THE REPAIR AND PRESERVATION OF HISTORIC MASONRY

Technical Conservation Note 1
May 2003

Cadw

1. Introduction

Cadw staff have many years' experience in the consolidation and repair of masonry and are often asked for advice. This note has been prepared to summarize best practice in preparation, repair and conservation of historic masonry and the choice of materials.

2. Recording

When scheduled ancient monuments are repaired, all external and internal areas of masonry to be affected by repair works should be photographed. Photographs should be taken with a 35mm or larger format camera, using black-and-white film where possible. They should be taken square-on to the elevation and accompanied with one or two general views to aid location. Beware of taking photographs against the light and try to include a scale, e.g. a ranging pole or rule. One round of photography should be undertaken after the vegetation has been cleared, but before works commence. Should areas of masonry be expected to be demolished because they are loose or trees need to be removed, then individual stones should be numbered to aid reconstruction. A second round of photography should be undertaken on completion of the work.

At least three sets of prints should be obtained. One set should be deposited with the National Monuments Record, Royal Commission on the Ancient and Historical Monuments of Wales, Crown Building, Plas Crug, Aberystwyth, Dyfed SY23 INJ (with the negatives where possible); one set sent to Cadw; and one set retained for the use of the contractor. Each set of prints should be accompanied by a list of the views they portray.

Good quality digital photographs are also acceptable and should be submitted on disk accompanied by paper copies.

3. General rules

Masonry in a good state of preservation need not be touched. As a general rule, no defective masonry that can be secured in situ should be taken down.

If it is necessary to introduce any new material on the surface to support dangerous or overhanging portions of the structure, it should be similar in all respects to the existing weathered face-work or core-work.

It is of the utmost importance that the areas concerned are carefully examined for archaeological and architectural evidence of what may have existed originally. For example, building new work to an overhanging arch must not obliterate fragmentary remains of a window or door jamb. Similarly, new face-work must never be built in advance of the original line, whether straight or curved, and where core-work is inserted, it should be set well back to allow for the facing stones which would have originally existed.

Pointing of both face- and core-work should match the texture, colour and general appearance of old work; the selection of aggregate and sand is therefore of the utmost importance. Analysis of existing mortar by a conservation specialist may assist in this. Disfiguring modern pointing should be removed if it is possible to do so without damaging surrounding masonry.

Plant growth should not be removed before work on consolidation is commenced, as its removal can tear away old mortar and expose the old stonework to weathering by frost and rain. Plant growth should be cut at the base and treated with a suitable herbicide. When consolidation starts, it is necessary to remove all roots and earth to prevent further growth and to ensure adhesion of new mortar to the clean faces.

Note Flora and fauna on masonry may include rare or endangered species. This must be checked prior to work commencing, and appropriate action should be taken. Historic masonry may also be home to bats, which squeeze into narrow gaps where mortar has fallen out. Bats are afforded special protection under The Wildlife and Countryside Act 1981. If evidence of bats is found, you should inform the Countryside Council for Wales, Maes y Ffynnon, Penrhosgarnedd, Bangor, Gwynedd, LL57 2DW, Tel 01248 370444 and allow time for them to advise on any special precautions which may be necessary.

4. Protection

After consolidation and pointing, stonework should be protected from inclement weather and from rapid drying out in the same way that modern building work would be protected — with tarpaulins or plastic sheeting. No work should be undertaken when aggregate is frozen or when the temperature is below freezing or is likely to fall below freezing before the mortar has set.

5. Raking out joints

Joints should be raked out to a minimum depth of 40mm or twice the thickness of the joint (whichever is greater) in order to remove all dirt, root growth and loose mortar. They should then be thoroughly washed by means of a hose or garden syringe. It is essential that masonry and brickwork is well wetted before pointing is carried out.

6. Filling joints

Joints should be filled thoroughly with mortar, finishing very slightly behind the surface of the masonry, and consolidated by pressing in with appropriate tools (made from 6mm round steel bar, approximately 250mm long, flattened and curved at the ends to form blades of different widths). No voids should remain. Superficial pointing should be avoided as it lacks durability.

7. Finish of pointing

New pointing should harmonize with old work in colour and texture. After the joints have been filled and compacted, stippling with a brush should produce a slightly roughened effect. This assists in tightening the joint and fills hairline cracks left through shrinkage. Care should be taken to ensure that the pointing does not dry out too quickly. No holes or cracks where water can collect should be left in the finished pointing, as the water will freeze and expand in very cold weather and loosen stonework.

New pointing must be kept damp during hot weather. It is desirable to avoid pointing during frosty weather, but if it is necessary to do this when there is a likelihood of frost, the work must be thoroughly protected.

It is sometimes unnecessary to point every open joint in a wall, as very often the mortar, although weathered back from the face of the stone, may still be sound and hard in the joint. Unless the mortar is recessed more than 12mm there is usually no need to fill such joints.

Medieval pointing was usually struck off flush with the face of the masonry. In the course of time the mortar has weathered back and the edges of the stone have become rounded off.

Therefore, in order to obtain a tight joint, the surface of the pointing should be slightly recessed so that the mortar does not spread over the rounded edges of the stone. If the mortar is brought out to the surface of the stonework a thin skin is spread over the edges of the stone. This skin will, in time, weather off, leaving a pocket readily enlarged by wind erosion. This will hold moisture and so accelerate the deterioration of the stonework.

Cement pointing is detrimental, particularly if applied to soft stone (or bricks) because it is hard, non-resilient and comparatively non-absorbent and it does not respond to the variations in the atmosphere to the same extent as the stone or brick with which it is in contact. If hard pointing is employed, the physical action causes rapid weathering and disintegration of the softer stone or brick. Many cases of stone decay have been traced to the use of impervious mortar with a porous stone. In such cases, saturation and evaporation are confined to the stone whereas the process should be distributed equally over both stones and pointing.

8. Wall tops

It is necessary as far as possible to prevent percolation of moisture into the heart of the wall. Normally the upper courses of the stone are found to be loose and the mortar disintegrating. The courses should be recorded, lifted and thoroughly cleaned, then re-bedded, taking care to finish the joints between the stones so that water cannot stand on the wall tops. Where the wall top presents an uneven surface the irregularity should be preserved but pockets, which could hold water, must be avoided.

9. Base of walls

Where accumulations of spoil or earth have been built up over the years, this protection should not be removed before the masons are ready to consolidate the wall at that point.

10. Displaced masonry

Displaced masonry, such as face-work that has bulged, should be taken down and the stones re-bedded in their original position. For this purpose the stones should be numbered or otherwise identified.

Where metal clamps or ties are necessary, these should be of a non-corrosive metal, such as high tensile brass or stainless steel. In no circumstances should any iron or mild steel be used.

11. Causes of stonework failure

- Settlement due to inadequate foundations. Where this occurs underpinning should be done in the normal manner before the stonework is re-pointed.
- Fracture due to overloading or other stresses. The cause of the stress should be determined and new stone or concrete plates or pads built in to spread the load adequately. When using concrete with reinforcement it is essential to provide sufficient cover to ensure that the reinforcement never comes into contact with the stonework. Stainless steel reinforcements are preferable. Where the walls are sufficiently thick and it is not practicable to re-bond the stonework in the heart of the wall, the structure may be stitched by inserting pre-cast concrete bonders (approximately 750mm long).

These are placed at intervals of 900mm, and are grouted, the fractures between the bonders and leaving the external faces to be re-stitched in stone.

- Pointing of masonry with a very hard setting mortar. Examples can be seen where the hard mortar remains and the stone surface has recessed behind the original face. The mortar must be removed and consolidation and pointing carried out as above.

12. Materials

Aggregates

When matching the aggregate of an historic mortar it may be necessary to mix several types of sand and gravel. Therefore it is essential to have a good knowledge of available sands in a particular region.

Take particular care about the grading of the replacement mortar's aggregate. It should be clean and well graded, ranging from fine to coarse, and be gritty in texture. This produces a stronger mortar with less shrinkage problems. Beware of artificially crushed stone dusts (especially limestone). These cause shrinkage problems, are weak and have poor adhesion.

The size of aggregate will depend upon the thickness of the mortar joint. Fine joints will not be able to accommodate large particles.

Cement

The use of cement is generally to be avoided on historic masonry.

Lime

Most pre-nineteenth century buildings used lime mortars and plaster. Materials used to repair or replace the original should have similar properties so as not to disrupt the balance of interaction within the building.

Lime Putty Limestone (calcium carbonate), when burnt in a kiln, loses carbon dioxide and becomes quicklime (calcium oxide). On contact with water, it combines with it, producing great heat, and forms slaked lime — lime putty (calcium hydroxide). This gradually takes up carbon dioxide again from the air and changes back to calcium carbonate. This 'setting' is called carbonation. Lime putty mixed with sand makes mortar. This then hardens into an artificial stone made up of grains of sand embedded in a mass of calcium carbonate. Lime putty is available from specialist suppliers who will ensure that it has been 'matured' for at least twenty-eight days.

Hydrated Lime This is sold in most builders' merchants as bags of dry powder. Soaked in just enough clean water for at least twenty-four hours, it makes a lime putty. This putty is generally of a poor quality owing to the risk of carbonation of the powder occurring in the bag before use and the possibility of there being unburnt/unslaked particles included from the manufacturing process.

Hydraulic Lime This is named 'hydraulic' because of its ability to set under water without the presence of air. This is supplied as a powder very similar to cement and should be used while it is still 'fresh'. It has the advantage that it can be used in situations where a faster set and/or stronger mortar are required. Only Natural Hydraulic Limes (NHL) should be used as others may have been adulterated with other substances. NHL is supplied in three grades:

Feebly Hydraulic (NHL 2) — slow set (15–20 days or longer) and low strength;
Moderately Hydraulic (NHL 3.5) — medium set (about 6–8 days, maybe longer) and medium strength;
Eminently Hydraulic (NHL 5) — fast set and high strength.

Manufacturers' recommendations should be followed regarding mix proportions and applications.

Mortar mixes

It is not possible to specify a general mix for mortar for all situations. Each location should be treated individually and a suitable mix agreed prior to work commencing.

However, lime putty mortars would normally use a mix based on 1 part lime: 3 parts aggregate. It can be increased up to a maximum of 1 part lime: 4 parts aggregate in sheltered locations, or decreased to a minimum of 1 part lime: 2 parts aggregate in exposed locations.

On finely jointed stone or brick a suitable mix might be 1 part lime: 1 part aggregate.

Suggested mixes for hydraulic lime mortars are as follows (these are dependent on location and type of aggregate).

NHL2: 1 part NHL2: 2 parts aggregate. This is suitable for work with friable or weak materials.

NHL3.5: 1 part NHL3.5: 2 or 3 parts aggregate. Suitable for general masonry/pointing.

NHL5: 1 part NHL5: 2.5 parts aggregate. Suitable for work in exposed areas or where high strength is required.

13. Further information

If you would like further information on this subject, please contact us.

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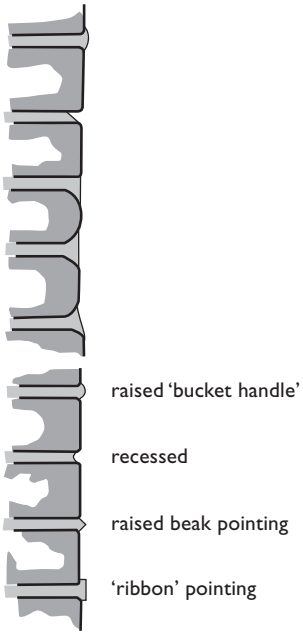
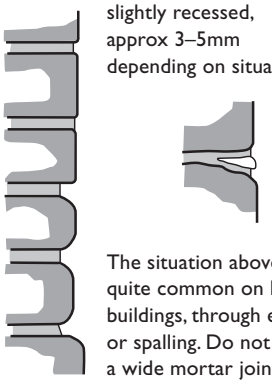
Common cases of incorrect pointing



Preferred methods of pointing



The situation above is quite common on historic buildings, through erosion or spalling. Do not form a wide mortar joint, but 'bed-in' a stone 'sneek' or 'slip'. Ensure that the new stone is sympathetic to the original.

If any of these pointing styles is found on a historic building, it should be carefully copied