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Guidance on Repointing Rubble Masonry in Archaeological Monuments and Historic Structures

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Table of Contents

1	Introduction	3
2	Aims of a repointing project	4
3	Approach	4
4	Maintaining character	5
5	The work.....	7
5.1	Raking out and cleaning	7
5.2	Salvage of stones and pinnings	9
5.3	Mortar	12
5.4	Mixing when using lime in powdered form	13
5.5	Pointing.....	14
5.6	Finishing.....	15
6	Aftercare	17
7	Sample area	18
8	Deciding on the correct lime to aggregate proportions	19
9	Exceptions	22

1 Introduction

The focus of this guidance is on how to maintain character when repointing rubble masonry in archaeological monuments and historic structures. It deals mainly with aggregate and its effect on appearance.

This guidance should be read in conjunction with the detailed specification for individual structures. This guidance **does not apply** to the repointing of ashlar or dressed stone. In addition, it is not applicable to earth-based mortars.

Various State grant funding schemes are enabling a nationwide programme of repairs to archaeological monuments and historic structures. Much of this work involves the stabilisation of masonry, including repointing. This guidance may also be useful to those working on other conservation and repair projects.

It is essential that works be undertaken in compliance with all statutory requirements, and that any necessary archaeological and ecological assessments will have been undertaken before commencement of stabilisation and repair works.

All grant-aided projects have a design team in place, usually led by a building professional with conservation expertise, such as an architect, building surveyor or structural engineer, and including other specialist members such as archaeologists and ecologists.

The design team works closely with the contractors and craftspeople who carry out the work on site. The success of the project depends largely on the team on site and their skills and knowledge in carrying out the work.

2 Aims of a repointing project

- To stabilise the structure and prevent deterioration.
- To prolong the life of the structure and hand it on to future generations.
- To maintain the character of the structure.

3 Approach

- Conservation is about careful repair, not ‘improvement’.
- Do only the minimum necessary. Do not remove sound historic pointing or take down sound masonry.
- What is done should be reversible. It should be possible to undo it without causing damage.
- Do not disturb surviving areas or patches of historic plasterwork in the course of the repointing works.
- Use the correct materials, tools and techniques that are proven over time.
- Keep a record of the work by means of regular photography.
- If in doubt about how to deal with a piece of work, refer the issue to the relevant conservation specialist in the design team.
- If anything unusual or unexpected is uncovered in the masonry, such as a piece of timber, a fragment of dressed stone or an archaeological object,¹ refer it to the design team and project archaeologist.
- The ecology of these sites can be an important part of their value. Specific timing of work and work methods may be required to ensure that the ecology is protected. Take account of the recommendations in any ecological assessment carried out.

¹ A person who discovers an archaeological object has a legal obligation to report such a discovery to the National Museum of Ireland, unless the discovery is made in the course of works licensed or consented to under the National Monuments Acts. Contact should be made with the National Museum as soon as possible, to ensure compliance with statutory timescales for reporting.

4 Maintaining character

- It is essential to maintain the character of the structure.
- Pointing has a major impact on the appearance of the structure.
- Most of the archaeological monuments and historic structures covered by this guidance are hundreds of years old, and some are over a thousand years old. They cannot be pointed with the same mortar, or using the same techniques, as would be used for new brickwork or new masonry.
- To maintain character the new mortar used should match the original mortar as closely as possible in strength, texture and colour. The aggregate used in the original mortar has probably come from a nearby source such as a riverbed.
- Surviving evidence of historic pointing finishes should be used to inform the new pointing.
- If little or no mortar has survived in masonry joints bedding mortar will have survived somewhere on site and can be used as a guide to the original mix.
- The size of the aggregate, often containing large stones, and the use of pinnings in the joints will affect the mortar colour, the size of the joints and the overall appearance of the masonry. Pinnings are larger stones of various sizes that were pushed into large joints of the fresh mortar during construction. An example of pinnings can be seen in Plate 1, and coarse aggregate in Plate 2.



Plate 1: Surviving mortar, probably original, in good condition. Note the pinnings; large stones inserted to reduce the size of the bigger joints and to compress the mortar. Note the size and colour of the other stones, and how they affect the colour of the mortar.



Plate 2: Size of stones in the mortar from Plate 1.

5 The work



Plate 3: Range of tools for use in raking out and repointing.

5.1 Raking out and cleaning

- Remove vegetation and humus from the masonry under guidance of the design team.
- If necessary, trim the vegetation underneath the wall being worked on, to provide an even surface.
- Spread a clean groundsheet or tarpaulin (not polythene) along the base of the wall to collect raked-out material.
- Do not remove sound historic mortar.
- Use a plugging chisel to rake out any defective mortar. It is more effective than a cold chisel or bolster in most cases, and its pointed tip is less likely to cause damage. A mini-pick is also useful for removal of mortar in certain

cases. Hacksaw blades or an old-fashioned Rawl tool can be used for fine joints (Plates 3–5).

- Never use power tools and never widen joints or damage the edges of the building stones.
- Rake out to a proper depth of 2.5 times the joint thickness. For example, a 20mm joint should be raked out to a depth of 50mm from where the new mortar will finish.
- Remove all loose material from the joints with a soft brush.
- Clean joints by flushing out with water from the top down, using a hose or a watering can. Do not power wash. Compressed air or a leaf blower may be used as an alternative to water.
- Leave overnight before pointing, to ensure water has drained from the joints.



Plate 4: Joint ready for raking out of defective mortar.



Plate 5: Raking out a horizontal joint using a plugging chisel.

5.2 Salvage of stones and pinnings

Collect the small, loose stones (part of the mortar) and the pinnings from the removed mortar on the groundsheet (Plate 6).



Plate 6: Pinnings and material raked out from the horizontal joint collected on the clean groundsheet.



Plate 7: The same raked-out material washed for re-use in the repointing. The salvaged stones will help to decide the size of aggregate required in the mortar generally.

Set the salvaged stones aside and keep (in water) for re-use in the repointing of the same area (Plate 7).

Unfortunately, the good practice of salvaging stone from raked-out material is not yet standard on historic sites. In most cases no groundsheet is used and the stone and pinnings are trampled into the grass and lost. The masonry is then repointed with a lime/fine aggregate mix, which completely alters the character of the structure (Plates 8–9). This approach is not acceptable when repointing an archaeological monument or historic structure.



Plate 8: Note the difference between the unsatisfactory new pointing on the left and the original mortar to the right. There is no coarse aggregate in the new mortar, resulting in a loss of the character of this structure.



Plate 9: This is a poorly repointed wall; no pinnings have been used in the mortar and there is no exposed aggregate. The character of the structure has been lost.

5.3 Mortar

Lime mortar is made from aggregate, that is, sand graded from fine to coarse (small stones), mixed with a binding/setting agent (lime) and water.

Lime comes in a number of different forms. The type of lime to be used in mortar on a particular archaeological monument or historic building is a matter for the specifier on each site and is not considered in this guidance document, however specifiers should be aware of how different types of lime affect the visual character of the monument. The only type of lime that is not suitable for this type of work is hydrated lime, commonly known as 'White Rhino.'

The choice of aggregate will affect the visual character and performance of the mortar. This is also a matter for the specifier and not considered in this guidance document.

The grading of the aggregate for each site (Plates 10–12) will also be specified after work on a sample area is complete (see section 7: Sample area, below). The aggregate for mortar for this type of rubble masonry can be graded from 10mm down, and it is coarser than stonemasons are accustomed to using when working on more modern buildings or structures.

Coarse aggregate should be of naturally formed stone such as river or pit gravel, never crushed stone.

The actual mortar mix and proportions for each specific site will be decided once the sampling (section 7: Sample area) and the measuring exercises (section 8: Deciding on the correct lime to aggregate proportions) described in this guidance document have been completed



Plates 10–12: Sample sand 5mm and smaller (left), and samples of different grades of aggregate (centre and right) that can be combined to achieve the correct mortar mix depending on the requirements as determined from the sample area.

5.4 Mixing when using lime in powdered form²

- Measure quantities carefully.
- Use a bucket or other container with volume marks.
- Never use a shovel as it is not accurate enough.
- Mix as follows:
 1. Add 1 part aggregate to the clean, dry mixer.
 2. Add 1 part lime and begin mixing.
 3. Add the remainder of the aggregate, usually 1.5 to 2 parts (according to the specified mix).
 4. Mix dry until the colour is consistent.
 5. Add water very slowly until the required consistency is reached.
 6. Err on the side of a drier mix. Use as little water as possible. Stiffer mortar works better.
 7. Mix for a minimum of 20 minutes after the addition of water.
 8. As the mortar continues to mix it will become more 'fatty' or workable.

When using hydraulic powdered lime a standard drum mixer will do, but it should mix for more than 20 minutes. The workability will be enhanced by allowing the mixed mortar to rest for 15 minutes before re-mixing for a further 5 minutes.

² This procedure is not applicable to hot lime mixes.

Note: The standard drum mixer does not work as well with lime putty. A mortar mill is more suitable when using putty.

5.5 Pointing

Do not work with mortar in cold weather (below 5 degrees Centigrade). Lime mortar is slower to set; if it freezes before setting it will never achieve a set. Be careful of, and protect against, cold or strong wind, which can reduce temperatures even further. Other extreme weather conditions such as hot, dry spells or heavy precipitation may also affect the setting of mortar.

1. Dampen the joints to be pointed by misting lightly with water using a hand-held spray (Plate 13).
2. Fill the joints in steps, depending on depth, dampening each time (Plate 14).
3. Where joints are empty, begin by backfilling, applying the mortar in steps of 20mm or so.
4. Leave the mortar to take a set after each step. This will help to avoid shrinkage.
5. Compact the mortar by ramming it back with a steel flat or short lengths of timber lath.
6. The final application of mortar should contain the larger stones selected at sample stage.
7. Leave the final application of mortar slightly proud of the face of the stone for 'beating back' (see section 4.6 Finishing).
8. If joints are big and wide, insert pinnings to reduce the size of the joint (Plate 15).
9. Protect the mortar at each stage as soon as it is placed (see section 6 Aftercare, below).



Plates 13–15: Dampening the joint, filling using a pointing iron and small hawk; inserting pinnings by tapping into place.

5.6 Finishing

1. Allow the mortar to stiffen and take a good set, usually overnight.
2. Finish the next day by 'beating back' with a stiff-bristle brush (Plates 16–17), striking the joint with bristles at right-angles to the face of the wall.
3. 'Beating back' or 'tamping' compresses the mortar, exposes the aggregate in the mortar and exposes the edges of the rubble stone.
4. Exposing the aggregate tones down the brightness of the new mortar (Plate 18).
5. If a stiff-bristle brush is not sufficient to clean stone, use a bronze or brass brush. Never use a wire or steel brush. These will damage the stone and cause ferrous staining.



Plates 16–17: Beating back in progress.



Plate 18: Fresh mortar below the white line. Mortar above the white line has been beaten back to expose aggregate, pinnings and the edges of the rubble stones.

6 Aftercare

1. Protect the mortar from sun, wind, rain and danger of frost, to allow slow setting.
2. Use hessian (not polythene) kept damp by spraying (Plate 19). Maintain a gap between the hessian and the wall.
3. In cold weather add an insulating material such as foil-backed fibreglass roll, with the foil to the outside protecting the mortar from rainfall.
4. Allow for a minimum of seven days' protection. Weaker mortars may sometimes need longer.



Plate 19: New mortar with slate pinnings, 'beaten back' and showing aggregate. Protective hessian in place, to drape over and protect the new work.

7 Sample area

Before work begins, the design team, together with the contractor, will select a sample area (2–3 m²) of the masonry on site for raking out and repointing. The approved pointing sample will be maintained on the site as the standard to be met in the remainder of the pointing work (Plate 20).

The sample will also be used to decide the mortar mix. The raked-out material from the sample area will help to establish the composition and grading of the aggregate in the existing mortar. A sieve analysis of the mortar may be necessary, so that the texture of the replacement mortar will match the original as closely as possible.

The contractor should provide samples of different sizes/types of aggregate to try in various mixes, in order to find the closest match to the original mortar. In deciding the mix, a member of the design team will liaise with the stonemason who will be doing the contracted work on site.

The stonemason will rake-out, prepare the sample mortar mixes, backfill, point and finish the sample area, allowing sufficient time for the pointing to take a set and be finished.

Details of the location of the sample, the lime used, the grade of sand and the coarser aggregate added, as well as the sources of these materials, should be recorded for reference in future work and included in the final report on the project.



Plate 20: Agreed sample of new mortar and pointing. Surviving mortar to the left of the black line and approved new work to the right.

8 Deciding on the correct lime to aggregate proportions

- Lime is the binder that holds the aggregate together. The proportion of lime in a mortar will be specific to the aggregate mix selected.
- Good mortar is made when the lime fills all the voids in the aggregate. So, the correct proportion of lime to a specific aggregate is decided by measuring the voids in the selected aggregate.
- The following simple measuring method uses two graduated glass containers: one for the selected aggregate and the other for water.
 1. Fill one container with the dry aggregate (dried in an oven or microwave) to a mark of 400ml (Plate 21).
 2. Tap the container to settle the mix down to the mark.
 3. Fill the second container to the 400ml mark with water.
 4. Add the water into the aggregate container slowly, until it comes to the top of the material at the 400ml mark (Plate 22).
 5. Note how much liquid now remains in the water container.
 - If 240ml of water is left, then 160ml was needed to fill all the voids in the aggregate. Therefore, the correct lime to aggregate mix in this case would be the equivalent of 160:400, or 1:2.5 (Plate 23).
 - If 270ml is left, then 130ml filled the voids and the lime to aggregate mix will be 130:400, or 1:3.
 - If 100ml is left, then the mix is 100:200 or 1:2.
- This exercise is best done in the contractor's yard and not on site.



Plate 21: Two graduated containers filled to the 400ml mark, with water on the left, and dry aggregate mix on the right.



Plate 22: Water added to the aggregate container until it comes to the top of the aggregate at the 400ml mark.



Plate 23: 240ml of water is left in the container, so 160ml was required to fill the voids in the aggregate. The lime to aggregate ratio for this selected aggregate is therefore 160:400 or 1:2.5. It will vary with other aggregate mixes.

9 Exceptions

There are a couple of exceptions to the foregoing guidance:

1. This guidance is aimed at the repointing of rubble masonry in archaeological monuments and historic structures. In some structures, where architectural elements survive (for example, door or window surrounds of carved stone with fine joints; see Plate 24), an exception arises. In such a case, the approach to repointing must be appropriate to the feature. The raking-out tools will be finer, such as a hacksaw blade, Rawl tool or hoof pick, and the mortar will have no coarse aggregate.
2. Generally, electric (or power) tools should never be used. In the case of a structure with hard cement-based pointing, however, removal by hammer and chisel may cause damage to the stone. This risk might be reduced by a skilled and experienced mason drilling holes at close intervals to break up the mortar, before its removal using a plugging chisel. Every care must be taken to avoid damage to stones.



Plate 24: Window surrounds with fine joints and fine mortar, in comparison with the coarser mortar elsewhere on the structure.

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