

## Lime Mortars and Renders

Historic Scotland advice: *'It is always better to leave masonry untouched rather than treat it incorrectly'*

**Please Note: No responsibility is accepted for errors or omissions. This Guidance Note merely provides an introduction to the principles of working with lime and should not be viewed as a comprehensive guide. Each building will need separate consideration and if in doubt expert advice should be sought at the outset.**

Why use lime?

*'Unlike modern products, lime-based materials let structures 'breathe' and move gently – essential properties with old buildings. They also contribute to their characteristic soft texture. Despite these advantages, building with lime is a slow process that demands skill and patience. This led to the widespread use of alternative materials, including Portland cement, gypsum plaster and plastic paints. It is apparent that these have shortcomings of their own and can seriously harm historic fabrics. Consequently, lime is enjoying a revival.'*

Douglas Kent, Technical Secretary - Society for the Protection of Ancient Buildings

*Regrettably masonry buildings have been constructed or repaired over the past century or so using inappropriate mortars and surface treatments resulting in a legacy of stone decay and water penetration problems.*



Photo of damage by incorrect cement pointing to an historic building in Lerwick (photo by A Taylor)

### What is lime?

*'The word 'lime' refers to quicklime or slaked lime, widely used to form the binder for mortars, plasters, renders and washes prior to the mid-19<sup>th</sup> century. Quicklime is produced when limestone is heated in a kiln. Slaked lime is obtained when this is then combined with water to create a putty (stored in tubs), hydrate (bagged powder) or, where the reaction takes place in sand, 'dry-slaked' mix. Lime-based products harden by absorbing carbon dioxide to revert back to calcium carbonate ('carbonation'). Chemically, this is the same as the original limestone, hence the term 'lime cycle'.'* - Douglas Kent

*"The exclusive use of Portland cement mortar can only indicate ignorance of the qualities of many natural hydraulic limes, and this want of knowledge is dearly paid for"*

C Graham Smith Stud Inst CE 'Engineering Papers' 1895

Lime is Calcium Carbonate that, when burnt and slaked with water, forms putty. Mixed with aggregates it produces a traditional mortar, render or harl. Lime mortar carbonises with air and allows the masonry and plaster to breathe and remain flexible. Cement, on the other hand, has a chemical set resulting in a hard impervious material, which can damage soft

stone and brickwork. Lime is a natural material requiring less energy to convert and, if kept airtight, can be stored indefinitely.

Mortars and pointing should always be weaker than the stone (brick or block), because if there is structural movement it will usually move or crack along the joint. All buildings move; hard strong, dense cement based mortars generally crack through the masonry, which makes buildings with such mortars harder to repair. Also, buildings with modern masonry need to have expansion joints due to the inflexible nature of cement mortar. Re pointing stone with harder cement mortar does not allow the building stone to dry causing deep-water penetration and masonry decay. This is due to the masonry being softer than the harder mortar, which is not able to 'wick' (the ability of the building fabric to transmit moisture vapour which can evaporate out of the stonework) allowing the building to breathe.

This breathing form of construction is common in most solid walled older buildings and is being used again in the 21<sup>st</sup> century as we are again becoming aware of the need for conservation of natural resources and the energy embodied in buildings construction. As with breathable wind proof membranes in modern outdoor clothing, the house is another layer of protection against the elements, it needs to breathe to stop condensation and damp.

Building techniques of the 20<sup>th</sup> century (including cavity wall construction that incorporate vapour barriers in the construction and the use of impermeable materials from insulation, cement render to paint) will cause problems if the building is not sufficiently ventilated. Problems such as internal condensation, mould growth may lead to Sick Building Syndrome or asthma in children. The mixing of inappropriate materials or unsuitable repairs such as cement based render or pointing can make damp problems worse.

### **What are the different types of lime?**

*'There are two main types for conservation work:*

- *Non-hydraulic lime: from relatively pure limestone. This hardens only by carbonation. It is classified as CL under European standards. The purest is described as 'fat', the less pure as 'lean'. Impurities in the latter impart a slight hydraulicity, but insufficient for it to be called 'hydraulic';*
- *Natural hydraulic lime from limestone with reactive silica and aluminium impurities. These have a harder set, as calcium silicates and aluminates form in the presence of water in addition to any calcium carbonate from carbonation. Natural hydraulic lime is classified as NHL 2, 3.5 and 5.' - Douglas Kent (editor; they now produce a weak NHL 1)*

### **CAUTION**

All buildings need to breathe. The most effective method is the movement of air through openings or the natural movement of this vapour through breathable walls. This movement of air can be affected by applying Ordinary Portland Cement based render or non-permeable panel. Increasing or decreasing the thermal performance of the wall, for example by insulation, should be looked at carefully as the 'dew point' (interstitial condensation) may move and cause damp. A simple calculation should be done by a professional taking into account the high air humidity levels in Shetland and working out

the best-and worse case scenario so that interstitial condensation does not occur on the internal skin of the building.

Additional information about lime in BS EN 459-1:2001; a diagram of types with additional notes is enclosed at the rear of this information leaflet, together with a list of references.

### **Lime can be dangerous if handled or used incorrectly**

#### **MATERIAL SAFETY DATA SHEET LIME FOR CONSTRUCTION**

Regulated by Standard NF P 15-311

In agreement with the order of 03/12/92, modified by the order of 01/03/94 and the ruling of 05/01/93

According to directives 91 /155CEE.

Also GE700 - HSE / CITB up to date health and safety guidance.

### **SUPPLIERS**

If you ask for lime at a builders' merchant you will almost certainly be offered dried non-hydraulic lime sold in bags. This lime which can be used like lime putty if allowed to soak in water for a period of time, is known as 'dry-hydrated' lime or 'bag lime', it is generally considered to be inferior to lime putty. **Good quality non-hydraulic lime putty is superior and should be used wherever possible.** Non-hydraulic lime putty and dried hydraulic lime are available from an increasing number of specialist suppliers, but they are rarely available from general builders' merchants. Lime putty is usually supplied in plastic bags or tubs in which it can be stored indefinitely. The supplier should mature it for at least one month before sale, and most suppliers' also stock three-month-old putty; check the age before buying. Lime putty can be stored for years, improving all the time. A list of sources of advice and some suppliers to Shetland is listed below.

*tip A good mature lime putty is like a soft cheese and will retain its shape when tipped out of its storage vessel, it will return to a workable state when 'knocked up'!*

#### **Is lime putty preferable to hydrated lime?**

*'With hydraulic lime, there will normally be no choice. Unless a weak hydraulic lime, it will, by definition, set if stored under water as a putty, so is almost always supplied as bagged hydrate. Non-hydraulic lime, however, can come in either form. Hydrated non-hydraulic lime is the standard lime widely available in builders' merchants. Whilst this is better than no lime, non-hydraulic lime putty is preferable because it gives a more workable mix with superior plasticity and binding properties, and is guaranteed to stay fresh.'* - Douglas Kent

### **AGGREGATES**

The choice of local Shetland aggregate is important in determining the appearance and performance of the lime mortar. Aggregate adds bulk to the lime and acts as filler, helping to reduce shrinkage of the lime as it dries out. This is best achieved using a well-graded, sharp aggregate. This means that the particles are angular rather than rounded and that there is a range of particle sizes, incorporating both fine and coarser particles. Such aggregates will interlock well, the smaller grains filling the spaces between the larger ones. Aggregates where the particles are all the same size or are soft and rounded do not interlock to the same extent and will form less cohesive mortars.

A well-graded aggregate will also impart a stronger texture to the mortar than one with uniform particle sizes. The texture of the mortar should reflect the type of masonry being re-pointed. Masonry with fine joints should be pointed with a fine aggregate whereas wider

Jointed masonry usually looks best pointed with a coarser mix. Most historic mortars are composed of whatever aggregate was available locally and many have a higher proportion of fine particles than would be recommended today. Although it is usually desirable to try to match the texture of the original mortar when re-pointing care should be taken to avoid reproducing mortars, which are too fine and may not perform well.

The colour of a mortar is influenced by the choice of aggregate. However, lime tends to whiten any aggregate with which it is mixed so that lime mortars are traditionally pale cream or buff. When carrying out re-pointing or re-rendering it is usually best to try to match the colour of the original pointing rather than that of any later work. Only rarely is a strongly coloured mortar appropriate so artificial pigments are very rarely needed.

The most common type of aggregate is sand, sometimes with the addition of grit where a coarse aggregate is needed. The sand should be well washed to remove impurities such as silts; clay, salts and organic matter, which could all, affect the performance of the mortar. The sand should then be stored away from possible contamination by soluble salts, and ideally in dry conditions. It is much easier to accurately measure volumes of dry sand than damp or wet sand. Most sands swell and increase in volume when damp or wet so if damp sand has to be used this 'bulking' must be taken into account and a greater volume of damp sand will be needed for each volume of lime.

Most builders' merchants sell sand of unspecified origin and it is only by looking at it and feeling it that you will be able to assess whether it is suitable for lime mortar.

*tip if you scoop up a handful of sharp, well-graded sand and clench your fist you will feel the sand grains interlock forming a solid mass in your hand. If you do the same with soft or poorly graded sand it will feel much less solid and still feel liable to "give" in your hand. You should also closely look at the grains to see their shape.*

Crushed limestone or chalk dust is sometimes used as aggregate. Particles of chalk or limestone are more porous than sand grains and can help entrap air and water into the body of the mix aiding carbonation and producing good, durable mortars. Although stone dust was often used traditionally, it can be very difficult to use successfully. Yet, stone dust is often supplied nowadays as a very fine powder requires the addition of a great deal of water to make that a workable mix and makes the mortar more prone to shrinking and cracking. If stone dust is added it should be crushed and sieved to produce a well graded aggregate.

Occasionally other materials, such as crushed shells, kiln slag and ash were used as aggregate in traditional mortars, and these will often be evident when looking at the old mortar. However, these materials are rarely used nowadays except for very specialised conservation work. The mix should be free from sulphates (Salt or ester derived from sulphuric acid, most sulphates are water soluble) as this tends to rule out the addition of coal dust even if found in the original mortar.

## **ADDITIVES**

Historic mortars often contain a variety of substances such as milk, blood, linseed oil and tallow, which were added to alter the mortar's properties. However, the benefit of some of these additives is questionable and nowadays such additives are only used in exceptional circumstances and following detailed analysis of their effects

Many modern mortar additives are available on the market but most of these are either unnecessary or unsuitable for use with lime mortar. Plasticisers are NOT needed, as lime mortar is naturally extremely workable. Accelerators or antifreeze additives can introduce harmful soluble salts into historic masonry and should NOT be used in mortar for historic work. If lime mortar must be used during periods of frost-risk the work should be protected from freezing until it has carbonated. Water barriers such as silicate washes and water impermeable/rain proof paint are also **unsuitable** for lime mortars as they reduce the ability of the mortar to breathe and thus reduce one of the greatest advantages of using lime mortar.

Certain materials, known as pozzolanic additives, may be added to lime mortar to accelerate its initial set and also to increase its durability in exposed locations. The most commonly used pozzolans are brick dust made by crushing and sieving soft, under-burnt bricks; volcanic ash called 'trass'; and calcined china clay (Calcined Lime (Calcium Oxide)) sold under the name of Polestar or Metastar. Lime mortars are frequently gauged with ordinary Portland cement or white cement to speed up the initial set, **however**, recent research has suggested that the addition of small quantities of cement may actually weaken the mortar and it is better to avoid the use of cement in lime mortars at all i.e. **NO Cement!**

Although pozzolanic additives can be extremely helpful their use is usually best restricted to the more specialised conservation projects. In many circumstances a simple lime mortar will perform perfectly well and be remarkably durable provided it is properly mixed and applied and allowed to dry out slowly and carbonate properly.

Non-hydraulic lime hardens by a slow process of carbonation, reacting with atmospheric carbon dioxide over a period of weeks. Hydraulic limes and cements set rapidly by reacting with water in a matter of hours. A non-hydraulic lime can be made to set much more rapidly by the addition of a hydraulic or 'pozzolanic' additive (the practice is known as 'gauging').

The additives include finely crushed brick powder (pozzolana) HTI (high temperature insulation - fired china clay), PFA (pulverised fuel ash), volcanic ash (as in the Pantheon, Rome)

Lime Plaster have a proven practice of adding animal hair is traditionally added to lime plasters and renders to reinforce the mortar and reduce shrinkage cracking. It is particularly valuable in strengthening plaster applied to wooden laths but is also frequently found in plasters on a masonry backing. It should be supplied washed and sterilised. Treated Hemp and other natural fibbers could also be used, depending on the conditions, specialist conservation architectural advice is recommended as to the wall type and application.

### **Which lime should I use?**

*'The SPAB generally advocates the use of repair materials that match those used originally. Our forefathers appreciated that the more hydraulic a lime the greater its strength, but the lower its permeability and flexibility; so, the right balance needed to be struck for the particular job in hand. The slow set and workability of non-hydraulic lime, for example, is ideal for internal plasterwork. Where, however, extra durability in early life is required, say with a moderately exposed external wall, a weak hydraulic lime (or, if unavailable, a non-hydraulic one with a pozzolanic additive such as tile dust) might be appropriate for pointing or rendering.'*

*Whereas lime putty was employed historically for plastering inside, mortar for masonry seems to have been produced more cheaply by dry-slaking. Some companies produce dry-slaked mixes.* - Douglas Kent

### **What are the other Benefits of Lime?**

There are sound arguments for using lime mortars in new build, relating to both performance and ecological issues. These include: -

- Using lime based mortars and plasters reduces the need for expansion / movement joints
- It allows masonry to be recycled when the building comes to the end of its life. There would be no supplies of second hand bricks if old buildings hadn't been built with lime
- It uses less energy than cement to produce
- It enables low energy, sustainable materials such as water reeds, straw, hemp, coppiced timber and clay to be used as construction materials as the lime breathes and keeps them dry
- It re-absorbs some of the CO<sub>2</sub> given off during the firing process when it sets
- Aesthetically, lime has contributed massively to our townscapes in Shetland by enhancing the beauty of the materials used in construction.

### **CONTACTS**

- The Scottish Lime Centre [www.scotlime.org](http://www.scotlime.org) training programmes and other services offered by The Scottish Lime Centre Trust & Charlestown Workshops, phone 01383 872722, E-mail [info@scotlime.org](mailto:info@scotlime.org)
- SPAB Society for the Protection of Ancient Buildings [www.spab.org.uk](http://www.spab.org.uk) TECHNICAL ADVICE / TRAINING DATES From SPAB website SPAB in Scotland, The Glasite Meeting House, 33 Barony Street, Edinburgh, EH3 6NX tel/fax 0131 557 1551 [info@spabscotland.freeserve.co.uk](mailto:info@spabscotland.freeserve.co.uk)

#### **Further Reading**

Scholfield, J (1997) *Lime in Building: A Practical Guide*, 3rd edn, Crediton: Black Dog Press - **AVAILABLE AT SIC GRANTFEILD RECEPTION @ £4.00**

Holmes, S and Wingate, M (2002) *Building with Lime: A Practical Introduction*, 2nd edn, London: Intermediate Technology Publications

Wingate, M (nd) *An Introduction to Building Limes*, London: SPAB

Historic Scotland <http://www.historic-scotland.gov.uk>

**Technical Advice Note 1 – Preparation and use of Lime Mortars**

The Building Lime Forum <http://www.buildinglimesforum.org.uk>

Hybrid mortars. For details of English Heritage's research into hybrid mortars, please phone English Heritage's Conservation team on 020 7973 3073 [www.englishheritage.org.uk](http://www.englishheritage.org.uk)

The Lime Centre [www.thelimecentre.co.uk](http://www.thelimecentre.co.uk)

Ty-Mawr Lime Ltd. <http://www.lime.org.uk>

## GLOSSARY

**Dew Point** - All air contains water vapour of varying quantities. The dew point indicates the amount of moisture in the air. The higher the dew point, the higher the moisture content of the air at a given temperature. Conversely, the dew point of humid air will be higher than the dew point of dry air.

Dew point temperature is defined as the temperature to which the air would have to cool (at constant pressure and constant water vapour content) in order to reach saturation. A state of saturation exists when the air is holding the maximum amount of water vapour possible at the existing temperature and pressure. **Condensation** of water vapour begins when the temperature of air is lowered to its dew point and beyond. The dew point, like other measures of humidity, can be calculated from readings taken by a hygrometer.

**HTI powder:-** High Temperature Insulation, a finely ground fireclay containing reactive silica and alumina.

**Interstitial condensation:** - Interstitial condensation occurs inside a material. Vapor can pass through porous building materials. If the **dew point** temperature occurs within that material then, as with surface condensation, the vapor will condense.

**PFA:** - Pulverized Fuel Ash, a waste product of coal fired power stations consisting of tiny granules of reactive silica. Effectively an artificial volcanic ash.

**Pozzolana:** - natural volcanic ash from Italy containing reactive silica. The most commonly used pozzolans are brick dust made by crushing and sieving soft, under-burnt bricks; volcanic ash called 'trass'; and calcined china clay (Calcined Lime (Calcium Oxide)) sold under the name of Polestar or Metastar.

**Trass:** - natural volcanic ash from Germany containing reactive silica.

**Render:** -smooth coating or stucco over masonry.

**Traditional Harl:** -Wet dashed roughcast in which, the mixture of the aggregate and binding materials of traditional harl is sand, lime (sometimes with the above additives), dashed on to a wall.

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Types of Building Limes BS EN 459-1:2001 diagram with additional notes

**AIR LIME**  
 high calcium lime, pure lime or fat lime.  
*Non-hydraulic limes require the presence of air in order to set and will not harden underwater*

**Calcium Lime CL**  
 produced by burning limestone at a temperature of approximately 900° C

**QUICKLIME dp, lu.**  
*The traditional method of slaking causes a violent reaction, not suitable on a modern site. When Calcium Oxide and water to make 'slaked lime or hydrated lime' if steamed it could produce hydrated lime powder.*

**Lime can be delivered to site in lump form and can be slaked on site by**  
 mixing with water and left to stand for at least two weeks

**Dolomitic Lime DL**  
 In certain types of limestone, referred to as dolomitic limestone; the calcium carbonate is combined with magnesium carbonate. This type of limestone produces dolomitic lime when it is burned at a temperature less than 900° in the same conditions as for non-hydraulic lime.

**HYDRATED LIME dp, sl, pu.**  
 For conservation work, non-hydraulic lime is usually used in the saturated form known as '**lime putty**'. This is supplied to site covered by a thin film of water in air tight tubs, to minimize the risk of carbonation. It is made by slaking the lime with a slight excess of water. When matured (lime putty continues to mature for months), the result is the purest form of non-hydraulic lime, ideal for making fine plasterwork and limewash, but also widely used for pointing masonry and making render, daub and other lime-based mortars.

**SEMI-HYDRATED LIME dp.**

**COMPLETELY HYDRATED LIME dp.**  
 See CL discription

**HYDRAULIC LIME**  
 capable of setting underwater  
 Starts to harden by reacting with water

**NATURAL HYDRAULIC LIME dp NHL**  
*A recent European standard for classifying hydraulic limes is rapidly replacing the old classification. Natural hydraulic limes are now designated as NHL with the suffixes '2', '3.5' and '5'. So, for example, a feebly hydraulic lime would be designated NHL2.*

**HYDRAULIC LIME dp**  
 Hydraulic limes are available from UK sources in limited quantities. They are also available from Europe but there **are some doubts about the qualities of French hydraulic limes of which, are alleged to, have some cement added. Generally, the hydraulic limes** from Italian sources come from ancient pits and are considered to be reliable. Care is required in using these hydraulic limes because if Eminenty Hydraulic (NHL5) the chemical set can be very rapid producing potential shrinkage and problems associated with too

**Additional notes**

**MAGNESIUM LIMES**  
*Non-hydraulic limes from limestones with a perentage of porous magnesium oxide, some of this*

**Key**

**dp:** dry powder  
**sl:** slurry (milk of lime)  
**lu:** lumps  
**pu:**