

## What is Traditional Lime Mortar?

Also known as Natural Lime Mortars, mortars of this type are made with sand and use lime as a binder. They should not be confused with sand, lime and Portland cement mortars, regardless of the relative proportions of the lime and Portland cement.

There are two basic types of lime for traditional lime mortars - those that set and harden by the reaction with air and those that do so by reaction with water (non-hydraulic and hydraulic limes respectively). Of the latter type there are sub-varieties.

### Non-hydraulic limes

Lime made from relatively pure forms of calcium carbonate (e.g. chalk or limestone) burned in a kiln produce calcium oxide (quicklime). When this is then reacted (slaked) with water it produces calcium hydroxide (hydrated lime). Calcium hydroxide reacts (carbonates) with carbon dioxide in the air to reform calcium carbonate, i.e. the composition of the raw material originally used to make the lime. In a mortar mix it is this "setting" that binds together particles of sand and bonds it to the masonry units.

The setting process is slow, taking several weeks to gain a basic working strength, and many months, or even years, to reach ultimate strength throughout. The setting is entirely dependent on air and not on water; indeed lime putty, a moist, plastic form of the hydrated lime, will keep for years in an airtight container or under water.

### Hydraulic limes

Naturally occurring deposits of calcium carbonate can include impurities, i.e. small amounts of other minerals, very often clay or silt. When burned in a kiln the calcium carbonate forms calcium oxide, but the "impurities" form calcium silicates and aluminates that will chemically react with water to set and harden regardless of the presence of air. In the manufacturing process just sufficient water is added to the kiln product to hydrate the calcium oxide to form calcium hydroxide in a dry powder form, but not enough to promote setting of the calcium silicates and aluminates. The material is bagged and stored dry to prevent the commencement of a set by atmospheric moisture.



Characteristic appearance of  
Hydraulic Lime Mortar

The composition of raw materials from different sources varies greatly and this relative content of "impurities" influences the setting and hardening characteristics of the lime produced. In practice hydraulic limes are graded according to the rate and ultimate strength of their set and they are described as "feebly hydraulic", "moderately hydraulic" and "eminently hydraulic" limes.

In geographical areas where available natural limes were not sufficiently hydraulic for some purposes, traditional practice included the use of additives to produce a set (Pozzolans), e.g. brick dust from a kiln or furnace ashes, to improve the setting and ultimate strength of mortars made with non-hydraulic, feebly hydraulic, or moderately hydraulic limes.

Mortars made with eminently hydraulic limes and/or Pozzolan additives can be quite strong and hard and, in these characteristics, resemble those of Portland cement mortars.

When traditional limes were the normal binder material used for mortars, their successful application depended on a good appreciation of the considerable variation in the performance of limes and of the properties of the particular materials available locally.

### **Appropriate and inappropriate construction**

Prior to about 1925-30 brickwork masonry was characteristically of heavy, solid construction jointed with lime mortar. Wall thickness was frequently of two-bricks (450mm) or more, and never less than one-brick (215mm). These thick walls provided ample structure to accommodate forces from dead-weight and imposed loads and so comparatively low stresses were developed in the masonry that were well within the capacity of the limited compressive strength of traditional lime mortars. Furthermore the stout form of the masonry inherently provided resistance to bending action and flexural stress was not a consideration.

In the 1930s and following the second World War, masonry construction underwent a profound change. Structural engineering developments permitted structures utilising thinner walls that economised on materials. The widespread adoption of cavity construction to provide economic rain resistant walling also reduced the need for thick walling. Thin walls provide less plan area to support loads and therefore higher stresses are developed in the masonry. Also thin walls are more susceptible to bending under the action of lateral load, e.g. wind forces, and so resistance to flexural stress is a common consideration in design. Mortars for this type of masonry are required to be stronger in both compression and flexure and, sometimes, shear.

### **Masonry design guidance and lime mortars**

By the mid 1930s great concern was being expressed in the Journal of the Royal Institute of British Architects about the quality of contemporary mortars. Because of regional variety, hydraulic limes did not always produce satisfactory mortar using methods established by particular localised craft traditions. There was no standard specification for building limes, nor were there any standard instructions for mixing mortars using them. It was observed that architects played safe by specifying Portland Cement for mortars because it was a consistent product made to a standard specification and its performance was predictable.

In the decades following the second World War development of the structural design guidance published by the British Standards Institution at first recognised non-hydraulic and hydraulic lime mortars. In the early editions of Codes of Practice CP 111 "Structural Recommendations for Loadbearing Walls" and CP 121.101 "Brickwork" they are described and basic compressive stresses quoted for brickwork built using them. However, low stresses are given that do not exceed those of brickwork using a Designation (v), 1:3:12 cement:lime:sand mortar. By 1973 non-hydraulic limes are excluded from the Code and although hydraulic lime mortars are stated as included there is scant guidance on their application.

In 1978 a new masonry design code, BS5628: Part 1, based on Limit State philosophy, was introduced to replace CP 111 and 121. Still in use, this Code specifies characteristic compressive and flexural strengths for masonry built in Portland cement bound mortars. Masonry built in lime mortars is not covered.

## What guidance is currently available?

Much of the current guidance on lime mortars has been based on good experience of non-hydraulic lime putty in fine plasters, renders and re-pointing mortars for the conservation of historic stone and brick masonry. But lime putty was never the most common form of lime used for general construction as mortar made with it is very time consuming to prepare, is expensive, sets slowly and lacks durability.

It is particularly inappropriate for modern thin masonry walls as ultimate strength is unpredictable and often insufficient.

Until recent years, less attention has been given to hydraulic lime mortars in traditional building, but some designers are now attracted to the environmental advantages that are claimed for lime mortars.

## Manufactures guidance

Most traditional UK sources of hydraulic limes no longer produce them because of lack of demand, but a few remain to supply specialist conservation activities. Hydraulic lime mortars are suitable for some modern masonry construction and are capable of producing sufficient strength and rate of setting for some thin wall brickwork applications.

Continental producers have supplied building limes to the UK for many years, principally for conservation and repair work to historic masonry. They provide some technical data to support their products. However, caution must be exercised when interpreting data. For instance, a lime mortar of comparable compressive strength to a Portland cement bound mortar does not necessarily indicate that it has similar flexural strength, shear strength or durability.

Some Continental hydraulic limes contain materials that make them more akin to Portland cement than traditional UK hydraulic limes.



The new RSPB headquarters was constructed using an hydraulic blue lias lime mortar

A UK hydraulic blue lias lime, currently available from Dorset, has been tested and found suitable for a range of modern and traditional applications and the manufacturer has a British Board of Agrément Certificate\* covering use of the material in mortar for building low rise structures of the domestic type.

Specifiers and builders should give careful attention to the conditions specified in the Certificate as they do depart from current standard building procedure in some significant respects.

\* Certificate no. 99/3581 (3 sheets): Hydraulic Lias Limes Ltd., Melmoth House, Abbey Close, Sherborne, Dorset

## CAUTION

- BS 5628:Part 3 and other current codified guidance does not cover the use of natural lime mortars.
- There is a lack of sufficient knowledge and data of the performance of natural lime mortars to justify their substitution for Portland cement based mortars in modern masonry design.
- In these litigious times wise designers, specifiers and contractors seek authoritative guidance on matters of specification and that is not generally available for lime mortars used in thin-wall brickwork masonry.
- Lime mortars are less tolerant of adverse weather and must be protected during laying and curing.
- Very few craftsman have sufficient experience with lime mortars to be left to use them as a matter of course.

## Advantages Claimed for Traditional Lime Mortar - justifiable or questionable?

- Good workability and handling characteristics during laying:- Yes, but they are heavier to handle as lime mortars are stiffer than Portland cement ones. They are also less tolerant of adverse weather during application and curing.
- Good bonding:- Yes \*
- Tolerant of movement:- Yes, but this does not mean that no movement joints are required when lime mortar is used. No authoritative guidance is available on this aspect of design. Historical examples of masonry with lime mortar and no movement joints are always thick heavyweight brickwork. Great weight imparts restraint and thick walls are able to absorb more heat than thin ones and so they react less to thermal change. The mass of masonry is more significant in limiting movement than the lime mortar.
- Autogenous healing of minor cracking in service:- Yes \* Less energy is used in manufacture of lime compared with Portland cement. Although kiln temperatures are lower for lime burning than for Portland cement production, lime kilns tend to be much less efficient. So this claim may only be theoretical.
- Carbon dioxide generated in production is reabsorbed in carbonation (therefore nil contribution to CO2 emission): Only theoretical. It would take very many years to completely carbonate a mortar mass in walling.
- Easier to clean off mortar from bricks when demolished: Yes, for the weaker mixes. But mortars with the more hydraulic limes and pozzolans would generally be harder and more difficult to remove.

\*A lime inclusion in a Portland cement based mortar also confers this benefit.

The views expressed in this note are supported by:-

- Brick Development Association
- Ceram Building Technology
- Mortar Industries Association