

INFORM

INFORMATION FOR HISTORIC BUILDING OWNERS

Hot-mixed Lime Mortars



HISTORIC SCOTLAND
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Introduction

Lime mortars have been used in buildings for thousands of years and continue to be used for the repair and maintenance of traditional buildings. Most lime mortars currently used in Scotland are based on Natural Hydraulic Limes (NHLs) which are sold in bags as a dry hydrate powder. These products have only been commercially available relatively recently. Prior to the introduction of dry hydrate powdered lime, lime mortars were prepared using either lime putty or quicklime mixes, the latter made as a 'hot-mix'. These traditional methods of preparing a lime mortar can still be used in building and repair work today.

This INFORM guide explains what hot-mixed lime mortars are and how they differ from other types of lime mortars. It considers the possible benefits of using them, and gives a brief introduction to their preparation on site.

Lime Terminology

Building limes are currently defined by British/European Standards, however there is no standard definition of a 'hot-mixed lime mortar' and opinions differ on the precise usage of the term. For the purposes of this guide, hot-mixed lime mortars are defined as mortars prepared on site by mixing quicklime with aggregate and water. Mortars prepared using lime putty, NHL or other types of hydrated powdered lime are never hot-mixed lime mortars. Terminology can be confusing, and it is important to understand the products available. A more thorough explanation of different types of lime and their properties can be found in Historic Scotland Short Guide 6: Lime Mortars in Traditional Buildings.

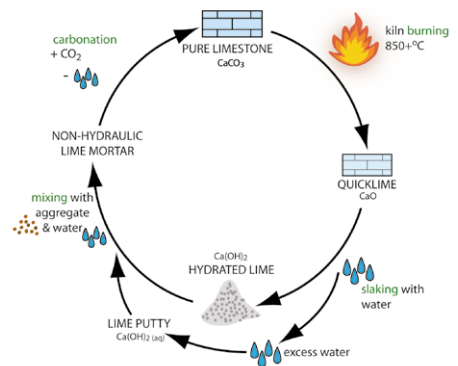


Fig. 1 The lime cycle.

Quicklime

Quicklime is the raw material produced when limestone (calcium carbonate) is fired in a kiln at a temperature of around 850°C. During this process the carbon dioxide is driven off, leaving highly reactive calcium oxide, known as 'quicklime'.

Quicklime reacts exothermically (generating heat) with water (termed 'slaking') to produce lime (calcium hydroxide). Quicklime is slaked with an excess of water to produce a lime putty, or by controlled addition of water to produce a dry hydrate powder. Lime made from pure quicklime is non-hydraulic (known as an 'air' lime). This means that, when used to make a mortar, it hardens purely through a process of carbonation (reacting with carbon dioxide in the air). This process essentially reverts the lime to its original state, forming a material that is similar in composition to the original limestone (Fig. 1).

This simple 'lime cycle' is true for pure limestone, yet in the past quicklime was produced from many different local sources of limestone, some of which contained impurities in the form of clays and other reactive minerals. When limestone which contains such impurities is fired, it produces a hydraulic lime - one that sets partially through a complex chemical reaction with water (hydration), rather than purely by carbonation. Most quicklime commercially available in Scotland today is imported and it is very pure, producing an air lime. Quicklime is available in lump, granular or powdered form from various UK suppliers (Figs 2-4).

Hot-mixed lime mortars

Hot-mixed lime mortars are prepared by adding specific measures of quicklime to aggregate and water and mixing together to form a mortar. The quicklime reacts with water generating heat, and simultaneously binds together with the sand or aggregate to produce a mortar. This mortar is 'hot', from the reaction, and can be used while still warm (for certain works) or stored ('banked') for later use. This differs from other methods of preparing lime mortars where slaked lime (lime that has already reacted with water

to form a putty or a dry hydrate powder) is added to aggregate to form a mortar. Hot-mixed lime mortars have some different properties to mortars prepared from mature lime putty or bagged dry hydrate powdered lime due to the effect of the heat of the reaction, and the high alkalinity of the lime, on the aggregates and other components in the mix.



Fig. 2 Lump quicklime.



Fig. 3 Granulated quicklime.



Fig. 4 Powdered quicklime.



Fig. 5 Slaking quicklime to produce lime putty.



Fig. 6 Mature lime putty.



Fig. 7 Natural Hydraulic Lime (NHL).

Lime putty mortars

Lime putty is made by slaking quicklime with excess water (without adding aggregate) (Fig. 5). The lime and water react and form a putty, which is normally stored and left to mature for several months (the lime continues to take up water and ‘fatten up’) (Fig. 6). Although the slaking stage generates heat,

the subsequent production of a mortar, by mixing the matured lime putty with aggregate, does not. Lime putty mortars, being ‘air limes’, rely solely on carbonation from exposure to the air in order to harden and can therefore be stored indefinitely if kept in sealed containers or under the cover of a layer of water.

Dry hydrate lime mortars

When a dry hydrate lime, such as an NHL, is used on site, it is supplied as a fine powder (Fig. 7) which is mixed with aggregate and water in specific proportions to produce a mortar. As the lime is already hydrated (by the controlled addition of water during manufacture) there is no ‘slaking’ reaction. Mortar made from NHL or other lime with hydraulic properties cannot be stored for long periods as it will begin to set and harden once combined with water.

Preparing a hot-mixed lime mortar

There are two main methods of preparing a hot-mixed lime mortar. Both methods produce a mortar that can be used for various types of lime work including bedding, pointing and harling.

Method 1 – typically used for building or pointing rubble masonry and harling

Quicklime is added to sand and water in the specified proportions and thoroughly mixed. Care needs to be taken to ensure that sufficient water is used, as the quicklime rapidly takes up the water and the mix can overheat. Conversely, too much water reduces the heat of the reaction and can lead to the mortar being over-wetted, or ‘drowned’. When the quicklime has largely slaked, but is still warm (or ‘hot’) and well mixed, the mortar can be used on site (Fig. 8).



*Fig. 8 Hot-mixed lime mortar ready for use on site.
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Fig. 9 Quicklime slaking with damp sand.

Method 2 – typically used for bricklaying or finer work

Quicklime is added to damp sand measured to specific proportions (typically 1:3) and left to slake on a board or in a tub on site, producing a dry mixture of sand and hydrated lime (Fig. 9). Water is then added to the lime/sand combination which is mixed to the desired consistency. The mortar is normally covered with waterproof sheeting and left to mature for a period of time (days, weeks or months) after which it is ‘knocked up’ and used on site. This type of hot-mixed lime mortar is sometimes referred to as ‘sand slaked’ lime mortar and is normally used once the heat from the reaction has dissipated. Such mortars retain most, but not all, of the characteristics of a mortar that is used while still hot.

Gauged mixes

Quicklime can be combined with NHL to produce a ‘gauged’ mortar. Historically, mortars derived from Scottish limestones were often slightly hydraulic. As hydraulic quicklime is not readily available in the UK, gauging an NHL with quicklime attempts to replicate a traditional hydraulic hot lime mortar. Most hot-mixed lime mortars used in Scotland are prepared as gauged mixes, or (more rarely) with pozzolans.

Pozzolans

Pozzolans are natural or man-made materials including brick dust and pulverised fuel ash (PFA), or proprietary additives, which are added in small, measured, quantities to lime mortars, just before use, to impart hydraulic properties.

Why use a hot-mixed lime mortar?

Hot-mixed lime mortars are thought to have some benefits which are not generally found with mortars prepared from dry hydrate lime:

Workability: Hot-mixed limes produce sticky, workable mortars that adhere well to masonry.

Good fill: Quicklime expands as it slakes, so the volume of a hot-mixed lime mortar increases during and, for a while, after mixing. When used hot, residual expansion can continue to an extent after the mortar is laid within the wall, allowing voids and joints to be well filled.

Early stiffening: Hot-mixed lime mortars take up water rapidly as they slake and so the mortar stiffens up quickly, allowing an efficient build rate.



Fig. 10 A lime mortar showing particles of un-slaked lime, characteristic of a hot-mixed lime mortar.

Frost resistance: Hot-mixed lime mortars, whether pure or gauged, seem to have good frost resistance. The reasons for this are not generally well understood, but it may be partly due to the way these mortars are produced: the slaking lime/sand mix produces steam, resulting in an open-pored structure. This seems to have a beneficial effect on the hardened mortar, improving its overall capacity to disperse liquid water and cope with the expansion of freezing water.

Addition of additives: The heat generated during slaking quicklime aids the incorporation of additives to moderate the properties of the mortar e.g. for improved workability or water resistance. Tallow, casein or similar proprietary materials will melt, dissolve or ‘saponify’ (convert to ‘soap’ by reaction with alkali) during this reaction, allowing a more thorough dispersal within the mortar. The heat generated may also help to speed up the reaction of these additives.

Economy: Quicklime is generally a cheaper product than lime putty, NHLs or other proprietary lime products. Quicklime can more than double in volume during its reaction with water and so less is required for a proportionate mix. Manufacturers and suppliers should be able to provide a figure for the bulk density of their quicklime to enable accurate batching.



Fig. 11 Weathered lime harling on an early 19th century building in Sbetland.

Authenticity: Analysis of historic lime mortars and harls often shows inclusions of particles of un-slaked and over/underburnt lime, indicating the use of a hot-mixed lime mortar (Fig. 10). These mortars tend to be lime-rich and surprisingly durable (Fig. 11). Modern methods of preparing lime mortars have typically relied on a 1:3 ratio of slaked lime:sand. This produces a leaner mix that will not be compatible with most historic mortars.

Skills

While there are experienced contractors who are able to prepare and use hot-mixed lime mortars on site, the use of these mortars has declined, partly due to the ready availability of bagged dry hydrate NHL, or pre-mixed mortars. However, the site practice and manual skills required are essentially similar to those for other lime or cement mortars and, with appropriate training, the preparation of hot-mixed lime mortars can be included within the repertoire of a skilled contractor. There is a revival of interest in the traditional methods of preparing lime mortars which is gradually leading to an improvement in the skills available (Fig. 12). Nevertheless, where hot-mixed lime mortars are specified, the work must be carried out by a contractor who can demonstrate their experience in the preparation of mortars using quicklime.



Fig. 12 Modern gauged hot-mixed lime harling on a building in Shetland.
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Health and safety

Quicklime is designated as a 'hazardous' material, but not 'dangerous', and can be used on site providing appropriate health and safety procedures are followed. It is a highly caustic, reactive material, and can cause irritation or burns if it is blown into the eyes or comes into contact with skin during slaking or mixing. Personal Protective Equipment (PPE) including gloves, goggles and a dust mask must be used at all times when handling quicklime. Sugar-water eyewash should always be available on site wherever mortars are being prepared (saline eyewash is ineffective for use with lime). Other materials used as binders are similarly hazardous; the same safety precautions are required when mixing cement or other types of lime.

Conclusion

Hot-mixed lime mortars are traditional materials and were still used in the construction of buildings until the 1930s and '40s. The various historical methods of preparing hot-mixed lime mortars are still a subject of on-going research and some debate, and there may well have been considerable local and regional variation. The preparation and use of hot-mixed lime mortars on site today is a reviving craft skill and is being practised in Scotland by some specialist contractors, although its use is not yet widespread. There is a range of lime products currently available, all of which have a place in the repair and maintenance of traditional buildings, but an appropriately specified hot-mixed lime mortar may be an option to consider when repairing traditional mortars and harls.

Further reading and contacts

The Building Limes Forum

W: www.buildinglimesforum.org.uk

The Society for the Protection of Ancient Buildings (Scotland)

W: www.spab.org.uk/spab-scotland

The Scottish Lime Centre Trust

W: www.scotlime.org

Short Guide 6: Lime mortars in traditional buildings, Historic Scotland (2014)

TAN 1: Preparation and use of Lime Mortars, Historic Scotland (2005)

INFORM: Lime and cement in traditional buildings, Historic Scotland (2007)

Practical Building Conservation Series: Mortars, Renders and Plasters, English Heritage (2011)

British Standard (BS EN 459-1:2010) Building lime Part 1: Definitions, specifications and conformity criteria

Lynch, Gerard (1994) Brickwork: History, Technology and Practice, Volume 1, Chapter 5, 'Mortars', pp.117-28, Donhead Publishing

Lynch, Gerard (1998), 'Lime Mortars for Brickwork: Traditional Practice, Modern Misconceptions', (Part 1 March and Part 2 July) The Journal of Architectural Conservation, Donhead Publishing

Lynch, Gerard (2007) The Myth in the Mix, [<http://www.buildingconservation.com/articles/mythmix/mythmix.htm>]

Historic Scotland's INFORM Guide and Short Guide series contain further information on the conservation and maintenance of traditional buildings. These publications are free and available from our technical conservation website, address above. Alternatively, you can contact us on hs.cgpublishings@scotland.gsi.gov.uk for these or any other publication enquiries.



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