Old House Store

AN OVERVIEW OF LIMES

FIRST OF ALL WHAT IS LIME?

Lime is produced by heating calcium carbonate (limestone, chalk, shells, coral etc.) in a kiln to a temperature of approx. 900 C. At this temperature carbon dioxide gas is given off and the calcium carbonate is chemically changed, or calcined, to form calcium oxide (known as quicklime or lump lime).

The raw material – calcium carbonate, will vary according to its point of origin and will contain impurities of various types in varying quantities. It is these impurities that give us the range of different building limes discussed below. To avoid overcomplicating the subject, I will concentrate on calcium based limes and avoid magnesian or dolomitic limes.

Lime can arrive and be used in different forms, but they all originate from quicklime. In the past it would have been commonplace for quicklime to be delivered to sites, but today we tend to process it beforehand. Water and quicklime are combined in a process known as hydration to produce hydrated lime. If only an exact amount of water is added the end product is a dry powder, which is sold in bags and generally known as hydrated lime or lime hydrate. If an excess of water is used (always putting the quicklime into the water for safety's sake) the process is normally referred to as slaking or slacking and the end product is a colloidal gel, often sold in plastic tubs and known as lime putty.

The properties of the dry hydrate or putty will depend mainly upon the source of calcium carbonate burned and, in particular, the impurities it contained. Very pure sources of calcium carbonate e.g. Buxton limestone, will produce pure quicklime and hence pure putties. Pure lime putty (calcium hydroxide) is known as fat lime and will not set under water. For this reason, we store it with a layer of water over the top. Mortars and plasters made from fat lime will not set under water and thus can be kept indefinitely if stored correctly.

These pure limes set by a two stage process. The first part (the initial set) is simply the excess moisture leaving the mortar either by evaporation or migration into the surrounding masonry. The mortar is then firm to the touch but can still be marked with a fingernail. The second stage (carbonation), is a very slow chemical reaction, caused by carbon dioxide from the atmosphere entering the damp mortar in solution and reacting with the lime (calcium hydroxide) to convert it back to calcium carbonate. This stage can be very slow; it will depend on the temperature, the pore structure and the moisture within the mortar and can take many years to complete.

Limestones that contain clay produce building limes that are known as hydraulic, because they have the ability to set under water. The clay impurities contain silica and alumina that give the limes a more complicated chemistry. The calcium ions react with the silica and alumina to form complex calcium silicates and calcium aluminates. This reaction can take place under water and thus hydraulic limes cannot be stored for any length of time as putties or wet mortars because they will start to set.

The formation of the above compounds will take place relatively quickly, but will then be followed by the slower carbonation process, whereby the remaining free lime (calcium hydroxide) within the mortar will react with atmospheric carbon dioxide (as with fat lime).

The properties of hydraulic limes are a direct consequence of the amount of clay impurity in the burned limestone (raw material) and of the burning temperature. The more clay impurity the faster the set and the harder the mortar, if the limestone is burned at the appropriate temperature. Thus, historically, we have had a whole spectrum of building limes available ranging from natural cements like Roman Cement (with a setting time of 20-30 minutes) to fat lime that will keep indefinitely under water.

Vernacular buildings would have been constructed from the locally available sources of lime. Very often an individual quarry would yield different types of lime from different strata. Where locally available lime did not have the required properties for a given task, either the required lime would have been transported

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from a source further afield, or the local lime would have been modified by the addition of other materials (to be discussed later).

Mortars and plasters are almost always lumped together because they are often similar materials. However, this can lead to confusion, thus I am going to treat them separately:-

PLASTERS/RENDERS AND FINISHES

Plasters/renders and finishes are, in general, thin materials that cover a large surface. They have a very large surface area compared to their volume. They are what we see when we look at a building or wall. Historically, they were where the money was spent e.g. rubble stone walls rendered and marked out to look like ashlar. Plasterers took great care in the preparation of their materials. The lime would have been slaked to form a putty, sieved and matured for many months before use. External finishes are susceptible to weather damage, particularly from the frost and hence the quality of the materials and the skill in their application was important to ensure longevity.

MORTARS

Mortars, on the other hand, have a very small surface area to volume ratio; most of it is hidden. In their simplest form they were often subsoil dug from the foundations or part of the site. Mortars were produced with economy in mind, e.g. an 18th Century London house might have had up to six different mortars:-

i. brickwork below ground floor level, this may be hydraulic.

ii. general construction mortar.

iii. mortar for internal walls.

iv. mortar for chimney stacks/breasts.

v. mortar for face brickwork.

vi. pointing mortar.

The pointing mortar would be where the effort was directed because, in common with plaster, it was the element that was seen. It may have only been a fraction of an inch thick, but it was the visible skin.

The general mortars for brickwork or masonry would have been produced quickly, cheaply and roughly. The process, sometimes referred to as hot mortar making, would have involved mixing the aggregate directly with the quicklime and then adding water. In some cases, an excess of water would have been added, the mix 'stirred' with a larry, banked up as it thickened and left for 24 hours. It was then cut off in slices and knocked up, with additional water if required, to suit the job in hand.

A second method would be to mix or layer the quicklime with damp sand, wet down the pile and leave for 24 hours. The quicklime would hydrate to form a dry powder and the heat would dry the sand. The resulting dry mix would have been thrown through an inclined sieve to remove large lumps of unslaked lime and then mixed with water to the required consistency. It is likely that many variations of method and timescale existed as well as the above generalisations. The important point is that, in general, mortars were produced quickly and cheaply, whereas plasters etc. were high quality products. In our haste to revive lime for the repair of old buildings, many of us have overlooked this distinction and followed the expensive plasterers' route. In general, lime is used mixed with an aggregate or mixture of aggregates. The aggregate provides the bulk and dimensional stability of the mix and the lime performs the role of the binder, i.e. it sticks the mix together. In order for it to do this, it must coat all of the particles of aggregate. Hence the minimum amount of lime needed within a mix is that which will fill all of the voids in the aggregate. The addition of more lime will help the workability of the mix, but may lead to shrinkage and cracking. The volume of voids will vary from one aggregate to another; but in general, for a well graded sand, they will be about 30%. Hence a 1:3 (lime: sand) mix is commonly used. However, it may not be good enough to simply specify a ratio without knowing which aggregate and which lime is to be used; e.g. hydraulic limes usually have to be used in richer

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mixes than fat limes and, historically, mixes can be seen to vary enormously from very rich to quite lean. Aggregates commonly used in the United Kingdom were naturally occurring silica sand, other mineral based sands and crushed stone; although others include:- crushed chalk, crushed shell, earth, crushed brick or tile. Other ingredients that were added to mortars and plasters were:- blood, urine, fat, tallow, oil and hair. These secondary ingredients may have been added simply because they were available in abundance and cheap e.g. earth, but were more likely added to modify the properties of the mix.

The Romans found that by adding volcanic dust from Pozzouli (near Naples) to non-hydraulic lime, it became artificially hydraulic. They also found that crushed brick or tile had a similar effect, and this type of additive is known as a pozzolan. Bricks and tiles are made from clay. When fired, crushed and mixed with lime, they give it similar properties to a lime with a natural clay impurity. Research has shown that the type of clay, the firing temperature and the particle size of pozzolans are all important factors and that clay as an additive or impurity without being fired, does not have a pozzolanic effect on a mortar.

In the United Kingdom at the moment, we have a limited number of commercial sources of lime, only a few of which are hydraulic. It is our hope that more local and diverse sources may again become available to give builders a choice, cut down on transportation costs and give local communities a sense of identity. Although there are not many sources, fat lime is produced in large quantities and readily available. Hydraulic lime, however, is imported on a commercial scale and, since most of these products are marketed as lime, it is difficult for the lay-man (or lay-conservation officer) to know where on the spectrum of limes they appear; whether they are close to fat limes with gentle properties, or in fact natural cements that can be too aggressive for use on old buildings, or even if they have had cement added at source to bring them up to a given standard. More native sources of lime and more information are required to help us understand further.

Let us not forget the properties of lime that make it useful to us, particularly in the repair of old buildings. It is soft, porous and flexible. It allows building fabric to move and breathe. History has shown us that fat limes can be used successfully in the majority of straightforward applications. However, there are areas where fat limes are inappropriate or not durable enough (e.g. they will not set in damp or wet conditions). In these areas, naturally or artificially hydraulic mixes are essential.

There are a few simple rules to follow when choosing mortars or plasters:-

i. A mortar should never be harder or less porous than the building elements – bear in mind that the overall compressive strength of a wall does not diminish much as the strength of the mortar is reduced.

ii. Good masonry relies on skill and bonding – the mortar evens out the discrepancies and fills the voids.

iii. A mortar that is too weak may require repointing in due course, whereas a mortar that is too hard can destroy the bricks or stones of the wall.

iv. Plasters/renders should be strong enough to resist damage, but flexible enough to cope with any movement.

v. Plasters/renders should be porous enough to allow the masonry behind to breathe, i.e. no water should become trapped by the plaster or render.

Lime obviously has a major role to play in the repair of old buildings. It is now widely understood that inappropriate cement based materials may have a tendency to crack and trap water, which can lead to decay and damage by salts and frost, whereas lime based materials are compatible and help to protect historic structures and fabric. However, it is now also becoming apparent that lime has a future in new buildings. The fact that it uses less energy to produce and absorbs carbon dioxide on setting (thus contributes less to the "greenhouse effect" than cement) makes it worth considering for new buildings. It is also beginning to excite some engineers who see that its

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flexibility can help do away with ugly expansion joints in large structures.

If one were to generalise, it would be to say that the future of fat limes and weak hydraulic limes lies in the repair of existing ancient buildings, where new repairs need to be soft and even sacrificial. Whereas the future of the stronger hydraulic limes might be in the new build sector where they are quicker to build with and closer in the way they are used to cement (coming as a dry powder in a bag) than 'confusing' lime putty. Who knows, with the benefit of greater awareness, understanding and training, we might develop enough understanding to mix their use as our ancestors did.

GAUGED MIXES

It has been common practice for some time to use mortars containing a mixture of cement, lime and sand e.g. 1:1:6 or 1:2:9 or 1:3:12. These mixes are well established and conform to British Standards, hence they are specified a lot. They are all harder and less porous than pure fat lime mixes. The English Heritage Smeaton project has shown that gauged mixes with small amounts of cement (less than 1:2:9) are, in fact, less resistant to frost than straightforward fat lime mixes, and I would suggest that mixes of 1:2:9, or stronger, are rarely appropriate on old buildings. Some may consider that gauged mixes have fulfilled a useful role in the absence of available hydraulic limes. We now have (hopefully) an increasing range of hydraulic limes available that should replace the need for cement/lime/sand mixes. However, on a note of caution, it has been tempting for people to specify mixing hydraulic limes with non-hydraulic to modify their properties. It is difficult to modify properties that are not fully understood and it seems that diluting a 'weak' hydraulic lime tends to lose most of the hydraulicity, although it may be more appropriate with stronger hydraulic limes.

To summarise, there have always been a range of building limes whose properties varied and the situations in which they were used was dictated by either vernacular tradition or experience. The above overview is a generalised simplification of a complicated subject; although there are a few basic rules, there are also many exceptions to them. It is important that people specifying and using lime understand the basics and take advice where necessary. Anyone interested in joining The Building Limes Forum can contact the Membership Secretary at P.O. Box 251, Edinburgh, EH6 4DW, UK.

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