

# Lime

## History

The earliest archaeological evidence for lime burning is a kiln from Mesopotamia dating c.2450 BC. Roman lime kilns have been found in Britain but in the post Roman period there is very little evidence for lime burning. A 12<sup>th</sup> century reference to the church in York being whitewashed in 690 AD may suggest Anglo-Saxon use of lime, though later building accounts also refer to making a whitewash from chalk dust and size made from leather scraps. Early kilns would have been of 'clamp' construction with clay or turf covering alternating layers of fuel and stone and would leave very little archaeological evidence; the earliest definite evidence for lime burning in post Roman Britain comes from a brick lime kiln found in Guildford, Surrey, dating from the 12<sup>th</sup> century. As with other building materials Medieval building accounts are a good primary source for information, holding references to the burning, buying and use of lime. Lime was either bought already burnt as quicklime or, for large building projects, was often burnt on site in specially constructed kilns. In 1229 the Abbot of Abingdon allowed Henry III to clear timber from 26 acres of Saghe wood to fuel kilns producing lime for work on the city walls. Early complaints were lodged at the destruction of woodland for fuel; the Hundred Rolls of 1275 complained that two of the king's lime kilns had devoured 500 oaks of the forest of Wellington. The destruction of timber for lime kilns lessened with the use of sea coal, though this also led to complaints, the smog produced being denounced as a nuisance in London in 1285 and coal being prohibited, though the prohibition was probably not observed, from 1307. Barrels that had contained tar were used for starting the fire inside lime kilns, the 3s paid to John Tyghler of Goring, West Sussex in 1365 for 9 empty barrels is just one such reference to this practice. The increasing use of brick led to a greater demand for lime for mortar in the 17<sup>th</sup> century as did the growing use of lime for agricultural purposes and the trade of lime burner appears at this time also. The use of lime, because of the cost, had been restricted to higher status buildings (except for use in limewash), but by the end of the 18<sup>th</sup> century, bigger, more efficient kilns and the expansion of the canal and rail network meant lime became more widely available as a building material.

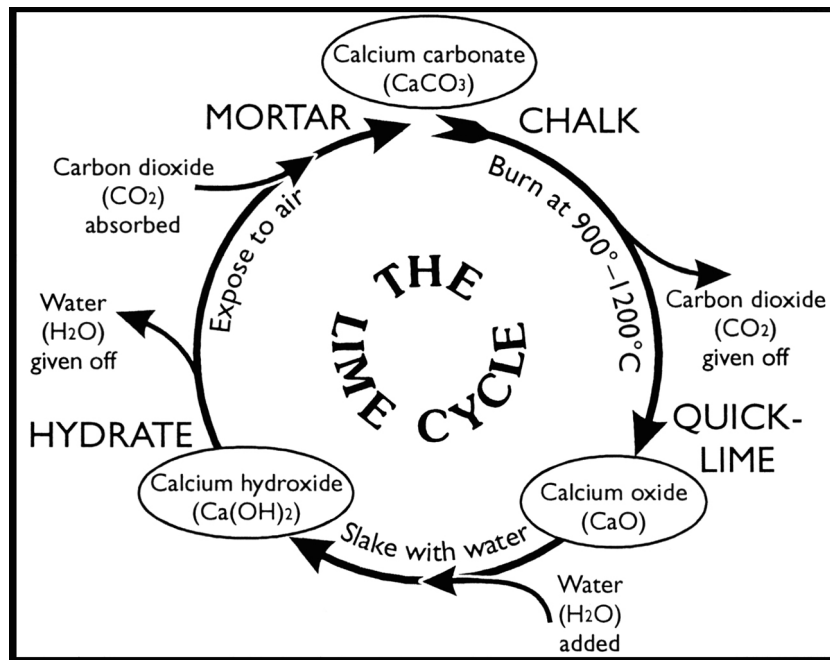


*Lime burning in the nineteenth century*

## Production

To produce lime calcium carbonate in the form of chalk or limestone is burned in a kiln at a temperature of 888 –1000° C (°F), this calcining drives off carbon dioxide to leave calcium oxide or 'quicklime'. The quicklime is added to water ('slaked') and produces calcium hydroxide in the form of a powder ('dry hydrate') or putty, depending on the amount of water used. When water and quicklime are mixed a violent exothermic reaction takes place, the quicklime heats up and spits and boils, and for this reason extreme care must be taken when slaking; quick lime should always be added to water and never the other way round. If being turned to putty, the slaking lime is stirred and raked with a 'larry', a large hoe like implement, of which there are a few in the Museum collection.

As the lime in limewash, render, plaster or mortar dries, it reabsorbs carbon dioxide from the air and turns back into calcium carbonate. This completes the 'lime cycle'.



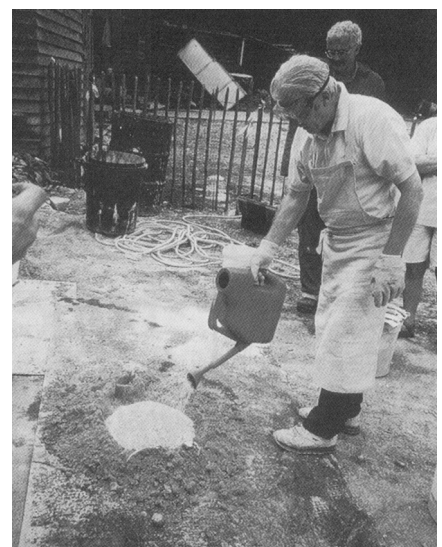
*The lime cycle*

There are two basic types of lime. Non-hydraulic lime is made from pure calcium carbonate and hardens by reaction with air, this was the most commonly produced and used in Britain. Hydraulic limes set by reaction with water and are made from calcium carbonate that includes impurities such as clay or silt, the amount of which makes the lime 'feebly', 'moderately' or 'eminently' hydraulic. Hydraulic limes have some similarities with cement, which is made by calcining limestone and clay together.

## Products

### Mortar

Lime mortar was used to lay brickwork, building stone and to point roof tiles. The main 'ingredients' were lime and sand but additives such as eggs, casein, keratin (from boiled hooves), tallow, blood, beeswax or bitumen to increase water resistance. Crushed brick or tile was often added to mortar to improve setting times, and other additions might be used for their aesthetic qualities – one Mediaeval building account lists '16 bushels of smithys dust provided for blacke mortar requisite for the laying of flint'. Mortar can be made by mixing putty with sand but, in the past, was also prepared by slaking the lime with sand as described in Richard Neve's *The City and Country Purchaser* (1726). Gerard Lynch has demonstrated this method at the Museum: a ring of sand is formed on a wooden platform, the quicklime is put in the middle and lightly watered. As it begins to slake the sand is drawn over the lime, the damp sand providing extra moisture for slaking and stopping the lime from over – burning. When judged ready the pile is broken open, resulting



*Gerard Lynch making mortar at the museum*

in a dry mix of sand and lime. After sieving water is added; Richard Neve notes the difference in opinion as to whether it should be left to lie for up to three years or used immediately. He also gives a lengthy discourse on the ratio of lime to sand as suggested by different workman and finally suggests that the proportions 'ought to be various' depending on the quality of the materials and the judgement and experience of the workmen. Non (and weakly) hydraulic lime mortars can be 'knocked up' and re-used and there are references to this in old building accounts. Pevensey Castle in 1288 had men 'digging stones and old mortar where the wall had been thrown down' and 'carrying chalk from the keep to the gate and making old mortar and new'. Lime mortars were used until the middle of the 20<sup>th</sup> century. Portland Cement was invented in 1824 but it was expensive and too strong for many building applications; cement based mortars didn't fully take over until after the Second World War with changes in building methods and materials. Lime was, and still is retained as a minor ingredient to improve workability.

## Render and Plaster

Render usually refers to an exterior finish and plaster to the interior, though the terms were, and are, sometimes used interchangeably. The methods of application were the same as were the materials, though internal plasters often had a finer finish and external renders do not always contain hair as a binder. The main 'ingredients' were lime and sand or finely sieved earth and external renders were, in the past, 'modified' with blood, beeswax, eggs, milk or even cheese to improve water shedding properties.

As with mortar lime renders and plasters vary considerably in composition, texture and in numbers of coats, or layers, with ratios of between 1 part lime to 3 – 6 parts sand or sieved earth. At the lower end of the social scale, lime might not have been used at all (see wattle and daub introduction sheet) or would have been used as one rough coat. Higher status houses would often have had three coats: a coarse undercoat applied direct to wood laths, brick, flint or stone, a second, slightly less coarse undercoat (or float) and a top or finishing coat of a finer grade. The base coat and second coat were usually reinforced with chopped ox or horse hair (or straw in rough work) which provided reinforcement and reduces the risk of shrinkage and cracking, as the straw does in wattle and daub. The lime putty for plaster should ideally have been left to slake for 6 months or more to ensure all particles have slaked, otherwise the lime can continue to slake in the plaster causing it to 'blow'. It is possible that renders and plaster were made in a similar way to mortar, slaking the sand and lime together.

From the mid 16<sup>th</sup> century, in the eastern counties, it became increasingly common to cover the whole face of a timber frame building with lime render, though this fashion only really spread as far west as Kent by the 18<sup>th</sup> century. Interiors were plastered too (from the 17<sup>th</sup> century within the Museum collecting area) with the plaster fixed over both the frame and daub infill or, later, to horizontal laths nailed on the face of the slighter timber structural frame. Rendered buildings sometimes carried combed, moulded or incised decorative designs known as pargeting though, again, this was more common in the eastern counties and Kent. As with wattle and daub panels, plaster was sometime decorated, either with 'combing' or paint; the panels from Fittleworth (in the entrance lobby to Crawley hall) and the wall paintings in the house extension from Reigate are good examples of this.

For interiors, lime plaster was not the only plaster available, 'gypsum', 'franco' plaster or 'plaster de parrys' was mentioned in building accounts as early as the mid 13<sup>th</sup> century, though this was confined to higher status buildings. From the mid 18<sup>th</sup> century gypsum plaster became more common and was, by the 19<sup>th</sup> century, widely used.

From the late 18<sup>th</sup> century until the mid 19<sup>th</sup> century stucco, a very fine exterior finish of lime render with brick or stone dust (and later, Portland cement), became very popular in towns and for substantial country houses, where it was usually applied direct to brick work. This effect filtered down to lower status dwellings such as Whittaker's Cottages, built c.1846, where the render is applied onto lath nailed to the light timber frame and lined to imitate stone blocks or ashlar. Cement based renders were introduced from the beginning of the 20<sup>th</sup> century and gradually replaced lime, though as with mortars, lime was often retained as a minor ingredient.



*Whittaker's Cottages with Interior detail showing timber frame, render and lath.*

## Limewash

Limewash or whitewash is made by either adding enough water when slaking quicklime to produce the required 'thin milk' consistency or by adding water to lime putty. Additives such as tallow, linseed oil or casein (in the form of skimmed milk) were added to improve water resistance, the tallow being added at the slaking stage so that it would melt. Limewash was used extensively, on wattle and daub and other earthen building materials such as cob, on lime renders or plasters, and on stone buildings. The Keep of Tower of London was known as the White Tower due to its brilliant whitewash and in 1255, at Guildford building accounts record that the hall, two royal chapels and other buildings were whitewashed inside and out. However, as mentioned previously there are also references to the purchase of chalk dust and size derived from leather for whitening walls so it is not always possible to tell if building accounts that write of wasshyng refer to this or lime. Limewash, applied in three or more layers, dries to a brilliant white as evidenced by the Museum buildings but pigments such as red or yellow ochre could be added. Images of London buildings with brightly coloured exteriors panels used to be dismissed as fantasy but with more examples being identified, by visual or scientific means, there is growing evidence that this it may not have been artistic caprice. Timbers could be painted too, North Cray's timbers carried a residue of red ochre (and size), and the timbers in the picture of the White Tower show red and blue tones. Limewash was also used to scrub and cleanse in kitchens, the slightly abrasive quality smoothing the wood, the mildly antiseptic and antibacterial properties cleansing the surfaces.



*The White Tower, with coloured timber framed buildings in the background*

## Lime in building conservation

In the recent past many buildings built with traditional lime materials have been repaired with cement which has led to problems with damp and structural failure. Lime based materials let the buildings 'breathe', allowing a certain amount of moisture in, but also allowing it to evaporate. Impervious coatings such as cement render, plaster, or modern paints trap moisture in the walls causing wattle and daub or other earthen building materials to decay and old brickwork to fail. In winter trapped water in walls may freeze, causing extra problems. Just like mending something with an adhesive that is too strong, cement based products can also create extra stress on the older fabric of the building. Cement mortars can cause hairline cracks in older brickwork by too strong and inflexible, this problem is exacerbated by moisture being drawn into the cracks and becoming trapped. Even in the recent past, traditional lime materials for conservation purposes had a little cement added as it was thought that this would make them fail safe but the thinking now is that lime should be repaired with like, with a scientific analysis of the original material being carried out if necessary.

## Lime for environmental purposes

There is also a growing interest in the use of lime for environmental reasons which is, inevitably, an area for debate. The 'eco' arguments are as follows:

1. Lime is produced at a temperature of around 900°C - cement at over 1200°C. As a result considerably more energy is required to produce cement thereby increasing CO<sub>2</sub> emissions.
2. During carbonation mortars renders and washes reabsorb considerable quantities of CO<sub>2</sub>, cements do not.
3. Buildings constructed with all but the strongest hydraulic limes can be altered easily and recovered masonry can be reused. In the UK 3,000 million bricks are fired annually consuming large quantities of fuel and adding significantly to CO<sub>2</sub> emissions. Bricks bound together with cement mortars can generally never be recycled - except as hard-core.
4. The bulk density of lime is half that of cement enabling fuel savings during distribution.
5. Modern paints cause environmental and health problems because of the energy used to produce them, the chemicals and substances used in or created by the manufacturing process, the waste produced during manufacture and non-biodegradability at the end of their life. Lime washes, where suitable, can avoid these problems.

As an example of the arguments against (or more a 'jury's out' stance), the Brick Development Association discusses (with special reference to mortar) whether the advantages claimed for lime are justifiable. Their points are:

Although kiln temperatures are lower for lime burning than for Portland cement production, lime kilns tend to be much less efficient, therefore (1), above, may only be theoretical.

It would take very many years to completely carbonate a mortar mass in walling, so therefore the idea that carbon dioxide generated in production of lime is reabsorbed, as (2) above, is again theoretical.

In reference to (3) above, it is easier to clean weaker lime mortars from bricks but mortars with the more hydraulic limes and pozzolans (additives such as fly ash or brick dust that encourages better setting, especially in wet conditions) would generally be more difficult to remove.

The Brick Development Association also points out that lime mortars are not suitable for modern masonry design, but the eco-friendly camp calls for change in building materials and methods anyway, which would make the use of traditional lime materials viable again.