Remedial Conservation Works on Scheduled Masonry Monuments:

Work Practice Guidelines

1. General Guidance

This guidance note details the procedures and methodology to be followed in remedial conservation works on historic masonry monuments, and is based on internationally agreed principles and standards, current research and recognised best-practice.

It should be understood that this work is very labour intensive. Repointing an area of modern masonry, using modern methods, will take considerably less time than repointing the same amount of area of a historic structure, using traditional methods. **Time-scales based on modern methods should not be imposed on conservation works**. Realistic assessment of the correct use of the materials and the procedures involved will permit more accurate time-estimation and budgeting for the work.

Every ruin is unique. Although the specifications will attempt to mitigate for unknown circumstances as far as is practicable, often many aspects of the monument in question will only come to light as works progress. Details of specifications may have to be amended in the light of developments, and mortar mixes may be altered when initial performance is observed.

It is preferable that the same team remains on the job to its completion, as it takes time for a team to become familiar with the materials and techniques required for each specific site. This is essential in the case of the site foreman, as earlier discussions with EHS will need to be brought to bear on later work.

2. Purpose and Approach

All historic masonry monuments are unique. Although falling into a broad range of defined types (e.g. churches, castles, towerhouses), the history, setting, construction, and later ruination of each will be individual to that site. Every building tells a different story, and the physical fabric holds historical information that careful analysis and recording will help to illuminate. Historic masonry structures should be treated as (albeit large) archaeological artefacts, and are subject to rigorous recording, study, and conservation needs as smaller objects.

Conservation works to scheduled masonry monuments follow three main principles:

i) minimum intervention,

ii) clarity of new work, and,

iii) reversibility.

i) Minimum intervention

Masonry monuments have come to us in varying states of repair and disrepair. Our task is to 'hold' these monuments, that is, to stabilise them and slow down the deterioration of their structure as far as is practicable. The greater the intervention to a monument, the more its historic integrity is compromised, and less original material is therefore left untouched. A masonry ruin should not look very different after conservation works except that the fabric is more stable and secure.

ii) Clarity

All efforts must be taken to ensure that necessary new work on historic structures looks appropriate and is in keeping with the fabric, materials and style of the original work. However, it should be possible to 'read' changes to a wall, both modern and historic, through close inspection. There is no single, best method of demarcation of new work, as the style of the original fabric, the nature of the new work, and the overall appearance and visual setting of the monument must be considered. How to indicate new work is therefore a matter that must be discussed with EHS on site, to arrive at the most suitable, practicable method for each monument.

No important architectural features, later changes, or other features of the monument should be masked, including original mortar, where this is sound.

iii) Reversibility

Any necessary intervention to a monument should always be reversible, both in the materials used and methods employed. This will ensure that, should better materials or methods come to light in the future, or if it is later realised that the intervention was unsuitable, then new, modern work can be taken out. This

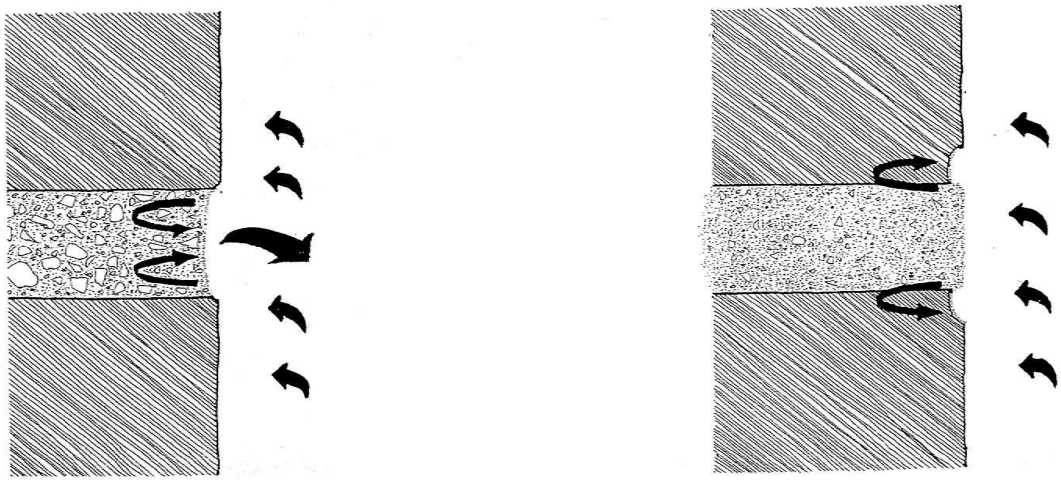
reversal will be helped by the detailed records made at the time of the intervention (see section 11 below).

3. Reasons for Lime Mortar.

Historic, traditionally-built structures are very different from more modern buildings, both in the materials that were used, and the techniques employed in construction. Therefore, the materials, techniques and approach used in modern buildings are not suitable for use on historic structures, and can, in fact, cause serious and irreparable damage to such monuments.

The most important material to be used in remedial conservation works on historic structures is lime mortar. This has several advantages over the use of cement.

Traditionally-built structures were never designed to be completely waterproof. Rather, the joints between stonework, and renders applied over it, acted as the 'lungs' of the building, allowing moisture to be absorbed and evaporated. In order for this to occur, mortars and renders needed to be more permeable than the stone that it surrounded, so that the moisture followed the easiest route both in and out of the building. Lime based mortars and renders were always considered to be the sacrificial elements of the building. Lime mortars and renders were also more flexible. Masonry set in lime mortar allowed movement within joints, both in the settling of the structure, and the small movements associated with seasonal thermal variations, without significant damage occurring to the overall structure.



Using a lime-based mortar: moisture penetrates and evaporates through the mortar, the easiest route. Over time the face of the mortar weathers back from the wall.

Using a cement-based mortar: moisture penetrates at the interface of the stone and the joint and evaporates through the stone. The face of the stone weathers back, leaving the harder mortar sitting proud of the eroded masonry face.

Illustration based on that found in *TAN 1: Preparation and Use of Lime Mortars*, see section 15

In comparison, cement mortars are much harder, denser and more rigid than lime-based ones. They are impermeable, so if used on soft, 'flexible', permeable buildings, moisture must enter and exit through the stonework instead of the joints. This often results in frost action damaging the arrises of the surrounding stones, as well as damage from salts that are leached out of the cement during it's setting. Eventually, the entire faces of particularly soft stones can spall off, leaving bands of the harder cement mortar sitting proud of the eroded stonework. Cement mortars do not allow minor structural movements in the building, which can result in cracking and more severe faulting in the walls in some cases. Therefore, cement-based mortars can cause, or accelerate, stone decay, and use in historic structures is inappropriate.

Unfortunately, the skills and knowledge of working with lime have been lost to a significant degree, as building over the past 100-150 years has been largely based on the use of cement. Lime based mortar is significantly different from cement based mortar, and methods of preparation, use and care of lime based mortars is very different from that of cement. Lime mortars are also much less

tolerant of poor site practices. Therefore, an understanding of the material and how to work with it is essential, otherwise the mortar will fail.

Two types of lime can be specified for remedial works on historic monuments: **lime putty** ('fat' lime) and **hydraulic lime**. Mortars based on lime putty set due to the slow process of carbonation, and if the masonry is well prepared, and the mortar is applied and cared for properly, it will become progressively stronger over time. Hydraulic lime contains clay minerals derived from the original limestone. These minerals produce a chemical set, as well as carbonating over time, and are more suitable for wetter, exposed situations. It is possible to give putty-based mortars a slight chemical set by the addition of a *pozzolan*, often either china clay or brick dust. If appropriate, this will be specified in the mortar mix.

What is commonly known as 'hydrated' or 'bag' lime should not be confused with hydraulic lime, and is not suitable for use on historic masonry monuments.

4. Aggregates

The main aggregate in lime mortar is usually sand, although clay, crushed shell, crushed brick and others were historically used in many cases. The aggregate in a mortar can be up to 75% of the total mix, so choosing the correct type and balance of aggregate is crucial to the workability, performance and therefore success of the mortar.

- Sand should be already washed clean of very fine particles of silt and from salts.
- It should be well graded, with a range of particle sizes, with the highest proportion around the mid range.
- It should be 'sharp', that is a high proportion of angular grains, which will fit closely together, producing a well-bonded mortar. An aggregate containing too many rounded grains will produce a material that is easily worked with, but will bond poorly.
- The proportion of voids in the sand should be around 33-35%, which means the proportion of lime added should be around one third of the

aggregate's compacted volume to fill all the voids and cover all the sand grains. The exact ratios will be worked out in advance in relation to the sand to be used. If not enough lime is used, then some voids will not be filled, and this will enable moisture to settle, freeze and expand during the winter, damaging the mortar. On site, a lime deficient mortar can be made more workable by the addition of water. This is very bad practice, as it will ultimately result in a weak mortar, prone to increased drying and shrinkage.

Although sands may comply with the relevant British Standards, the grading of these sands is quite wide, and a sand passing the British Standard may not necessarily be suitable for making a good lime mortar. Therefore, sand should not be selected solely on compliance with a British Standard.

EHS carries out aggregate analysis of the mortar in advance of conservation work, to determine the type of aggregates used in the original mix. This will then be used to help source a similar sand in colour and appearance, so that repointing work will visually complement the ruin as far as possible. In the past, sands used in lime mortars were usually locally sourced, and the same aggregates may not be now available, so 'best-fit' aggregates are chosen. Historically, other organic additives were also used to improve the performance of mortars, such as hair, urine, beer and blood. These will not necessarily be apparent now. It is not possible, and not necessarily advisable, to try and match the original mix completely. Today we are asking masonry ruins to do something they were never designed to do: that is, stand exposed to the elements, usually without a roof, protective rendering, and often without the linked structural support of all the walls, which have often been robbed away in the past or fallen. The decisions taken regarding the mortar mix must be based on what is known about the building, its current condition, exposure and the availability of materials.

5. Mixing

Accurate and careful measuring of the specified ratio of materials is crucial to the success of the mortar.

Lime putty mix:

This should preferably be mixed in a traditional roller pan mixer, which compresses the binder (the putty) with the sand. This should be done for at least half an hour, until the sand grains are completely covered and evenly distributed within the putty. **No water should be added**, as the putty will already contain enough water, which is progressively released as the mixing continues. It is preferable to store lime putty mortars after initial mixing for around 12 weeks, to allow the mortar to properly mature. It will then require knocking up (below).

Hydraulic lime mix:

This can be mixed in a conventional rotary drum mixer, aided by 2-3 large (clean) stones to help the compression of the mortar as it is turned. The drum should be as horizontal as possible, to reduce the likelihood of improperly mixed mortar gathering at the back of the drum. The hydraulic lime powder should be mixed with the specified amount of aggregate in a dry state, **adding a little water at a time**, to ensure that excess water is not accidentally added. Excess water will weaken the mix and increase shrinkage. The mortar should be mixed for a **minimum of 20 minutes**. The more the mortar is mixed, the more workable it will become. If bucketed and brought to the wall but not used immediately, extra compressing in the bucket with a block of wood will help achieve maximum workability when it is about to be used.

Knocking up:

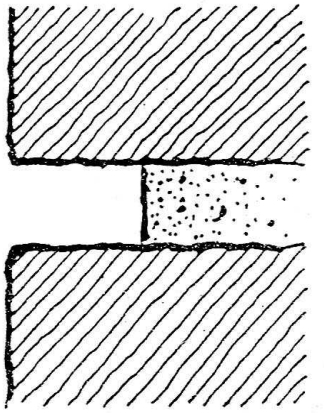
Lime mortars will stiffen up (especially in storage) and initially appear too dry. Knocking up in the mixer will bring the mortar back into a workable plasticity without the addition of extra water. Pozzolans, if specified, or other specified additives (such as hair), should be added at this stage. Mixing with water, rather than knocking up, or not mixing for a proper length of time, are thought to be significant factors in the poor performance of lime mortars. When ready for

use, good lime mortar should have a consistency similar to modelling clay. It should stick to the surface of an inverted hawk or trowel - if it doesn't, it is too wet.

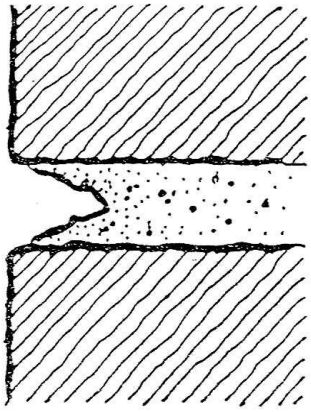
6 Preparation of Masonry

This is essential for the success of a lime mortar. (All vegetation must have been removed in advance, see methodology in the EHS guidance booklet *The Treatment of Vegetation on Scheduled Masonry Monuments*).

All loose, powdery and decayed mortar should be raked out. Traditional lime mortars are often soft, and soft mortars should not be mistaken for decayed mortar. Joints must be cut back to an even surface. It must not be feathered off at the ends into old work, which would result in voids occurring between the old and new mortar leaving it liable to frost damage. This would also reduce the key of the new work onto the old work.



A clean square joint creates a good key for new mortar



A v-shaped joint provides a poor key for repointing

Illustration taken from *Lime: A Guide to the Use of Lime in Historic Buildings* see section 15.

Areas to be pointed, capped, or where replacement stones are to be set, must be **thoroughly washed out clean**. Dust and loose material within joints prevents the mortar from forming an adequate bond to stonework. Cleaning should never be done under high pressure.

Before new mortar is placed onto a wall, **the masonry surfaces that will come in contact with the mortar must be dampened down**. If this is not done, the

dry stonework will suck all the moisture out of the new mortar, it will dry too quickly, and fail. Adequate dampening will also reduce lime staining on the surrounding wall face. Stonework should be damp to the touch, but not dripping wet. If excessively wet, the mortar will not dry out at all. The amount of preparatory wetting required will depend on the type of stone. Very porous stone such as sandstones or old brick will require a lot of wetting, as they will readily absorb a great deal of moisture; less porous stonework such as granite or basalt, will require much less. Excessive wetting in these cases will result in additional water being added to the mortar which will weaken its bond with the masonry.

7. Repointing, Tamping and Pinning

Repointing:

Mortar should be placed on a hand-held hawk (or trowel), held against the wall below the joint, and a small wedge of mortar scooped onto a pointing key and pushed into the joint. Firm pressure is needed to compact the mortar, there should be no gaps behind the new mortar. Mortar should be brought out to the wall face, and left overnight to make an initial set.

Deep Joints:

Very deep joints will need to be tamped out in stages. This involves the compaction of mortar deep into the joints using a tamping iron or a block of wood. **The mortar must always be thoroughly compacted**. This should be done in roughly 5cm stages, and left until the next day before the next layer of tamping, or final repointing is carried out. Walls with internal voids may need to be grouted at a later stage.

Pinnings:

It is not recommended to fill very deep or wide joints with large areas of mortar alone, as this will reduce the set and encourage increased shrinkage. Small slivers of stone known as ‘pinnings’ can be inserted into joints to reduce the overall area of mortar, and therefore the amount of mortar needed. Loose pinnings may be already present in the wall. During the raking out and cleaning process, they should be taken out and placed back in or as close as possible to

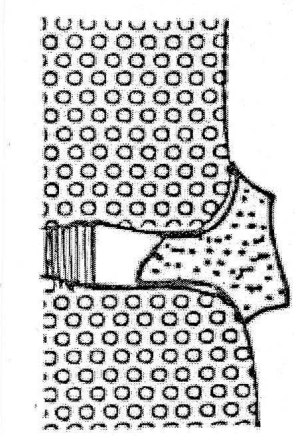
their original positions in the wall, awaiting repointing. Loose stones on the ground surface can sometimes be used for additional pinnings (should more be required), but this will always be detailed in the specific site works specifications. As a general rule, the style and amount of pinnings on repointed areas should follow the style of the surrounding masonry. Pinnings can also be added to the deeper areas of joints at the tamping stage, to fill out a joint, but can be mortared over completely so they are not seen on the finished wall face. **It is essential that pinnings also are soaked in a bucket of water before they are placed into the wall**. The soaking time will depend on the porosity of the stone. Dry pinnings will suck moisture out of the mortar in the same way as larger, dry masonry, and will make the mortar liable to failure.

Finishing:

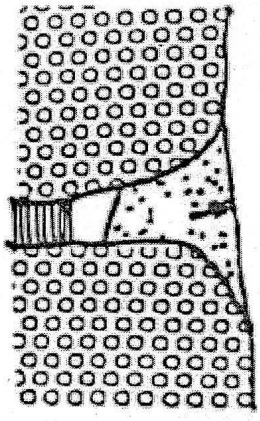
Once an area has been repointed it should be kept damp (see section 8 'After-care' below) and left to make an initial set overnight. The following day the mortar should be ready for finishing, when it has hardened up enough so that a fingernail pressed onto the surface barely leaves an impression. **The mortar should then be pressed and compacted further into the joint, ensuring that there are no gaps at the back and producing a good seal with the masonry**. Any small, localised cracks that have formed as the mortar has begun to dry can be pressed out at this stage, when it is still workable to do so. Early shrinkage may be caused by too much water in the mix, or by failure to compact the mortar as it starts to stiffen up. Tell-tale signs of this are hairline cracks along the surface of the mortar, or the slight separation of the mortar from the adjacent stonework. Left unchecked at this stage, these will allow water to penetrate the inside of the wall, and accelerate its deterioration.

The joint surface should then be beaten with a **churn brush**. This helps the compaction and also brings out the texture of the mortar. It also helps to remove feather edges of the mortar from the surrounding stone surface, and reveals the shape of the stone. The mortar should not be brushed along the joint, as this will leave unsightly brush marks. Joints appearance should be in keeping with the surrounding original work, but in general should be slightly recessed from the surface of the stone. This means that it is the stone that

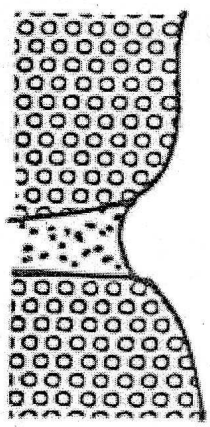
assumes the primary visual role, not the joint, and in the case of naturally weathered or spalled arrises, the newly repointed joints do not appear wider than they were originally.



Mortar is poorly placed. It has been placed over the joint rather than in it. It has not been compacted and does not have a key to the old mortar behind. The mortar on the face is masking the shape and style of the original joint.



Mortar is poorly placed. Again, it has not been properly compacted and it masks the shape of the joint, giving the appearance that the original joints were much wider than they actually were.



Mortar is correctly placed. The joint was properly prepared in advance, properly keyed in to the older work. It has been sufficiently compacted, with a churn brush finish. It is slightly recessed to give prominence to the stonework and the original style of the joints, the arrises of which have now weathered.

Illustration based on that found in *Historic Buildings Technical Note No. 37: Repointing of Stonework* see section 15.

8. After-care

The importance of making sure that the mortar dries out slowly cannot be over-emphasised. If it dries out too quickly, it will become crumbly and friable and fail. If the mortar starts to turn very white, then it is drying out too quickly, and the lime is being drawn out to the surface as water evaporates. **Work that has dried out too quickly cannot be revitalised later by wetting, and will have to be redone**.

To ensure slow drying, it is necessary to keep all new work damp. This can be done by mist spraying at regular intervals, and covering if necessary with damp hessian and polythene sheets. These covers should not come in contact with the wall surface, as this will prevent air from circulating and the mortar from

drying at all. The hessian and polythene can be secured on the ground, or on the scaffolding, with stones. It is important to make sure this does not create a wind tunnel which will accelerate drying, and that the edges of the covers are carefully secured, otherwise rapid drying of the edges of the new work will result. Excessive whitening of mortar indicates that it has dried too rapidly.

Lime putty mixes will require up to 14 days of after-care in this fashion. **Hydraulic mixes will require 5-10 days**, although both estimates must take into account the weather conditions at the time of the work. Hot, sunny, or windy weather will accelerate drying, and so particular care must be taken in these conditions and new work must be adequately protected. Mild, calm, slightly damp conditions are, in fact, optimum for the curing of lime mortars. More attention must be given to dampening and covering in advance of weekends or holiday periods, and the work schedule on site should be organised with this in mind. It is important to ensure that scaffolding is retained in place long enough to carry out the after-care process, even if the rest of the site works have been completed. Premature removal of scaffolding, and subsequent lack of proper aftercare of the new mortar, will increase the liability for the mortar to fail and will result in the much greater expense of having to do the work over again.

As temperatures fall, the speed at which lime mortar sets decreases, with minimal setting at temperatures below 5°C. Frost is a real threat to the success of lime mortars, particularly lime putty mixes, for up to 12 weeks after application. For this reason, it is crucial that work with lime mortar must only take place during the summer months, usually April – September, and that mortar is provided with the best start possible with proper preparation, application and after-care.

9. Wall Head Capping

Wall heads are the most exposed of all the areas of historic masonry and are often broken, filled with significant depths of soil and debris, and have large tree or ivy roots growing in them. It will often require a significant amount of time to properly clean out a broken wall head. This is sometimes the most difficult and

most time-consuming part of the remedial works on site, particularly if it is carried out at height. As it is the most exposed area, the specification will often detail a stronger mortar mix for this area, or in cases of walls containing very soft stone, the addition of a pozzolan.

Often a considerable amount of stonework and core mortar has been lost from the top of the wall, and this may require the addition of other stones to fill voids and seal the surface of the wall head. Large areas of mortar must be avoided, as detailed in section 7. The procedure and after-care of the mortar of the wall head follows the same methodology as that detailed for repointing work; even more attention to the after-care of this area of the ruin is advised.

It is the ultimate goal to retain the shape of the wall head as closely as possible to how it was found. If it was found with a ragged, broken and uneven profile, then every effort must be made to keep this, while capping the wall in such a way that water runs off the wall head, and does not pool in localised hollows on top of the wall. This is an exceptionally skilled job, which requires a great deal of thought and careful execution on the part of the stonemason. . The constructional appearance of the wall head must also be retained as far as is practicable, without compromising the overall protection of the core of the wall beneath.

10. Tools

As work with lime mortars is very different from modern building work, it requires specific, specialist tools to carry out a proper job. These must never be seen as merely ‘desirables’, as work carried out with inappropriate tools will result in a substandard job being carried out, and reduce the chances of success of overall success. The **necessary** tool kit comprises of:

- Pointing keys, varying widths: these are essential, as plasterers leaves or pointing trowels are too flexible, and will not give proper, firm compression into the back of the joints.
- Tamping irons, varying sizes: a block of wood can occasionally be substituted instead.

- Churn brushes: ordinary hearth brushes often have bristles that are too soft, or often moult. Churn brushes are sufficiently coarse and stiff for this job.
- Hand-held hawks.
- Tungsten-tipped chisels or quirks with a channelled blade: careful and experienced use of these will help to ensure stonework, particularly the arrises, are not damaged.
- Lump hammer.
- Hoof-picks/ bent metal spikes/ other custom-made items to clean out difficult joints.
- Hand-held plastic spray bottles (these are useful for the after care of small areas) and / or a hose with a fine mist sprinkler nozzle.

Examples of tools used in conservation works to scheduled masonry monuments.

11. Recording by EHS

As stated in section 2, historic masonry ruins are large archaeological artefacts, and are treated as such. This means that comprehensive recording of the structure before work commences is essential. This takes the form of photographic, drawn and written records, and will usually form the basis for the conservation works specifications. As work is carried out, all interventions, both major and minor, are recorded by EHS, to provide a detailed record of the new work, both in photographic and written form, as the new work will weather in and become less distinguishable over time. This accurate record of the new work also serves to make the work completely reversible (as outlined in section 2), which can be removed at a later date without risking unintentional disturbance or removal of original work.

Stonework should never be dismantled without prior approval. Should temporary dismantling of loose stonework be necessary, it will be recorded by EHS using a plastic sketch-drawing frame, the individual stones will be numbered, and then may be taken down and carefully stored for resetting. The dismantled stonework will then be rebedded accurately in its original positions, using the sketch frame as a guide.

Illustration of the frame used to record stonework prior to dismantling. The position of the masonry and the profile of the wall is accurately sketched onto the plastic. The stones are numbered on the sketch and then correspondingly numbered as they are taken down. The frame is then used as a guide to rebed each piece of masonry in its correct position.

12. Sample Panels and Checks

EHS shall usually ask for sample panels of pointing to be undertaken in advance of the main body of work. This will allow for detailed discussion and agreement on the appearance, style and technique to be used on the ruin.

EHS will also spot-check a selection of joints as the work progresses, by asking the mason to cut them out, to check whether the joints have been properly cleaned, prepared and filled. Contractors and site supervisors should be aware that this will be a standard request from time to time.

EHS reserves the right to insist that unsatisfactory work, whether in terms of style, appearance, application, or treatment and after-care shall be cut out and redone to an acceptable standard.

13. Health and Safety

Working practices with lime mortars will generally fall within the scope of the *Health and Safety at Work (Northern Ireland) Order, 1978*, and specifically the *Control of Substances Hazardous to Health* [COSHH] *Regulations (Northern Ireland) 2003*.

Lime products should be handled with care. They are a caustic alkali and are irritant or drying to the skin and particularly dangerous to the eyes. Lime is considered a hazard, and as such, must be risk assessed, and personnel working with lime should be informed of the findings of the risk assessment.

Hazards:

- Skin contact: avoid skin contact wherever possible. Especially in warmer weather, shaven parts of the face and neck are liable to irritation.
- Eye contact: lime dust in the eyes is extremely painful and may cause damage.
- Inhalation: inhaling lime dust may cause throat irritation.
- Ingestion: slaked lime is likely to cause irritation of the gastro-intestinal tract if swallowed in large doses.

Personal Protective Equipment:

- Wear clothes that provide maximum skin cover.
- Wear protective gloves. In wet conditions, or where the hands may come into contact with lime putty or milk of lime, waterproof gloves should be used.
- Use a barrier cream on the hands, wrists and exposed areas of the skin.
- Use eye protection when working with lime based materials overhead.
- Wear goggles to prevent lime entering the eyes. Full, wide-vision goggles with anti-mist properties are preferred.

- Wear a dust mask when exposed to lime dust. A dust mask consisting of gauze-covered aseptic cotton wool filter pads, held in a wire frame with a headband, is effective for protecting the mouth and nose.

14. Scaffolding

All access scaffolding to be used must be erected, inspected, adjusted and dismantled in accordance with current Health and Safety Legislation and Approved Codes of Practice.

All access scaffolding to be used must be of a free-standing, self-supporting nature, i.e. 'retention scaffolding'. Scaffolding should be erected in a manner which is not reliant on a monument for stability. The scaffolding must not touch, lean on, or use the historic structure for support (or leverage) at any time. No compression ties or reveal ties are permitted without prior approval from EHS.. Through ties may be permitted through window openings, ONLY if the scaffolding does not come in to contact with the masonry at any time.

15. Further Guidance

This guidance note was produced with the assistance of these publications, which can be referred to for further detail and advice:

Environment and Heritage Service 1992 *Historic Buildings Technical Note No. 45: Masonry Walls.* Department of the Environment.

Environment and Heritage Service 1990 *Historic Buildings Technical Note No. 37: Repointing of Stonework.* Department of the Environment.

South Somerset District Council. date unknown *Lime: A Guide to the Use of Lime in Historic Buildings.* South Somerset District Council, reproduced by E.M. Byrne at The Traditional Lime Company.

The Scottish Lime Centre. 2003 *Technical Advice Note 1: Preparation and Use of Lime Mortars.* Revised Edition. Historic Scotland.