GUIDE TO THE USE OF LIME IN HISTORIC BUILDINGS NEW EDITION

Draft 2010

INTRODUCTION

Lime is the binder in almost all traditional mortars, plasters and renders. The use of lime is central to successful maintenance and repair of traditional buildings and natural stonework. An understanding of lime is essential for anyone working on historic buildings.

Lime has had a long history of use for building in Britain. The Romans employed it in their construction operations and it was used extensively in mortars and surface finishes from then until the nineteenth century when patent cements, such as Portland cement, were introduced. The use of lime declined in the twentieth century, but increasingly it has been recognised that hard, cement mortars are unsuitable for use on old buildings, and lime is enjoying a revival. However, much of the skill and knowledge needed to use lime successfully had nearly died out so when lime began to be more widely demanded in conservation work there was often a lack of suitably experienced specifiers and skilled craftsmen. The practical techniques required for the use of lime can be mastered by anyone with good building skills or a practical aptitude, but for successful use of lime it is essential to understand how the material works and to follow basic guidelines when using it.

This booklet explains how lime works, why it is of such benefit in maintaining and repairing historic buildings and gives guidance about using lime. It will be useful to owners of historic buildings who lack the confidence to use lime themselves or who would like to know more about it before instructing a builder to use it. It may also be handy for builders who are unfamiliar with lime, and serve as a reminder for those who have not used it for years.

The advice given in this publication will apply to many repair and maintenance problems encountered in historic buildings in South Somerset but it does not cover every eventuality. If you have a special case, such as surviving medieval render, stonework with very fine joints or decorative plasterwork for example, or if you have any doubts, you should seek further information before embarking on a project. The best way to learn about using lime is to have some practical training. A list of organisations offering training courses is included in Appendix 1. No responsibility can be accepted for unsuccessful work following the advice in this publication.

Applications

Lime is used in buildings in many different ways. It is mixed with sand to make lime mortar for bedding masonry and for pointing, rendering and plastering. For the very fine joints in ashlar masonry pure lime putty was sometimes used. Lime is diluted in water to make limewash for painting both internal and external walls. A coloured limewash is made by adding pigment.

Lime can also be mixed with carefully chosen sands and stone dusts to make repair mortars for damaged stonework. Lime also has valuable applications for specialist stone cleaning and conservation techniques.

Why use lime mortar?

Traditional building construction in South Somerset is based on the use of relatively soft and porous materials such as stone, brick, timber and cob, together with lime mortars for bedding and plastering. These buildings have solid walls, with no cavity, and are often built on poor foundations. They are therefore liable to settlement and movement associated with

seasonal changes in ground conditions and temperature fluctuations. Lime mortar is softer and weaker than the stone or brick that it bonds and is able to accommodate such slight movements without significant cracking. Also, it is permeable and allows water vapour to pass through it. It is this permeability, or 'breathing', which helps to keep the building dry inside without a damp proof course or chemical treatments.

What is wrong with cement mortar?

Modern cement mortar is very different from lime mortar. It is hard and brittle, less porous, less permeable, and sometimes completely waterproof. Its use on traditional masonry is damaging in several ways.

Cement pointing is harder than soft brick or stone and is too rigid to accommodate settlement or movement, such as often occurs in traditional buildings. When movement occurs the edges of the stone or brick are forced against the hard mortar spalling the masonry and often cracking the mortar itself.

Further damage is caused by rainwater seeping into the cracks in the pointing and around the edges of the stones. Because the mortar is not permeable this moisture cannot evaporate from the mortar joint once rain stops. Instead it is forced to evaporate through the brick or stone, and soluble salts present in the water crystallise in the surface layers of the masonry leading to crumbling and decay. This is sometimes so severe that the entire face of the stone is lost and the hard cement pointing is left standing proud. Further rainwater is trapped and the decay continues. The concentration of trapped water in the masonry also increases its susceptibility to frost damage in winter.

In contrast soft lime mortar allows moisture movement and, being more porous than the masonry, encourages evaporation and salt deposition in the mortar joints. Thus it is the mortar which decays and not the stone or brick. It is much easier and cheaper to re-point a wall than to repair or replace damaged brick or stone, and there is less loss of historic fabric.

Cement render causes slightly different problems. Hairline cracks inevitably form in the surface of the render either as it sets or afterwards due to slight movement in the wall. Rainwater is drawn by suction into these cracks and then diffuses into the wall. Once inside the wall this moisture, together with any rising damp, is trapped as it cannot evaporate outwards through the hard, impermeable render. Moisture levels start to build up in the wall and the moisture tends to diffuse towards the inner surface of the wall resulting in internal dampness and damage to plaster and decorations. So, strange as it may seem, applying a waterproof render can actually increase levels of damp inside the house. A porous lime render encourages evaporation of moisture from its surface, helping to minimise the effects of penetrating and rising damp.

Health and Safety

All lime and lime mortars are caustic and can dehydrate the skin. When using lime it is advisable to wear gloves, protective overalls and goggles and, if working with lime for prolonged periods, to protect exposed parts of the body with barrier cream. Goggles should always be worn if there is a risk of splashing from lime putty, mortar

MATERIALS

LIME

There is a wide range of different types of lime, each with varying properties suited to particular applications. When selecting the right materials for a project, it's not just a simple case of using lime rather than cement; the critical issue is selecting the correct lime for the job.

Non-hydraulic lime

At the lower end of the lime range is non-hydraulic lime. This is the softest and most porous of all limes, but when used correctly it can be extremely durable. Non-hydraulic lime is very widely used for conservation work today. It may also be referred to as high calcium lime, pure lime or fat lime. Non-hydraulic lime is suitable for use with the traditional building materials of South Somerset such as stone, clay brick and cob, in a variety of situations.

The Lime Cycle

Non-hydraulic lime is made from chalk or limestone (calcium carbonate) burned in a lime kiln to form quicklime (calcium oxide). The quicklime is added to water in a process known as slaking to form a creamy lime putty (calcium hydroxide). Lime putty can be mixed with sand to form lime mortar, or with water and pigments to make limewash. Lime mortar and limewash harden by a chemical process called carbonation as water evaporates and the lime reacts with carbon dioxide in the air. During each of these processes the lime undergoes a chemical change but the final stage, carbonation, converts it back to calcium carbonate, which is chemically and physically similar to the original limestone. This is known as the "lime cycle". Carbonation is a very slow process, so non-hydraulic lime hardens very gradually over several weeks, and it can take many months for it to achieve its full strength.

Non-hydraulic lime is available either as a dry powder or as lime putty. Both are chemically identical (calcium hydroxide) but the dry powder is made under carefully controlled conditions which ensure that there is no excess water once slaking is complete, whereas lime putty contains more water than is necessary for complete slaking, resulting in a sticky, wet paste.

Maturing

After slaking, the lime putty should be matured in a pit or container, which allows excess water to drain away, before it is ready to use. When quicklime is slaked it increases in volume and if quicklime is not fully slaked before it is used for plastering or rendering there is a risk that any unslaked particles will slake in situ, causing minor eruptions or 'lime pops' in the finished surface. Maturing ensures thorough slaking of all the lime particles and is essential in lime destined for plaster or render. Maturing also increases the density of the putty and allows the lime crystals to become smaller and flatter, which increases the workability of the lime and increases the speed of setting due to the large surface area of the crystals. Lime putty must be matured for at least one month before use, and ideally for at least three months. The longer it is matured the better, and for the best work use putty which is six months or one year old. The excess water in lime putty helps to protect it from reacting with the air so, once matured, putty can be stored indefinitely in airtight containers, without carbonating.

Powdered lime can start to deteriorate from the moment it is made. The powder particles have a large surface area which, when exposed to air, results in partial carbonation of the lime even before it is used for making mortar. Therefore it cannot create such an effective bond with sand or masonry. Furthermore, because the lime has not been matured in water

the crystals are much larger than in mature lime putty resulting in poorer workability and reduced speed of carbonation. Workability improves a bit if it is mixed with water and stored for at least 24 hours before use, but for best results use good quality, mature lime putty, not hydrated lime powder.

Hydraulic lime

The remainder of the lime range consists of hydraulic lime, of which there are several different types. Hydraulic lime is made by burning impure limestones, which contain, in addition to calcium carbonate, other minerals, particularly clay minerals such as silica and alumina, which become reactive when burned in the kiln, and combine with quicklime to form hydraulic compounds. Hydraulic quicklime can be slaked with water in a similar way to non-hydraulic quicklime, but because hydraulic lime starts to harden by reacting with water, hydraulic lime putty would have to be used soon after slaking and could not be stored for very long. Nowadays, hydraulic lime is supplied in powder form, which, if kept airtight and dry, has a longer shelf life. Hydraulic lime gains strength faster than non-hydraulic lime, because the hydraulic compounds react with water to form solid compounds comparatively quickly. Hydraulic lime also contains variable proportions of calcium hydroxide, which carbonates slowly, in exactly the same way as non-hydraulic lime, and results in a gradual increase in strength of the lime, following the initial comparatively rapid hydraulic set.

In the past the practice was to take hydraulic quicklime to the building site, where it was mixed with the right amount of sand and just enough water so that the lime slaked to a dry powder. The dry lime/sand mixture was then screened to remove lumps, and water was added to form mortar, which could be used for building and for rough rendering shortly after mixing. Such mortar was not used for fine work because there would be a risk of unslaked lime particles slaking in situ and disrupting the finished surface; for such work mature non-hydraulic lime putty was used.

Many people prefer hydraulic lime to non-hydraulic lime because, being a powder, it can be mixed and used in the same way as cement (with which they may be more familiar than lime putty) and because the rapid initial set can speed up the rate of work. However, as the strength of hydraulic lime increases, porosity and permeability decrease. This can cause problems for traditional buildings, since the lower the porosity and permeability of pointing or render the greater the risk of trapping moisture and of encouraging harmful decay processes in masonry and timber.

Drawing: simplified hydraulic lime cycle

<u>The Current Classification</u>
The proportion of clay and other minerals occurring in the limestone affects the strength of the lime and the speed with which it will initially set. There are three classes of natural hydraulic lime, termed NHL, under the current European standard - NHL2, NHL3.5 and NHL5. The classification is based on the compressive strength of the lime, with NHL2 being the weakest and NHL5 the strongest.

<u>Comparison with the Historic Classification</u>
In the past, hydraulic lime was probably the most widely used lime for general building and rendering. However, mainly due to less efficient burning methods, such lime was very weak compared to most modern hydraulic limes, and, in a classification dating from the nineteenth century, was quaintly termed ‘feebly hydraulic’ lime. Stronger hydraulic limes were classed as ‘moderately hydraulic’ and ‘eminently hydraulic’ and were reserved for engineering works such as bridges and tunnels. It is a common belief that the current three classes of hydraulic lime equate with the historic classes, but this is not the case. Most NHL2 lime on the market

is more akin to the traditional ‘moderately hydraulic’ lime than to feebly hydraulic lime. There is a big jump, in terms of strength and porosity, between non-hydraulic lime and NHL2. NHL3.5 is very popular nowadays, possibly on the false assumption that it is of ‘average’ strength and therefore suitable for the ‘average’ job. However, it can, in fact, achieve the strength and density of some modern cement mortars, whilst NHL5 is pretty much off the old scale of hydraulic lime and equates to materials historically termed ‘natural cements’.

In an attempt to bridge the gap between non-hydraulic lime and NHL2, an English manufacturer has recently started production of a true feebly hydraulic lime, which it terms NHL1, and which is available through specialist lime suppliers. The testing methods used to classify lime according to the European standard (which are the same methods as those used for cement) are not sufficiently sensitive to classify lime strength below NHL2, so the European standard does not recognise NHL1. This does not mean that the English NHL1 product is inferior or unsuitable for use, but rather that the testing regimes are inappropriate. This is being addressed and it is hoped that the European standard may be amended in future to include NHL1.

Sources of Hydraulic Lime

In South Somerset blue Lias limestone was historically an important source of feebly hydraulic lime for building mortars. Sadly its use declined and eventually ceased during the twentieth century. However, a full range of English hydraulic limes, made from Lincolnshire limestone and chalk, is available. Alternative supplies are imported from France, Italy and Switzerland.

Applications

The grade of hydraulic lime must be carefully chosen for the particular application but in general hydraulic lime is suitable for use with moderately durable stone and brick, especially in exposed conditions. As it is stronger than non-hydraulic lime most hydraulic lime (apart from NHL1) is unlikely to be suitable for use with weak materials such as cob and soft stone or brick. Unlike non-hydraulic lime, hydraulic lime is capable of setting underwater, and so may be suitable for use in areas where masonry is permanently damp.

Hydrated lime

The term ‘hydrated’ is often used when referring to lime and there is sometimes confusion about the differences between hydraulic lime and hydrated lime. ‘Hydraulic’ refers to types of lime that set partly due to a chemical reaction with water. The term ‘hydrated’ simply refers to any type of lime, hydraulic or non-hydraulic, which has been slaked, or in other words, ‘hydrated’ by combining with water. The terms ‘hydrated lime’ and ‘slaked lime’ mean exactly the same thing. Non-hydraulic lime putty, hydraulic lime putty, powdered non-hydraulic lime and powdered hydraulic lime are all hydrated limes.

However, many people, even professionals, use the term ‘hydrated lime’ to describe only the powdered non-hydraulic lime sold in bags at builders’ merchants. Although technically imprecise, this meaning of the term “hydrated lime” appears to have become the industry norm.

Suppliers of lime

If you ask for lime at a builders’ merchant you will almost certainly be offered powdered non-hydraulic lime sold in bags, usually called hydrated lime. However good quality non-hydraulic lime putty is superior and should be used wherever possible. Non-hydraulic lime putty and powdered hydraulic lime are available from an increasing number of suppliers, some of which are listed at the end of this booklet, but they are rarely available from builders’

merchants. Lime putty is usually supplied in plastic tubs in which it can be stored indefinitely if protected from frost. It should be matured by the supplier 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.
Alternatively, you can make your own lime putty by slaking quicklime as described below, but unless you are know exactly what you are doing, and have plenty of time and storage space, it is best to buy ready slaked lime or ready mixed mortar. Quicklime is usually only available direct from the quarry or plant where it was burned. For suppliers see the list in Appendix 2.

Slaking lime

Slaking quicklime causes a violent reaction during which a great deal of heat is generated and the lime will pop and spit. It is a dangerous operation and safety precautions must be taken. Protective clothing, including waterproof jacket and trousers, gloves and boots should be worn and eyes must be protected with goggles. Anyone not protected in this way should keep clear of the slaking area.

Non-hydraulic lime

Non-hydraulic quicklime should be slaked in a metal tank such as an old galvanised water tank, metal bath or feeding trough. For small quantities a galvanised metal bucket or dustbin can be used. Plastic should never be used because the heat generated may melt the plastic. If using a tank or bath with a plug hole it should be fitted with a bung and supported on bricks or blocks so that it can discharge into a suitable storage container. Traditionally this would have been a wooden lined pit dug in the ground but nowadays plastic tubs, dustbins or skips are often used.

Fill the tank with clean water to a depth of about 12 inches and add the quicklime a bit at a time using a shovel. Always add quicklime to water rather than adding water to quicklime, (which would cause an explosive reaction). The amount of quicklime to use can best be judged by experience but as a rough guide use 1 volume of quicklime to about 2 volumes of water. Fresh quicklime will react vigorously with the water generating a great deal of heat. As the mixture boils it should be stirred and agitated using a long wooden paddle, rake or hoe to prevent lumps of quicklime from being encased in slaked lime which would halt the reaction. Older quicklime will be more sluggish and the reaction can be speeded up by using hot or boiling water and by lightly crushing the first few shovel-fulls of quicklime. Keep stirring from time to time until the visible reaction stops. Add more water if the mixture starts to become dry and crumbly. You should be left with a thick creamy mixture with a few bits of grit and gravel at the bottom. Leave to cool.

Release the bung and allow the milky lime to pour into the pit or storage container via a sieve (2.36 mm mesh, or 10 holes to the inch) to collect the grit. If using a bucket or dustbin for slaking carefully pour the lime through a sieve into the storage container. The lime will settle out to form a mass of lime putty with a layer of water on top. The water protects the lime from the atmosphere preventing it from carbonating. Mature the lime putty as described above for at least 1 month, and preferably for three months, before use.

Hydraulic lime

Because hydraulic lime putty cannot be stored for long before it starts to set there is little point in slaking hydraulic quicklime to putty. The traditional procedure for slaking hydraulic lime with sand is described later, in Making Mortar.

AGGREGATES

The choice of aggregate is vital in determining the appearance and performance of lime mortar. Aggregates add bulk and strength to the lime, and act as a filler, helping to reduce shrinkage of the lime as it dries out. Technically, this is best achieved using a well-graded, washed aggregate. This means that there is a range of particle sizes, incorporating both fine and coarser particles, and that very fine clay and organic matter has been removed by washing. Such aggregates will interlock well, the smaller grains filling the spaces between the larger ones. If you scoop up a handful of well-graded sand and clench your fist you will feel the sand grains interlock forming a solid mass in your hand. Aggregates where the particles are all the same size or which include clay do not interlock to the same extent and will form less cohesive mortars. If you clench a handful of soft or poorly-graded sand it will tend to feel mobile in your hand. This is a useful test when buying sand. You can also use a x10 hand lens to look more closely at the range of grain size.

A well-graded aggregate will also impart a more pronounced texture to the mortar than one with uniform particle sizes. The texture of the mortar should reflect the type of masonry being repointed. Masonry with fine joints should be pointed with a fine aggregate whereas wider jointed masonry usually looks best and will perform better when pointed with a mortar containing some coarse material.

However, most historic mortars were composed of whatever aggregate was available locally, and rarely met the criteria of well graded and washed. In many areas, quarry waste was used for mortar making and in the Cotswolds there are records of masons using stone dust, crushed by carriage wheels, which accumulated at the side of the turnpike roads. Subsoil was commonly used as the aggregate in mortar, and in fact a great number of vernacular buildings were built using simply sub-soil as the bedding mix, relying on the clay content of the soil, rather than lime, to bind the material together. In such cases a surface pointing of lime mortar was essential as such mortars had little resistance to weathering. Rounded aggregates are commonly found in historic mortars, and many old mortars have a much higher proportion of fine particles, including earthy material and clay, than would be recommended today. Such fine material imparted a richness of colour to the mortar, but increased the tendency of the mortar to shrink as it dried out. For bedding mortars this was not particularly problematic, as the weight of the masonry helped to compress the mortar and close up any shrinkage cracks as they formed, whereas for a later re-pointing exercise the mortar would be subject to much less compression and therefore be prone to shrinking. Although it is usually desirable to try to match the composition and texture of the original mortar when re-pointing care should be taken to avoid reproducing mortars which contain too much fine material and which therefore may not perform well.

The colour of a mortar is largely controlled by the choice of aggregate. However, lime tends to whiten any aggregate with which it is mixed so that lime mortars are traditionally white, cream or pastel shades. 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 used today is sand, sometimes with the addition of grit where a coarse aggregate is needed. For most applications, the sand should be well washed to remove impurities such as clay, salts and organic matter which could all affect the performance of the mortar. On occasion, it may be appropriate to use unwashed sand but specialist advice should be sought. Sand should 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. This is because 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.

Useful sands for work in South Somerset are Chardstock, West Knighton, Moreton Cullimore and Warmwell sands, with smaller quantities of Corfe Mullen and Fine Yellow sand to give depth of colour. Good quality, named sands are available from the suppliers listed in Appendix 2. 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.

Crushed limestone dust is sometimes used as aggregate. Particles of limestone are more porous than quartz sand grains and can help entrain air into the body of the mix aiding carbonation and producing good, durable mortars. But, although stonedust was often used traditionally, it can be very difficult to use successfully for re-pointing mortars. As it is often a waste product from masonry sawing and processing it is usually very fine, which requires the addition of a great deal of water to make a workable mix and makes the mortar more prone to shrinking and cracking. If large amounts of stone dust are to be used, it should be crushed and sieved to produce a well-graded aggregate. Since most users do not have access to a set of standard mesh sieves, and since most suppliers would charge a small fortune to sieve stone dust for you, it is probably better for DIY users to avoid using it, or at least to use it in small quantities of say no more than $^1/_4$ part stone dust to 2 parts of sand.

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. With care, such mortars can be closely matched if required.

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 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, which will take several months. Waterproofers 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 pozzolans, may be added to lime mortar to increase 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 sold under the name of Metastar (see list of suppliers in Appenidx 2). These materials all contain clay minerals which have been heated to high temperatures (either naturally in the case of volcanic dust, or artificially in the case of clay bricks and china clay). This enables them to react with lime and water to form hydraulic compounds, similar to those occurring naturally in hydraulic lime.

Some builders gauge lime mortars with Ordinary Portland Cement or white cement to speed up the initial set. However research has shown that the addition of small quantities of cement actually weakens the mortar and cement should not be added to lime mortars. If

additional strength or speed of set is required, either use the appropriate hydraulic lime or gauge with a pozzolan.

Don’t be tempted to add a pozzolan to increase the strength of lime mortar in order to compensate for poor workmanship or bad site practice. In many cases non-hydraulic lime mortar or feebly hydraulic lime will perform perfectly well and be remarkably durable provided it is properly mixed and applied and allowed to dry out slowly and carbonate properly.

Animal hair is traditionally added to lime plasters and renders to reinforce the mortar and reduce shrinkage cracking. It is essential in strengthening plaster applied to wooden laths but is also frequently found in plasters and renders on a masonry backing, and occasionally in raised pointing. It should be supplied washed and sterilised. Synthetic fibres, such as polyproplyene, are also available. They are designed to reduce shrinkage in Portland cement screeds and renders but have been used successfully with lime mortars. However, to match historic work animal hair should always be used.

READY- MIXED MORTAR

A number of suppliers offer ready-mixed, non-hydraulic lime mortar. This is usually sold in 25kg bags, 15litre plastic tubs or, for larger quantities, in 1 tonne dumpy bags. Provided the lime putty has been matured, such mortar requires only tipping out and knocking up before use. A pozzolan can be added immediately before use if required. Each supplier will have a selection of standard mortars for different purposes such as pointing, plastering or rendering, but special mixes to match historic mortars can be supplied on request. Mixing your own lime mortar is time consuming and hard work so ready-mixed mortar, which is tried and tested, is ideal. Suppliers will also usually give advice about using the materials.

STORAGE OF LIME AND READY MIXED MORTARS

Lime putty and ready mixed mortar can be stored indefinitely in sealed tubs or plastic sacks provided it is protected from frost. Mortar is likely to stiffen over time and may require re-mixing or whisking with a plaster whisk to restore its plasticity before use.

Powdered lime must be stored in sealed bags in a dry place. Refer to the manufacturer’s instructions regarding the shelf life of unopened bags. Once opened the contents should be used within a couple of days, as even if the top of the bag is folded down, air will have got in and the lime will have started carbonating or, in the case of hydraulic lime, the hydraulic reaction will have started. If the lime feels gritty or there are any lumps in it then it should be discarded.

MAKING MORTAR

MIXES & PROPORTIONS

When using lime mortar to re-point or re-render an old building it is usually considered desirable that the new mortar is as close a match as possible to the original in terms of colour, texture and composition. Where a building has been re-pointed at some time in the past traces of the original pointing mortar can often be revealed in the joints behind the later pointing or render. It must not be confused with mortar used for a previous re-pointing or with the mortar used for bedding the masonry. Some lime mortar suppliers have facilities for analysing the constituents of old mortars so that they can be accurately matched, but for many simple vernacular buildings, mortars can be matched by eye and by making up a few trial mixes. Where it appears that the original mortar contained a high proportion of fine material and that a replica mix may perform poorly then it might be better to use a better-graded aggregate rather than to repeat a mistake for the sake of historical accuracy.

Where there is no evidence of the original pointing mortar an appropriate new mix can be made taking into account the type and hardness of the building material and the exposure of the building. In general, soft, porous or severely weathered stone must be treated with a softer, weaker mortar than hard, dense stone.

Which lime?

The decision whether to use non-hydraulic or hydraulic lime usually depends on the nature of the wall being treated and its degree of exposure, although sometimes the need to accurately match a historic mortar may be the deciding factor. Always use the weakest lime that is suitable for the particular application. In recent years there has been a tendency amongst some contractors and specifiers to use NHL3.5 in instances when such a strong lime is not needed, and where indeed its use could be harmful.

Scientific analysis of historic lime mortars, plasters and renders suggests that the majority of work in the past used lime in the non-hydraulic to NHL1 range of strength. Occasionally lime of roughly NHL1 to NHL2 strength was used, and only exceptionally was anything stronger encountered. One analyst, with over 25 years' experience of lime mortar analysis, has very rarely found a historic mortar as strong as a modern NHL3.5 mortar.

For internal plastering and for external work to soft walling materials, particularly in sheltered locations it is generally accepted that non-hydraulic lime will be suitable. For harder masonry and more exposed locations either a natural hydraulic lime or a pozzolanic lime might be more suitable. Guidance published elsewhere suggests that NHL1 is suitable for many purposes, including pointing and rendering weak masonry or cob, and for stronger materials in sheltered environments. NHL2 is appropriate for use on harder masonry in moderately exposed situations. NHL3.5 is suitable for lime concrete and should only be used for pointing or rendering historic buildings on the advice of a suitably experienced professional. NHL5 should generally be reserved for specialist works in extreme environments.

This is a subject about which there are strong and varied opinions, and many experienced and successful contractors contend that non-hydraulic lime or very feebly hydraulic lime is adequate for all but the harshest conditions, and that it is quality of workmanship which contributes to success or failure rather than strength of materials. There are certainly examples of non-hydraulic lime mortar being used to render church towers in exposed parts of the south-west with excellent results. If a contractor is very experienced and can point to examples of non-hydraulic lime work that have lasted well then it would be wise to take their advice and use a weak lime rather than to insist on a stronger one and run the risk of harming the masonry.

Where a hydraulic lime is appropriate, the choice between a natural hydraulic lime or a pozzolanic lime often rests with the personal preference of the person applying it or the architect specifying it. Non-hydraulic lime is very sticky and nice to use but it can be hard work incorporating the pozzolan evenly, especially for large volumes of mortar. Using a pozzolanic lime mortar can work out more expensive than using a hydraulic lime. Hydraulic lime tends to be leaner, or less sticky, and so can be more difficult to use. Because hydraulic mortar can be mixed more easily (see later section) it can work out cheaper to mix your own hydraulic lime mortar in a drum mixer than to buy ready mixed non-hydraulic mortar. However, hydraulic lime can be more irritating than lime putty as the fine powder readily becomes airborne and can get in the eyes and on skin or be inhaled into the lungs.

Generally it is not advisable to use a mixture of hydraulic and non-hydraulic lime in the same mix as the behaviour of such hybrid mixes is not properly understood, and in any case there is really no need to do so, as limes of every required strength are available without the need for blending. Some experienced contractors have used such hybrid mixes with success, but in less experienced hands they are best avoided. However, a very small amount of lime putty, say up to 10% by volume, added to a hydraulic lime mortar will improve workability without loss of performance.

Proportions

For a workable and durable mortar the minimum requirement is that each grain of aggregate must be coated by lime and the space between the aggregate grains should be filled with lime. If there is too little lime in the mix the mortar will be hard to use, there will be an inadequate bond between the aggregate and the lime and once cured, the mortar will be very porous and liable to frost damage.

The volume of lime required to coat each grain of aggregate and to fill the spaces between is equivalent to the total volume of voids in the dry aggregate. This can be determined by taking a known volume of dry aggregate and measuring the amount of water needed to completely saturate it, without any excess water being left on the surface. For example, if it takes 100ml of water to saturate 300ml of aggregate, the void ratio is 1:3 and it would take 1 part of lime to 3 parts of aggregate to make a workable, effective mortar.

Pic; measuring flasks showing the procedure

However, it is important to remember that wet lime putty contains water as well as lime, and that powdered lime contains a large amount of air in addition to the lime. So, gauging lime by volume is difficult as you have no idea how much actual lime is in any given volume of lime putty or lime powder. For lime powder, the amount of lime in any given volume depends on how much the lime has settled and compacted, and this is likely to vary each time the lime is measured out, as it is almost impossible to ensure the same degree of compaction each time. For lime putty the amount of lime in a given volume will depend on the maturity of the lime and the degree to which water has been allowed to drain from it. Therefore, in the majority of cases, when using lime in the proportion of 1:3 by volume there will be insufficient lime to produce a workable, durable mortar.

A number of historic records refer to mortars made of 1 part lime to 3 parts sand, but in this case the lime used was quicklime, not lime putty or hydrated powder (see ‘Mixing Hydraulic Lime Mortars’ below). As quicklime slakes it can expand by up to twice its original volume. Accounting for the air gaps between the nuggets of quicklime one volume of quicklime might yield say one and a half volumes of slaked lime, so a mixture of 1:3 quicklime:sand might

produce a 1:2 slaked lime:sand mortar. Analysis of historic mortars has shown that they were invariably richer in lime than modern mixes based on 1 volume of lime to 3 volumes of aggregate.

Quicklime is much lighter than lime putty and therefore more easily transported to site. Lime putty is heavier to transport and it is difficult to work sand into stiff lime putty, so it is likely that putty was only used as the basis for fine plasters rather than for general building mortars. For the majority of building works it was the custom to slake quicklime by placing a volume of quicklime, crushed to the size of small gravel, on the ground, adding a small amount of water and covering with damp sand. The lime would slake but in the absence of large quantities of water it would be converted to a dry hydrate rather than to putty. This could then be dry mixed with the sand, screened through a sieve to remove lumps of unslaked lime, and then mixed with water to form building mortar ready for use. Move to bit on making mortars.

Put in a box

Batching by weight

For accurate batching the amount of lime should be calculated by weight. To do this, you need to know the bulk density of the lime in kg per litre (available from the manufacturers) and to multiply this by the volume of lime required, as determined by the void ratio test. For example, a typical NHL2 hydraulic lime has a bulk density of 0.65.kg/l so for a sand with a void ratio of 1:3, for each 30 litres of sand, the amount of hydraulic lime needed is (10 litres x 0.65) = 6.5kg. If the volume of the 6.5kg of lime is then measured and found to be, say 15 litres when reasonably well compacted, this would make the volumetric ratio 1:2 rather than 1:3. Most practitioners will either be reluctant or will simply not have the facilities to gauge mortar by weight. It is therefore essential that manufacturers instructions are followed regarding the volumetric proportions of lime to sand, particularly when using hydraulic lime powder. This will invariably mean a higher proportion of lime to sand should be used – usually closer to 1:2 or 1:2½ depending on whether the mortar is for pointing or for rendering – to compensate for the volume of air in the dried powder.

For many well-graded aggregates 1 volume of lime to 2½ volumes of sand will be ideal to make a good bedding or pointing mortar. For re-pointing very finely jointed stone or brick a more lime-rich mix is usually used; a mix of 1 volume of lime to 1½ volumes of fine sand is quite common, and for the very finest of joints of only a millimetre or two, lime putty alone is often used. For rendering, the proportion of lime is usually increased, to say 1 volume of lime to 2 volumes of aggregate, because of the need for enhanced workability. A typical fine top coat plastering mix would be 1 volume of lime to 1 volume of fine silver sand.

By varying the type of lime and aggregate and their relative proportions an infinite variety of mortars can be created to suit the requirements for pointing, rendering and plastering. If you are in any doubt about the correct mortar mix, seek professional advice. A great advantage of buying ready-made lime mortar from a reputable supplier is that there is no guesswork involved, and most suppliers will advise on the correct mix to use for a particular project.

If you wish to mix your own mortar, the following table gives examples of mixes which might be suitable for certain applications.

MIXING NON-HYDRAULIC LIME MORTAR

It is vital that lime mortar is thoroughly mixed before use to ensure that the lime is well distributed and that any lumps are broken down. Good mixing is also needed to make the mortar more workable. Mature lime putty is initially stiff with a dry, cheesy consistency. It is rather hard to mix sand into this stiff mass and there is often a temptation to add water to help in mixing. However, with persistent chopping and beating with a shovel (extremely hard work), working with a plaster whisk (a little less exhausting) or mixing in a mortar mixer the lime becomes softer resembling cream cheese or toothpaste, and the sand can be worked into it without the need for extra water.

Traditionally mortars were hand mixed in a large, shallow wooden box using a hoe-shaped tool known as a larry. The mortar could be thoroughly mixed by turning it with the larry and by pressing it against the sides of the box. Some practitioners still use this method for hand mixing. Alternatively mixing on site can be done using either a shovel, plaster whisk or mortar mixer as follows:

Accurately measure the quantities of sand and mature lime putty using gauging boxes or, more commonly, plastic buckets. For the simplest hand mixing of small quantities tip the lime and sand onto a clean wooden mixing board. Using a clean shovel chop and press the mixture with the back of the shovel using as much downward pressure as possible and working across the heap from the far side back towards your feet. A dirty shovel with dried-on lumps of mortar will make mixing even harder work than normal, as the lime will stick to the shovel. Turn the mix over with the shovel and repeat the chopping and pressing until the sand and lime are well mixed and the consistency is soft and workable. This may take up to twenty minutes. It is unlikely that any water will need to be added as in most cases the water present in the lime putty is sufficient.

For mixing using a plaster whisk tip the ingredients into a large, flexible plastic tub and work with the whisk until the lime and sand are well mixed. Running the whisk in reverse helps to prevent the mortar splattering up into the air.

The revolving drum type of cement mixer is not ideal for mixing lime mortar. As there is no pressure applied to the ingredients the lime tends to remain lumpy and usually just sticks to the sides of the mixer without mixing with the sand. The temptation is to add more water but mortar made this way is too liquid and prone to shrinkage as the water evaporates. Instead put some bricks or stones into the drum whilst it is mixing, to help beat and compress the ingredients. Be prepared to tip the mortar out, stop the mixer, scrape the sides of the drum to remove adhered lime putty and then re-start the mixer for a final mixing to incorporate all the lime putty. A reasonable mix can be made this way after about 25 to 30 minutes mixing.

Commercially-made mortars are mixed in either a mortar mill or paddle mixer, which crush and squeeze the mortar ingredients together. The pressures involved ensure an intimate contact between the sand and the lime as well as eliminating lumps.

When properly mixed, a blob of mortar dropped from a height of a few inches onto a hawk will stick to the hawk when it is turned upside down.

The mixed mortar is known as coarse stuff and can be used immediately. It can also be stored indefinitely in airtight containers protected from frost. Some practitioners consider that coarse stuff improves by storing or ‘tempering’. When you come to use it you will probably find that it has stiffened up and it will need re-mixing with a shovel, plaster whisk, or mixer as described above, to restore its plasticity. This is called ‘knocking up’. No additional water

should be added.

If you buy ready mixed mortar you will simply have to knock it up ready for use. This is much easier than mixing your own mortar and for most people the extra cost of buying mortar is more than offset by the savings in time and effort. If the mortar is too sloppy leave it to firm up on a wooden board.

MIXING HYDRAULIC LIME MORTAR

Making mortar using hydraulic lime in powdered form is easier than using lime putty as, for small quantities, the sand and lime can be dry-mixed using a shovel or plaster whisk before the water is added, in the same way that cement mortar can be made. Alternatively, it can be successfully mixed in a drum mixer. Whatever method is used, you must be careful to avoid adding too much water. The mortar will become wetter and more plastic as mixing continues, and what might appear crumbly and unusable initially will produce a workable mix after about twenty minutes of mixing. The finished mix should be reasonably firm, not sloppy. Leave for about twenty minutes to allow the lime to swell or 'fatten up', to improve its workability, then mix again briefly immediately before using.

Hydraulic lime mortar will normally start to stiffen within a few hours, the actual time depending on the grade of lime and the temperature. Once it has started to stiffen, some manufacturers advise that it should not be re-worked (or knocked-up) to improve its workability as this will destroy part of the hydraulic set and reduce the strength of the mortar. However, some hydraulic limes can be left to fatten up overnight and be re-worked up to 24 hours later without harming them, so it is essential to refer to manufacturer's advice for the specific lime product you are using. No two limes are exactly alike, so the advice from one manufacturer of, say, NHL2 may be different to that of another manufacturer of NHL2. A hydraulic lime that is knocked up is likely to be stickier and more workable than one that is used shortly after first mixing.

The traditional procedure for making hydraulic lime mortar involved slaking hydraulic quicklime with sand. Place 3 volumes of damp sand on the ground and hollow it out in the middle to form a ring. Place 1 volume of nugget-sized quicklime in the centre of the ring, sprinkle with the same volume of water and carefully draw the surrounding sand over the quicklime to cover it completely. As the lime starts to slake (which may take some time as hydraulic lime is less reactive than non-hydraulic lime) it will expand and fissures will form in the sand. Pat these down with the back of a shovel to keep the mound of sand smooth; this keeps the heat in and speeds up the slaking process. The sand will probably get quite hot and it will start to dry out. Leave for several hours until all signs of expansion have ceased and the heap is cool to the touch. The quicklime should have slaked to a dry powder which can easily be mixed by shovel with the dried sand. Pass the sand/lime mix through a coarse sieve to remove any lumps of unslaked lime and the mixture can then be mixed to the desired consistency with water. On building sites in the past, it was often the custom to start this process on Friday afternoon, leaving the mix over the weekend to complete slaking. Enough lime/sand would be prepared for the following week's building.

A variation on this method of slaking is to add more water so that the quicklime is slaked to putty. The sand should be mixed in during slaking and the mortar then used whilst still hot for building. Such hot lime mixes are particularly effective in bonding with dense stones such as granite and chert, and have advantages for winter working. It is also possible that the heat generated during slaking might activate certain minerals in some sands resulting in slightly hydraulic properties.

RE-POINTING

WHEN TO RE-POINT

Pointing is vital in keeping a masonry wall weather-tight and sound. Many traditional walls were constructed using subsoil as the bedding ‘mortar’ and as infill between the two skins of masonry, with lime mortar being used only to seal the joint. Subsoil is firm and consolidated whilst dry but quickly turns to mud and is easily eroded when wet. The lime pointing is therefore essential to keep the bedding mix dry and to prevent instability in the wall. Even where lime mortar was used for bedding, the pointing is the primary defence against the weather. Lime pointing is intended to be sacrificial so that it decays in preference to the stone or brick. It therefore needs to be replaced from time to time.

Traditional lime mortars are usually comparatively soft and, although they can sometimes be scratched with a fingernail, they still perform their function of keeping the inside of the wall dry. Re-pointing is only necessary when the mortar has become so loose, powdery, decayed or eroded that water can penetrate the joints. Do not mistake soft lime mortar for decayed mortar. In most cases if much effort is required to scrape out the mortar then the wall does not need re-pointing. It is quite common to find that only some of the joints in a wall have decayed and in such cases only these joints should be re-pointed. If the replacement mortar is carefully selected the patching will quickly weather to match the rest and of course it is cheaper to re-point only those joints that need it rather than a whole wall. A great deal of money is wasted on unnecessary re-pointing, reducing the amount of money available for other repairs.

Loose or cracked cement mortar should be removed, but ‘sound’ cement mortar can sometimes be very difficult to remove. If that is the case, removing it may damage the stone so unless there is a problem of damp inside the building it may well be best to leave it until it cracks of its own accord (which it almost certainly will). Once it has cracked away from the face of the stone it can then be picked off quite easily. Unfortunately by this time the stone may have been damaged by the mortar but probably no more than would have occurred by trying to remove the mortar whilst it stuck firmly to the stone.

PREPARING THE WALL FOR RE-POINTING

Although lime mortar seems sticky when being used it will not stick well to smooth surfaces as it dries out and so it requires a good key (or roughening of the surface) to help to hold it in place. Thorough preparation of the surface is essential to create a good mechanical key.

Raking out lime mortar

Old lime mortar should be raked out using hand tools, preferably scraping and picking rather than hacking or chiselling. A hoof pick or bent spike is often handy for this. If the mortar is very firm it can be chiselled out using a quirk which is specially shaped to channel the mortar fragments out of the joint, or firesharp or tungsten carbide tipped masonry chisels. Avoid using a chisel that is wider than the joint as it will tend to wedge in the joint spalling the arris as it removes the mortar. Alternatively, on rubble stone a pecking hammer can be used. A reciprocating-blade saw can be helpful in removing lime mortar but is only likely to save time on masonry with regular coursing such as brickwork and squared rubble. Even then, the final clearing of the joint will have to be done by hand. The mortar must be cleaned off the top and bottom of the joints to leave a clean square joint, avoiding a V shape. It is vital that the joints are properly cleaned out or the new pointing will not last well and money will have been wasted.

Pic; selection of tools for raking out

Removing cement mortar

The difficulty of removing cement pointing varies enormously, depending on its condition, strength and how deeply it is applied to the joints. Where it is cracked, loose or has been applied fairly superficially without much raking out of the joint beneath, it may be fairly easy to prise, lift or chisel out of the joints. If the cement mortar is very deep it may be harder to remove, particularly if a strong mix was used. On no account should cutting discs be used to remove cement mortar as this will invariably damage the stone. Small tungsten carbide-tipped masonry or claw chisels, narrower than the joint, may help. They should be used across the width of the joint, the aim being to cut a small slice off the mortar, rather than trying to force the chisel under the edge of the mortar and prise it out of the joint, as this may well remove the edge of the stone along with the cement. Try to remove a small amount of mortar at a time rather than digging in deeply. A reciprocating-blade saw might work on fairly weak cement mortar without harming the masonry, but on hard cement mortar the blade is likely to bounce off the surface without getting a purchase.

Pic. Removal of cement pointing
Pic: Reciprocating saw

Very fine joints can be cleaned out using a hacksaw blade. On no account should you widen the joints to make pointing easier.

Rake out all loose, powdery or decayed mortar until sound mortar is reached, but in any case to a depth of at least the width of the joint, preferably one and a half times the joint width. For very narrow joints of only a few millimetres width it is advisable to rake out to a depth of at least 20mm. If you only rake out to the same depth as the joint width the resultant new pointing will have such little volume that it will be very difficult to avoid rapid drying of the mortar.

Sometimes, especially in the case of rubble walls which have been re-pointed in cement mortar, there may be large voids behind the pointing where bedding and core material have settled or been washed down and it will be impossible to reach sound mortar. Ideally such walls should be grouted to restore some strength and solidity, but alternatively the voids may be deep filled and tamped as described later.

Pic: Cleaned joint ready for pointing
Checking the depth of the raked out joint
Drawing;

Brush loose material out of the joint using a churn brush or old paintbrush. Dust can be removed by blowing down a length of tubing such as hosepipe (wear goggles to prevent dust in your eyes) which helps to avoid a slurry of old mortar running onto the face of the masonry when it is sprayed. Loose material can also be removed by using a hosepipe with a low pressure water jet nozzle, but it is essential to thoroughly rinse the surface of the masonry, or when the water dries there will be streaks of lime down the wall.

Once loose material has been removed, spray the wall with water to dampen joints and the mortar in the back of the joint (this will not be necessary if the wall has been cleaned out using a water jet, unless it has dried out before pointing starts). Depending on the scale of the project, a hand held pump-action water sprayer can be used, or a hosepipe with a spray

attachment. The masonry must be thoroughly dampened before the mortar is placed, otherwise it will draw the water out of the mortar before it has started to carbonate. Spray again a few minutes before pointing so that the joints are visibly damp, but there must be no water standing on the surface of the stone or puddles inside the joint. It is surprising how much water old masonry can absorb, especially very porous stone or bricks. Less porous stones, such as blue Lias or chert will require less dampening down than Hamstone or oolitic limestone.

Pic: spraying

TOOLS FOR RE-POINTING

A few simple tools are required for re-pointing. You will need a water sprayer or hose pipe for dampening the wall, a hawk to hold the mortar whilst you work and pointing irons or trowels that fit into the width of the joint to be pointed so the mortar can be pressed in firmly. Ordinary pointing trowels are seldom satisfactory, as they do not fit into the joint, although they can be cut or ground down to size, and may be useful for pointing rubble with very wide joints. Using the wrong tools makes the work surprisingly difficult and invariably results in a messy finish and less durable pointing. For finishing off you will need a short length of timber batten and a stiff bristle brush, such as a churn brush, or a piece of hessian.

PLACING THE MORTAR

Knock up the mortar immediately prior to use to ensure that it is workable. It should be sticky but not too sloppy and, when dolloped onto a hawk or trowel, should stick even when turned upside down. Dampen the hawk and scoop some mortar onto it using a gauging trowel. Draw the trowel across the mortar with a downwards motion, keeping the underside of the trowel firmly pressed against the edge of the hawk, to help the mortar stick to the hawk.

Pic: Putting mortar on the hawk

Hold the hawk close to the wall. Using the pointing iron cut off a thin wedge of mortar from the side of the hawk closest to the wall and push it into the joint, sliding the pointing iron to the right (if you are right handed) to press the mortar firmly into the joint and release the blade of the pointing tool. If you simply push the mortar into the joint and then pull the pointing iron straight out much of the mortar may well remain on the tool rather than in the joint. If you are right handed you should work along the joint from right to left so that each wedge of mortar is packed down onto the previous one. Be sure to push the mortar right to the back of the joint so there is no gap behind the new pointing.

Pic: Placing mortar

To re-point the perpendicular joints, angle the blade of the pointing iron slightly downwards when cutting the wedge of mortar on the hawk, and push firmly downwards as you slide the mortar towards the edge of the hawk. In this way, the mortar is pushed firmly onto the blade and should stick to it when you lift the tool clear of the hawk. You can then turn your hand through ninety degrees and press the wedge of mortar into the vertical joint. It takes a bit of practice but is a satisfying skill to master. For brickwork it is customary to re-point the perpendicular joints first, then the bed joints.

Pics.

Lime pointing should be built up in thicknesses of no more than 25mm to allow air to penetrate and initiate the hardening process. For joints of up to about 50mm fill the back of

the joint sufficiently to leave a regular 25mm joint remaining empty. For wide joints push some small bits of stone or clay tile into the backing mortar to reduce shrinkage and also save on mortar. Allow a couple of days for the backing mortar to firm up, before pointing up the last 25mm.

For joints deeper than 50mm, or where there are large voids, it is impractical to fill in 25mm layers which means that the mortar at depth is unlikely to completely carbonate, or will do so only very, very slowly. This is not necessarily a problem because the wall will still be stronger and more solid than it was before you started, and the main purpose of pointing is to provide protection from surface water, so provided the outer layer carbonates properly the pointing will fulfil its purpose. However, where maximum strength is required the mortar for deep filling could be gauged with a pozzolan or a hydraulic lime mortar could be used. Deep filling, especially of large voids, uses a lot of mortar and you should take account of this when estimating the amount of mortar you will need. Packing out the mortar with small stones or bits of broken clay tile saves both time and mortar.

Do all the deep filling first until all the joints are just 25mm deep, then do the final pointing of the whole area in one go to achieve a uniform finish. For wide joints push bits of damp stone or tile into the mortar, ensuring that they will be below the desired final surface. In some areas and with some stone types, such as the flint buildings of Sussex and for Scottish granite, it was the custom to leave these small ‘gallets’ or ‘pinnings’ showing, as this reduced the area of mortar exposed to weathering, but this is not the tradition in the south west.

Pic. Galleting in sussex

Slightly over-fill the joint. Do not try to smooth the surface with the pointing iron immediately, just push the mortar into the joint and leave it rough and proud for the time being. Sponge off any mortar that accidentally gets onto the face of the stone using clean water.

TENDING AND FINISHING

Leave the mortar until it starts to harden. It is important that the mortar is allowed to dry out very, very slowly so that setting and carbonation can occur. If it dries out before the chemical reactions have occurred it will be crumbly and friable and soon fail. The speed of set slows down as temperatures fall, and for hydraulic limes it is negligible below 5^0C. If you are lucky enough to have mild, calm, slightly damp conditions whilst re-pointing, the mortar will probably need little attention as it firms up. But if it is sunny or slightly windy you will need to protect and tend the work. The aim is keep the mortar damp by reducing evaporation of the moisture within it, rather than by re-wetting the mortar. The ideal way to do this is to cover it with a couple of layers of damp hessian, and to spray the hessian very gently from time to time, which will reduce evaporation of the water from the mortar, but will allow moist air to circulate across the surface of the mortar. If wetting the hessian with a hosepipe be very careful that the water jet doesn’t go straight through the hessian and soak the new pointing.

If strong winds and driving rain are forecast you may need to provide additional plastic sheeting or tarpaulins for protection. Ideally these should be fixed a few inches away from the surface of the wall so that air can circulate behind, but if they have to be fixed in contact with the hessian they should be removed as soon as the wind or rain has ceased, so that air can reach the mortar and continue the carbonation process.

The importance of slow drying cannot be over-emphasised, and applies to both hydraulic and non-hydraulic lime. If the mortar starts to turn very pale, almost white, then it is drying out too quickly, and lime is being drawn to the surface as water evaporates. Work that dries out too quickly cannot be successfully re-vitalised later by wetting and will simply have to be

re-done.

As the mortar slowly dries out it may shrink and crack. The cracks should be firmly pressed in, using a pointing iron or a piece of wooden batten, to close them whilst the mortar is still soft and pliable. Shrinkage is most likely on the widest joints, since there are larger volumes of mortar in such joints.

The mortar is ready for finishing when it is still damp and can be marked with a thumbnail, but has hardened up so that a thumb pressed onto the surface barely leaves any impression.

Pics:

A piece of timber batten or stick with a rounded end cut to the width of the joint can be used to press the mortar back into the joint and to rub it back very slightly to define the edge of the joint and bring out the texture. The joint can be further consolidated using a stiff bristle brush to beat the surface of the mortar. Avoid brushing along the joint as this can leave brush marks and can smear mortar over the face of the stone. A piece of hessian can also be used to push the mortar in and raise the texture. The purpose of this stage is to close up any cracks that might have formed as the mortar dries out and to ensure that the mortar is firmly pressed back into the joint. It also helps to remove feather edges and reveal the shape of the stone and brings out the texture of the mortar. This technique usually provides a good match for weathered historic pointing.

Pics

It is important that the mortar has reached the correct degree of stiffness before attempting to finish it. If the mortar is too wet the brush will leave bristle marks in the mortar, creating a frothy finish, and the mortar may be at risk of cracking as further drying and shrinkage take place. If the mortar is too dry, the finishing process will have little consolidating effect and tool marks left as a result of placing the mortar will remain apparent.

Pics:

At this stage skill is required to avoid creating an uneven, wavy surface to the joint. It is best to aim for a flat, vertical face to the joint, flush with the face of the stone. One of the main purposes of pointing is to help the wall shed rainwater quickly, and the flatter the surface of the wall the faster water will run down it. For ashlar and squared stone in good condition it is easy to achieve a flush finish simply by filling the joint to the arris of the stone.

Pic/ drawing

On rubble stone, which has fewer sharp arrises than ashlar or squared stone, achieving a finish that looks good and functions well can be a bit harder. It is necessary to bring the mortar over the edges of the stone, in order to form a more even wall surface. A slightly wetter mortar will be needed; aim for a consistency half way between a stiff pointing mix and a rendering mix. This technique uses a lot of mortar, and in some cases the wall ends up with almost as much mortar as stone showing. Traditionally, many simple vernacular buildings were finished this way, followed by protection with several coats of limewash. However, an even more common finish for rubble stone was lime render, forming a smoother, smarter finish than bare stone, and providing maximum protection from rainfall.

On squared stonework with weathered or spalled arrises it is also usually best to bring the new pointing flush with the face of the stone. This will have the effect of visually widening the joints quite considerably, compared with the fine joints of the unweathered masonry.

However, once stone has weathered to this extent it's appearance will have been significantly altered in any case, and it is usually better to use the pointing to help create a flatter wall surface which will shed water effectively and could be argued is more in keeping with the original smooth squared stone. If the pointing is set back within the original joint width it will create an undulating wall surface, which may increase the risk of water penetration. Occasionally there may be cases when recessed pointing is appropriate and if your building is listed you should seek advice from the Conservation Unit regarding an appropriate finish for re-pointing.

Lightly spray the new pointing using a fine mist spray and continue protecting with hessian (and possibly polythene) to prevent rapid drying. Both hydraulic and non-hydraulic limes must be kept slightly damp whilst they carbonate but at the same time air must be allowed to circulate. The aim is keep the mortar damp by reducing evaporation of moisture from the mortar rather than by re-wetting the mortar with a sprayer, although in all but ideal circumstances some light mist spraying will usually be needed. Keep an eye on new work for at least a week, ensuring the hessian remains damp, and dampening the mortar itself if it appears to be drying out.

Frost can cause damage to new pointing if temperatures drop below freezing whilst the mortar is still quite wet. It is best to avoid working outside with lime between October and April. It is a common misconception that hydraulic lime is suitable for winter use as it has a faster set than non-hydraulic lime. However this is not true because the speed of hydraulic set is temperature dependent. It is much reduced below 12 degrees centigrade, almost ceasing at 5 degrees (although it will recommence once temperatures rise). This means that hydraulic lime work carried out in low temperatures will gain strength exceptionally slowly and may be at risk from driving rain and frost damage for many months.

HISTORICAL FINISHES

The method described above will result in pointing that is a good match for old, weathered pointing. However, it is not an authentic historical technique. In the past pointing was finished using trowels and pointing irons, creating a smoother, denser surface with visible tool marks, and often with a distinctive profile, and much of this type of pointing survives to this day.

A common technique was to finish the mortar slightly raised with a pointed or 'birds beak' profile. This is also called 'double struck' pointing because the joint was finished by striking off first one side and then the other side of the joint with a pointing iron. This profile survives on both formal squared masonry and on rubble stone with comparatively wide joints. Another technique widely used was to finish the mortar more or less flush with the face of the stone by striking off excess mortar with a trowel, and then to run the pointing iron across the middle of the joint forming a 'false joint' line across the mortar. In both cases, it is very likely that the wall would then have been limewashed, so that the pointing would show through giving the impression of fairly regular finely jointed stone, even on a rubble stone wall.

Pics

Where extensive historic pointing of a distinctive style survives the aim should be to retain it and to carry out any patch pointing in a matching style. In the case of a listed building you should consult the Conservation Officer for further advice regarding a suitable finish.

RENDERING AND PLASTERING

LIME RENDER & PLASTER

Lime renders were traditionally applied to give protection to walls built of poor quality rubble stone or porous brick or to walls in exposed locations facing driving winds. They help by acting like a sponge, absorbing rainfall then allowing it to evaporate rather than soak into the wall. Most cottages and houses built of rubble stone would have been rendered originally and they tend to suffer from penetrating damp if the lime render is removed or replaced with a cement rich render.

There is a very wide range of types of lime rendering. Rubble walls of the simplest vernacular buildings and of many mediaeval buildings were often treated with just a single coat of render, or even a scratch coat amounting to not much more than a full, flush pointing. Such render is thicker in the hollows and very thin over the stone faces. There was little attempt to create a completely flat surface so the undulations of the wall and even some of the stones themselves were not concealed. Such render was invariably limewashed. On more prestigious buildings the aim would be for a more uniform finish achieved by applying a scratch coat to fill the hollows and take up some of the unevenness followed by one or two more coats which were worked to a flatter surface. Sometimes joint lines were ruled into the damp top-coat to create the illusion of ashlar, but a common finish for many houses and cottages was a rough-cast where the final coat consisted of a mortar slurry containing coarse grit applied by throwing from a special trowel. Protection with limewash was the norm. For interiors a fairly smooth surface could be obtained using a coarse render mix, but for top quality internal plastering the final coat would be richer in lime and polished up to a smooth, close finish.

Renders and plasters can be applied to a variety of backgrounds including cob (which should nearly always be rendered), stone and brick. Plaster is also applied to wooden laths for ceilings and internal partitions.

By carefully selecting appropriate aggregates it is possible to match existing renders and successfully repair failed patches without the need for complete re-rendering. Hollow or detached plaster can often be consolidated and saved and further advice should be sought before replacing it, especially if it is very old.

PREPARING A MASONRY WALL

Any hollow or decayed render should be hacked off and loose pointing should be raked out and any deep filling completed prior to rendering. Sound joints should be lightly raked out to provide a key. Brush the wall to remove loose material. Do not use metal? plasterers' angle beads on corners as this will create a modern appearance. Do not use chicken wire or metal lath to form a key as it can cause stress in the render due to differential thermal movements and leads to large-scale failure when it rusts.

Thoroughly wet the wall with clean water using a hose-pipe or sprayer. The more porous the background the more water will be required. Allow the water to soak in a bit then spray again, and repeat until the surface layers of the wall are thoroughly damp. When the render is applied the wall should be damp but not wet.

PREPARING STUD AND LATH

For plastering onto existing wooden laths check that they are firmly fixed and free of traces of old plaster. New laths should ideally be riven oak or chestnut. Sawn laths are inferior as they are smoother and weaker than those split along the natural grain of the wood. Laths should be fixed so that they are roughly a little finger's thickness apart. This allows the right amount of space for the plaster to be pushed between the laths and flop over the top of the lath to form good strong nibs. Do not apply preservative treatments to either old or new laths as they can introduce harmful salts into the plasterwork. Metal lath is sometimes used internally instead of timber laths as it is quicker to fix and cheaper, but it is harder to plaster onto as it is slippery and the sharp edges may cut into and weaken the plaster nibs. Timber laths should be thoroughly dampened before plastering.

MIXING PLASTER AND RENDER

A basic lime render or plaster can be made using the same ingredients and mixed in the same way as a pointing mortar. A coarse sand can still give a smooth finish suitable for most vernacular buildings although the mix should be slightly richer in lime than a standard pointing mix, say one part of lime putty to two or two-and-a-half parts of sand. Do not be tempted to use a soft, fine sand - you will just end up with lot of cracks. The mix will need to be slightly wetter than for pointing but it should be slightly stiffer than its modern cement or gypsum counterpart. Once you start plastering you will soon discover whether your mix is the right consistency: too thick and it will be virtually impossible to apply it smoothly and get it to stick to the wall; too thin and it will go on beautifully then slump, sag or drop off.

Whether you mix your own or buy ready mixed lime render or plaster it is a good idea to ensure that the lime putty used is at least three months old. This will ensure that the lime is thoroughly slaked. If the lime is younger than this any unslaked particles in the mix may slake some time after plastering causing a small eruption or ‘lime blow’. Many practitioners advocate the use of six month old putty for plastering, but few suppliers stock anything older than three months. If you are able to buy some and keep it yourself for a few months before use, so much the better.

When plastering onto lath it is essential to add hair to the mix to reinforce the nib of plaster between and behind the laths. Whilst it is not essential to use a haired mix for other backgrounds it can help to reduce shrinkage. Goat, cattle and horse hair are all suitable. Hair should be added to the mix just before use. Do not add hair to coarse stuff that is to be stored for more than about four weeks as the hair will rot quite quickly if left in damp lime mortar. The hair should be gradually teased into the mix so that it is well distributed and does not form clumps. As a rule add 5kg of hair per cubic metre of mortar for walls and at least 6kg per cubic metre for ceilings. For the second coat halve the quantity of hair. To check whether there is sufficient hair in the mix, scoop a dollop of mix into a gauging trowel, tap the underside of the trowel smartly against the top edge of a bucket so that the blob flattens and the surplus mortar falls off the edge of the trowel. There should be a fringe of hair at roughly 1mm intervals around the edge of the trowel.

APPLYING RENDER

There are many different ways to apply render depending on the type of finish required, the type of lime used and the preference and experience of the person applying it. The following should give you an idea of some of the common procedures but is by no means the final word.

Rendering or plastering is not something that can be easily taught without a practical demonstration, but if you have already done some plastering or can get someone to show you how, there are several guidelines that will help you to use lime render successfully.

Lime renders shrink as the water in them evaporates. This can be minimised by using a well graded aggregate, by ensuring that the wall is well wetted before you start and by applying the render in thin coats of no more than half an inch. It also helps if the mix is as dry as possible but obviously it has to be wet enough to be workable and if you observe the other points you can get away with a slightly wetter mix which is easier to use.

If there are deep hollows in the surface of the wall dub them out first using lime mortar and small bits of stone or tile, and allow this to firm up before applying the first coat of render. There is no need to try to create an absolutely smooth flat surface as on most old buildings lime render and plaster looks best if it follows the contours of the wall.

Lime renders must be applied using as much pressure as possible to force the mortar into the surface crevices or between the laths to form a close contact between mortar and backing. For masonry walls, whilst it is possible to apply render using either a gauging trowel or a plasterer's trowel the best result is achieved by throwing the mortar on from a trowel. This technique ensures the best bond between the mortar and the wall, expels any air in the mix and ensures that the mortar is well compacted. If you use a float or gauging trowel it is very difficult to apply the render with equal pressure all over the wall: it will tend to be under more pressure over the high spots and under less pressure in hollows and therefore more likely to drop off. Throwing render sounds difficult but it is surprisingly easy particularly for the scratch coat or dubbing-out coat, and involves less physical effort than using a trowel. This is particularly important if you are not used to plastering on a regular basis. It doesn't matter if the first coat goes on rather unevenly as you can remove any excess mortar by running the edge of a trowel over the surface to cut off the rough bits. Just remember to protect windows, rainwater goods and any other areas that you do not want covered with lime mortar, including yourself, particularly your eyes. If you prefer to trowel the mix on you may find it easier to apply the mortar using a gauging trowel rather than a plasterers trowel as it is better for getting into the hollows and maintaining an even pressure over the entire wall.

Once you have applied the scratch coat and got a fairly flat surface, subsequent coats can be applied successfully using a trowel, although it is still less effort to throw it on.

Tyrolean rendering machines which splatter mortar onto the wall do not achieve the necessary level of compaction of the mortar as it hits the wall and are not suitable for the application of traditional lime renders.

For plastering onto wooden laths a plasterers trowel is suitable, but you must apply the plaster with enough pressure to force the mix between the laths so that it can flop over behind the laths and form the key.

Use a clean tarpaulin or sheet of polythene to protect the floor or ground along the foot of the wall. You will then be able to scoop up and re-use any mortar that doesn't stick to the wall first time. If you simply cannot get the mortar to stick try re-wetting the wall or

experiment with a slightly wetter mix.

As you apply the render do not try to smooth the surface by stroking with a steel trowel or float. Working the surface of the wet mortar with a steel tool will draw the lime to the surface creating a lime-rich layer over a weak, lime-depleted layer, which can lead to premature failure of the render. Simply apply with one stroke, pushing hard or throw it on. If there are high spots or ridges hold the edge of the trowel against the wall and draw it across the surface. This will cut off the rough bits and leave a good open texture.

As the mortar starts to firm up it may develop cracks, although cracking will be minimised if the points above are observed, and hydraulic lime tends to suffer less from shrinkage and cracking. Cracks in the base coats can be left as they will not compromise the strength of the plaster and will be covered by subsequent coats. However, you must make sure that the cracks are due to shrinkage and not because the coat is peeling away from the backing; push the coat gently to check that it is firm against the backing.

Create a key for the second coat by scoring the surface in a pattern of wavy lines using a lath scratcher. Alternatively you can use a length of batten with nails hammered into but do not use the edge of a trowel as this will create too fine a groove to provide a good key. Some practitioners advocate throwing on the scratch coat and leaving it rough to provide the key for the next coat, but this depends on being able to throw the mortar on reasonably evenly in the first place or it will be almost impossible to render over it if there are huge humps and hollows. It is vital to take time and trouble over creating a good key as the adhesion of subsequent coats depends on it. Do not be tempted to miss areas in awkward places or at junctions with architraves or ceilings.

Pics

There are two schools of thought regarding when to apply the second coat. Some practitioners advocate applying the second and subsequent coats whilst the previous coat is still ‘green’ or ‘leather hard’, that is after it has firmed up sufficiently to resist indentation with a thumb but is still soft enough to scratch with a finger nail and is still damp. In many cases this will mean the next day, but varies according to drying conditions. For internal plaster it may be anything up to a week or so between coats. This method requires less dampening of the surface before application of the second coat and may achieve a better bond between coats. However, there is a risk that there might be further shrinkage in the base coat after the second coat has been applied, and it will take a lot longer for the undercoats to fully carbonate and achieve full strength.

The alternative approach is to allow the base coat to dry out slowly and start to carbonate. The work should be protected from drying out too quickly by covering with damp hessian for at least one week, and often for two to three weeks according to conditions. By this stage carbonation will have started (but not be very far advanced) and there should be no further shrinkage in the base coat. The base coat needs to be thoroughly dampened down before applying the next coat. This method is more dependent on a good mechanical key between the coats, and requires a longer period for completion of the work than the first method.

In the second coat cracks should be closed up by scouring the surface with a wood float using a circular movement and pushing hard to consolidate the coat. This will also enforce the bond between the coats and remove the high spots creating a flatter surface ready for the next coat. You may need to do this several times until the mortar is firm and no further cracks develop. The importance of this scouring and consolidation process for the success of lime rendering cannot be over emphasised. It must be done thoroughly no matter how wrist-breaking it may be.

Timing is also important. For non-hydraulic lime the mortar must be firm enough that the scouring will not just re-work the mortar, but not so firm that the cracks cannot be closed up. This can be anything from several hours to several days depending on conditions. For hydraulic lime renders once the mortar starts to firm up (which is usually within an hour or two of application) great care must be taken not to disturb the main body of the coat or the hydraulic set may be damaged. So, avoid vigorous scouring after this time, and simply press in the cracks to close them up.

Always ensure that the previous coat is damp before applying the next one. If applying a fairly fine top -coat, keying of the previous coat is best carried out using a comb scratcher or a devil float which creates a finer key than a lath scratcher. If the keying is too coarse it may well result in cracking of the top coat along the lines of the key because the render will be comparatively much thicker in these places.

Pics

The final appearance depends on the type of mortar used for the top coat and the tools used to finish it. Scouring with a wood float will result in a fairly open texture suitable for the majority of external renders on vernacular buildings. For internal plastering a combination of wood and sponge floats and a plasterers trowel can be used to create a smooth polished finish. A traditional type of external finish for simple cottages and farmhouses is known as roughcast. A slurry of mortar containing some quite coarse particles of gravel is thrown onto the top coat of render from a dashing trowel. This creates a rough, slubby texture with a large surface area which helps the wall to breathe, but requires some expertise to avoid a porridgey mess.

The work must be protected to prevent rapid drying. Both hydraulic and non-hydraulic limes must be kept slightly damp but at the same time air must be allowed to circulate. The ideal way to do this is to cover it with a couple of layers of damp hessian, and to spray the hessian very gently from time to time, which will reduce evaporation of the water from the render, but will allow moist air to circulate across the surface of the mortar. If wetting the hessian with a hosepipe be very careful that the water jet doesn't go straight through the hessian and soak the new pointing. If using polythene or tarpaulin to protect the render from wind and rain it should be fixed so that there is a gap between it and the wall. Otherwise, protect temporarily with plastic during rain or strong winds and remove the plastic when conditions improve.

Remember that water will drain down through the render under gravity so the upper parts of a wall will start to dry out faster than the lower parts and you may need to spray these areas more frequently. Frost can be a particular hazard to a young render as it can cause damage weeks after the render was applied, especially if preceded by heavy rainfall. It is a fallacy to believe that by using hydraulic lime or a pozzolanic additive you can "beat the frost". It is only the initial setting which takes place by hydraulic reaction and the mortar still requires a long period of time to carbonate and strengthen. If hard frost is forecast within a couple of months of application then ideally the render should be protected by hanging polythene, bubble wrap or hessian over it, although on most buildings this may be impossible. A render that survives its first winter unscathed is more likely to wear well subsequently.

REPAIRING RENDER

If patches of render have fallen off cut back the edges to sound plaster. The best tool for this is a craft knife. You can cut back using a bolster chisel but you risk loosening adjacent plaster. Ensure that the edges of the patch are cut square to provide a key for the new mortar, and eliminate feather edging.

Where render is cracked or hollow it may be possible to consolidate and save it and further

advice should be sought before hacking it off, especially if it is believed to be very old. However if it is beyond repair or not worth saving hack it off, cutting back around the edges to sound plaster.

Rake out any loose pointing in the wall behind and repoint roughly. Brush out loose dust and apply the render in thin coats following the guidance above, taking care to ensure that it is gently but firmly pushed in beneath the undercut edges of existing plaster. Be careful not to force the new mortar into the undercut as this might lift the surrounding render. Apply the final coat with a neat butt joint between the old and new and with a slight bulge in the middle of the patch so that the final consolidation will create a flat patch, flush with the surrounding render. Do not feather the edge of the patch over the surrounding plaster. Push back and consolidate the patch with a wood float. For small patches it is best to use miniature wooden floats which can be made by fixing a small handle to a short piece of batten and rounding off the edges with sandpaper.

A separate leaflet describes the techniques for repairing lath and plaster ceilings. See ****

LIMEWASHING

LIMEWASH

Limewash is the traditional paint for decorating rendered and plastered surfaces. In its basic white form it is known as whitewash but it can be tinted with pigments to form colourwash. It provides protection whilst allowing the wall to breathe. Its use has been largely superseded by modern masonry paints but these are much more expensive and even the so-called micro-porous paints are not as porous as limewash. Additional protection for external renders can be achieved by adding a water repellent such as tallow or linseed oil to the wash, although this reduces the porosity. Limewash is available from specialist suppliers, and it is easy to make from lime putty.

MAKING LIMEWASH

Limewash is best made from mature lime putty, ideally at least one year old. If young lime or dried lime is used the limewash will be more likely to flake and wash or brush off. Unfortunately many suppliers' oldest lime putty is three months old, so it is a good idea to try to buy it well in advance of when you might need it. Remember to wear protective clothing and goggles as making and using limewash inevitably causes splashes.

Put a couple of trowel-fulls of lime putty into a clean bucket and add a few inches of water. Mix gently using an old whisk or potato masher to break up the lime and create a thick creamy mass. Add more water mixing all the time until the mixture is the consistency of single cream. For large quantities you can use a power drill with a plaster mixing attachment. Pour the mixture through a sieve into a second bucket.

If using tallow melt a dessert spoonful of shredded tallow in hot water and add to the limewash stirring briskly. Alternatively add two spoonfuls of linseed oil to a bucket of limewash (about 3% by volume).

Add more water until the limewash is the consistency of milk. It is now ready for use. It will be much thinner than normal commercial paints and must be applied in several coats to achieve an opaque covering. For bare plaster you will probably need at least five coats to give good obliteration. Avoid the temptation to use a thicker consistency and fewer coats as you will increase the risk of the limewash crazing and flaking off.

For a coloured limewash mix some pigment in hot water and stir well. Stir the pigment into the limewash until the colour in the bucket is considerably darker than the required shade as it will lighten significantly as it dries. However, do not add large quantities of pigment in an effort to obtain strong or dark shades of limewash as the addition of too much pigment weakens the limewash making it powdery and liable to brush off. Limewashes are traditionally pale, earthy colours. For stronger colours it is necessary to add less water so that the limewash is thicker and there is proportionally more lime to bind the pigment but there is then the risk that the limewash will crack as it dries so it is best to stick to a thin, watery limewash and pale colours.

It is extremely difficult to make a second batch of limewash exactly the same colour as the first unless you record accurately the amounts of lime, pigment and water used. It is best to mix enough limewash for the complete job in one go, but to be on the safe side, keep a note of the recipe used.

APPLYING LIMEWASH

Brush down the wall using a stiff brush to remove loose debris. Always dampen the wall

before applying the limewash. If applying to new lime render wait until the render has hardened but is not fully carbonated, usually about a week or so depending on the rate of drying.

Use a large bristle brush to apply the limewash in a thin coat, working it well into any cracks or crevices in the surface. The limewash will be little thicker than water and liable to drip and dribble. Protect floors and furniture with polythene or dust sheets and protect yourself with goggles, gloves and overalls. Remember to stir the bucket of limewash from time to time as the particles of lime will tend to sink, and if you have added tallow or linseed oil it will start to separate out.

Protect the newly limewashed surface from rain or rapid drying using polythene sheeting, fixed so that it is not in direct contact with the painted surface.

Apply the limewash in several coats until the desired degree of opacity is achieved. For new plaster or render at least four or five coats will be needed, but for freshening up existing limewash two or three coats will be sufficient. Allow a day for each coat to dry before dampening the wall and applying the next coat.

FURTHER READING

Ashurst, John : Mortars, Plasters and Renders in Conservation. Ecclesiastical Architects and Surveyors Association 1983

Ashurst, John & Nichola : Mortars, Plasters and Renders - English Heritage Technical Handbook Volume 3. Gower Technical Press Ltd 1988

Cowper, A D. Lime and Lime Mortars. Facsimile of 1927 publication. Donhead Publishing 1998

English Heritage Directory of Building Limes. Donhead Publishing Ltd 1997

English Heritage Directory of Building Sands and Aggregates, Donhead Publishing Ltd 2000

English Heritage : *The Smeaton Project: Factors Affecting the Properties of Lime-Based Mortars* in Bulletin of the Association for Preservation Technology Volume 25, No 3-4.

Frew, Craig: *Pointing with Lime* in Building Conservation Directory 2007. Cathedral Communications 2007

Historic Scotland Technical Advice Note 1. Preparation and Use of Lime Mortars. Historic Scotland, revised edition 2003

Historic Scotland Technical Advice Note 15. External Lime Coatings on Traditional Buildings. Historic Scotland 2001

Homes, Stafford and Wingate, Michael. Building with Lime: A Practical Introduction. Intermediate Technology Publications 1997

Hughes, Phillip. The Need for Old Buildings To Breathe. Society for the Protection of Ancient Buildings: Information Sheet 4 1986

Lynch, Gerard. *The myth in the mix; the 1:3 ratio of lime to sand* in Building Conservation Directory 2007. Cathedral Communications 2007.

Millar, William. Plastering Plain and Decorative. Facsimile of 1897 publication. Donhead Publishing Ltd. 1998.

Pasley, C W. Observations on Lime. Facsimile of extracts from 1838 publication. Donhead Publishing Ltd. 1997

Schofield, Jane : Basic Limewash. Society for the Protection of Ancient Buildings: Information Sheet 1 1985

Schofield, Jane. Using Lime. Black Dog Press ???

Townsend, Andrew. Rough-cast for Historic Buildings. Society for the Protection of Ancient Buildings: Information Sheet 11 1990

Vicat, L J. Mortars and Cements. Facsimile of 1837 publication. Donhead Publishing Ltd 1997.

Williams, G B A. Pointing Stone and Brick Walling. Society for the Protection of Ancient Buildings: Technical Pamphlet 5 1986

Wingate, Michael. An Introduction to Building Limes. Society for the Protection of Ancient Buildings: Information Sheet 9 1988

APPENDIX 1: TRAINING COURSES

Ty Mawr
Mike Wye & Associates
Floods
DCRS
Lime Centre

APPENDIX 2: SUPPLIERS

Quicklime

ARC, Batscombe Quarry, Cheddar, Somerset. 01934 742733

Bleaklow Industries Ltd, Hassop Avenue, Hassop, Bakewell, Derbyshire. 01246 582284

Buxton Lime Industries Ltd, Tunstead Quarry, Wormhill, Buxton, Derbyshire. 01298 768444

H J Chard and Sons, Albert Road, Totterdown Bridge, Bristol. 0117 977 7681

Hargreaves Quarries Ltd, Hartley Quarries, Kirkby Stephen, Cumbria. 0176 83 71479

RMC Industrial Minerals, Hindlow, Buxton, Derbyshire. 01298 71155

Singleton Birch Ltd, Melton Ross Quarried, Barnetby, North Lincolnshire DN38 6AE. 01652 686000

Lime putty

R H Bennet, The Lime Centre, Nr Winchester, Hampshire. 01962 713636

H J Chard and Sons, Albert Road, Totterdown Bridge, Bristol. 0117 977 7681

Chichester Cathedral Works Organisation, Chichester, West Sussex. 01243 784225

Limebase Products Ltd, Walronds Park, Isle Brewers, Somerset. 01460 281921

Rose of Jericho, Westhill Barn, Evershot, Dorset. 01935 83662

J & J Sharpe, Merton, Okehampton, Devon. 01805 603587

Twyford Lime Products, 1 Twyford Place, Tiverton, Devon. 01884 255407

Mike Wye and Associates, Glebe House, Buckland Filleigh, Beaworthy, Devon. 01409 281644

Rory Young, 5 Park Street, Cirencester, Gloucester. 01285 658826

Hydraulic lime

Chichester Cathedral Works Organisation, Chichester, West Sussex. 01243 784225 (imported)

Limebase Products Ltd, Walronds Park, Isle Brewers, Somerset. 01460 281921 (imported and English)

Rose of Jericho, Westhill Barn, Evershot, Dorset. 01935 83662 (imported and English)

Singleton Birch Ltd, Melton Ross Quarried, Barnetby, North Lincolnshire DN38 6AE. 01652 686000 (English)

Telling Lime Products, Strawberry Lane, Willenhall, West Midlands. 01902 366718 (imported)

Hydrated high calcium lime (dried, bagged lime)

Available from most builders merchants

Ready mixed mortars

R H Bennet, The Lime Centre, Nr Winchester, Hampshire. 01962 713636

H J Chard and Sons, Albert Road, Totterdown Bridge, Bristol. 0117 977 7681

Limebase Products Ltd, Walronds Park, Isle Brewers, Somerset. 01460 281921

Rose of Jericho, Westhill Barn, Evershot, Dorset. 01935 83662

J & J Sharpe, Merton, Okehampton, Devon. 01805 603587

Twyford Lime Products, 1 Twyford Place, Tiverton, Devon. 01884 255407

Mike Wye and Associates, Glebe House, Buckland Filleigh, Beaworthy, Devon. 01409 281644

Limewash

R H Bennet, The Lime Centre, Nr Winchester, Hampshire. 01962 713636

H J Chard and Sons, Albert Road, Totterdown Bridge, Bristol. 0117 977 7681

Liz Induni, 11 Park Road, Swanage, Dorset. 01929 4237756

Limebase Products Ltd, Isle Abbotts, Somerset. 01460 281921

Potmolen, Warminster, Wiltshire. 01985 213960

Rose of Jericho, Westhill Barn, Evershot, Dorset. 01935 83662

J & J Sharpe, Merton, Okehampton, Devon. 01805 603587

Twyford Lime Products, 1 Twyford Place, Tiverton, Devon. 01884 255407

Mike Wye and Associates, Glebe House, Buckland Killeigh, Beaworthy, Devon. 01409 281644

Western Decorating Supplies, Old Creamery, Lynx Trading Estate, Yeovil. 01935 411707

Pigments

Brodie and Middleton Ltd, 68 Drury Lane, London. 0171 836 3289 (mail order service available)

Cornelissen and Sons, Great Russell Street, London. 0171 636 1045 (mail order service available)

Limebase Products Ltd, Walronds Park, Isle Brewers, Somerset. 01460 281921

J Myland Ltd, 8 Norwood High Strret, London, SE27 9NW. 0181 670 9161

Rose of Jericho, Horchester Farm, Holywell, Dorchester DT2 0LL. 01935 83676

Hair

ETP Sales, Goldcroft, Yeovil, Somerset. 01935 33538

H J Chard and Sons, Albert Road, Totterdown Bridge, Bristol. 0117 977 7681

Limebase Products Ltd, Walronds Park, Isle Brewers, Somerset. 01460 281921

Mayfield Exports Ltd, Wheatly, Oxford. 01865 58874

Rose of Jericho, Horchester Farm, Holywell, Dorchester DT2 0LL. 01935 83676

Linseed Oil

Raw linseed oil is available from builders merchants, hardware shops, decorating suppliers and art suppliers.

Tools

Sculptors' tools including small spatulas which are useful for repointing can be obtained from

South Western Industrial Plasters, The Old Dairy, Hawk Street, Bromham, Devises, Wiltshire. 01380 850616 (mail order service available)

Alec Tiranti Ltd, 70 High Street, Theale, Reading, Berkshire. 01734 302775 (mail order service available)

and at 27 Warren Street, London. 0171 636 8565

FURTHER INFORMATION