This phenomenon was expected and accepted as beneficial to the long term health of the floor. Two months later a crop of salt crystals was removed from the mortar surface which was now hardening steadily. It is hoped that all subsequent efflorescence will be likewise removed from these buffer zones so they can continue to alleviate salt levels in the floor. The glazed tiles are particularly vulnerable and precious.

As shrinkage cracks appeared the mortar was compacted and given a wood float finish, their surface plane being adjusted so it was always between 1mm and 3mm below the adjacent floor surface. One deep lacuna contained loose tile fragments and other debris. It was decided that the tiles should be used on the surface above where they were found. So they were set in a small area of contrasting (pink) coloured mortar to indicate a conjectural reconstruction. When the lacunae and all the joints and larger cracks had been filled one could read the floor as one continuous surface. Though fragile under-foot it looked solid; its delicate integrity had been regained.

The achievement of a new integrity by consolidating old fabric with minimal intervention was the principal aim in all four case studies, together with an acceptance of the need for regular repair.

Abb. 1. Der „Alte Bauhof“ in Bad Windsheim nach der Instandsetzung. Blick auf die Nordseite mit dem Haupteingang. Foto K. Bedal, Bad Windsheim. >