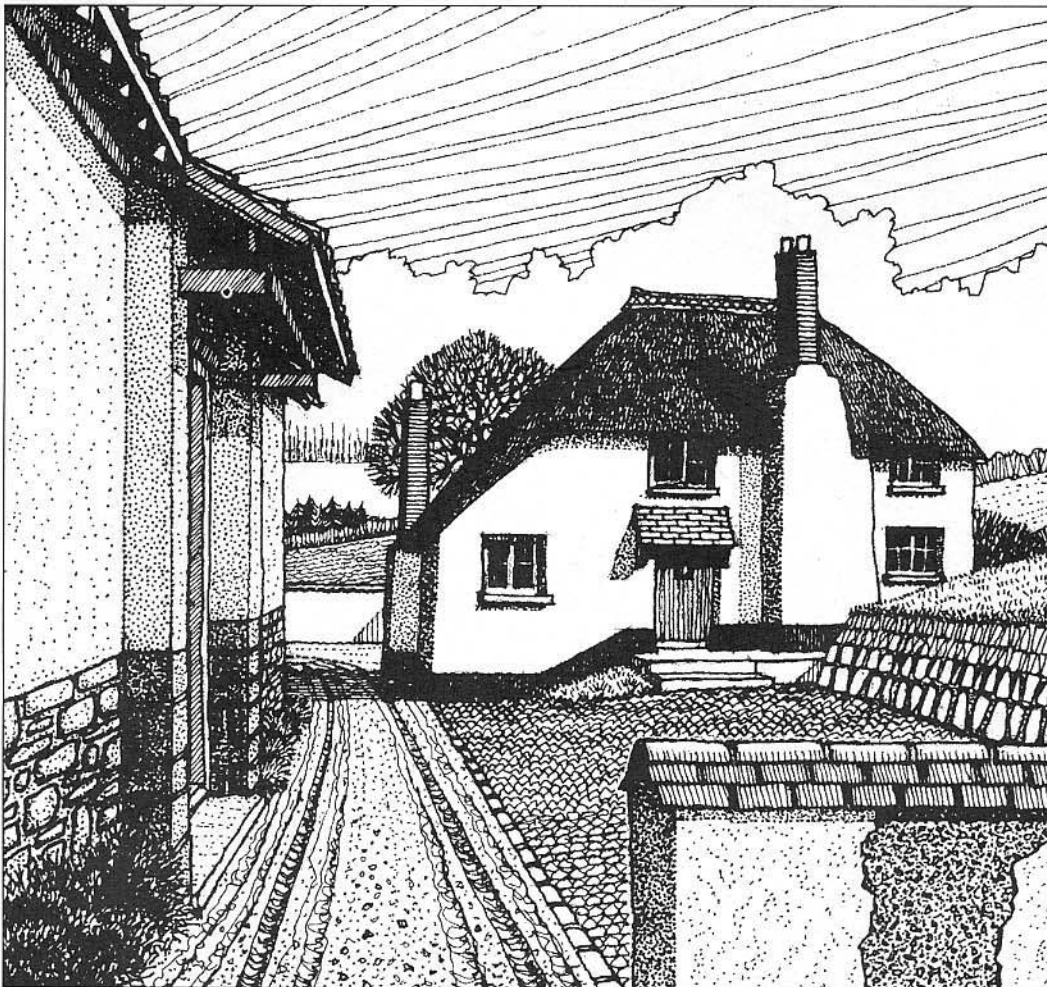




**DEVON EARTH
BUILDING
ASSOCIATION**



Appropriate Plasters, Renders and Finishes for Cob and Random Stone Walls in Devon

Second Edition 2002

INTRODUCTION TO SECOND EDITION

This is not intended to be a do-it-yourself manual. The information is given as guidance for those who are contemplating working on old cob or masonry buildings, whether they are owners, builders, surveyors or architects.

It is essential that the correct precautions are taken when tackling any building task and that the work is carried out by skilled experienced people. Consult your local authority to find out if the building is listed or in a conservation area before commencing any work. The organisations listed in the advice section will be able to help.

This second edition of the leaflet consists of the original text with some minor revisions and corrections, and a revised list of suppliers and materials; also a supplement containing notes on hydraulic limes and pozzolanic additives, permeability of applied finishes, and mud plasters; none of which topics were fully covered in the first edition.

The information contained in this document is given without responsibility on the part of the Association, publishers or authors.

Lime Based Mixtures

Most old houses built of cob and random rubble stone were intended to be coated with plasters and renders made with lime and finished with layers of limewash externally and limewash or distemper internally.

Advantages of Lime - Breathing and Moving

Old buildings need to 'breathe' and move. Cob buildings are especially sensitive to dampness and temperature change. Modern materials can cause severe damage to cob and masonry walls because they tend to restrict movement and breathing.

Lime-based materials, however, do allow walls to 'breathe' and move, produce inherently softer and more porous finishes than Portland cement, and adhere much better to cob and walls made of weak brick or stone.

Temperature and moisture cycling tends to produce micro cracking in all renders. Water is not absorbed easily into dense cement-based renders and is therefore concentrated at cracks. Water entering these cracks cannot easily escape and creates damp conditions in walls. A lime-based render acts more like blotting paper absorbing and releasing moisture relatively freely.

In addition small cracks may be closed by redeposition of soluble material from the lime.

Lime-based renders and plasters require more care and attention in their application and as they 'dry out'. For the reasons stated above the extra effort required is well rewarded.

Strong cement/sand renders and plasters with or without chicken wire or metal lathing as reinforcement, waterproof masonry points, modern emulsion paints and vinyl papers all slow down the passage of moisture evaporating from the wall which often leads to the render/plaster separating from the wall. Water may be trapped between wall and render/plaster, which can be harmful to the wall itself. If cob is allowed to become very wet it will most likely suffer progressive deformation and in some cases collapse.

Dampness

Damage caused by damp is most likely the result of the following:-

1. Failed flashings.
2. Defective gutters, downpipes and drains.
3. High ground levels against the building.
4. Rain splashing up from hard surfaces.
5. Failed or hard cement renders.
6. Plastic paints and wallpapers etc.
7. Poor design of windows and doors.
8. Failed roof coverings, e.g. slipped tiles and slates or decaying thatch, which expose the face and top of the wall.

By curing these problems the wall and the render/plaster will probably dry out. This can take several months with cob buildings. With luck no further work is required, but drying out can bring about failures due to the movement and crystallisation of soluble salts in the wall.

Render at the foot of the wall is in a vulnerable position and can be eroded due to splash-up from hard surfaces such as concrete, brick or stone paving, or because of rising damp. It is not good practice to apply a hard cement mix in these areas (although this has often been done in the past). Where there are no gutters and water runs off the roof and onto the ground - as is often the case with thatched roofs - a strip of gravel, say 1'6" to 2'0" (450-600mm) wide against the wall foot will minimise splash-up. This may also help alleviate rising damp by providing an area through which groundwater can evaporate.

The causes and effects of dampness in cob walls

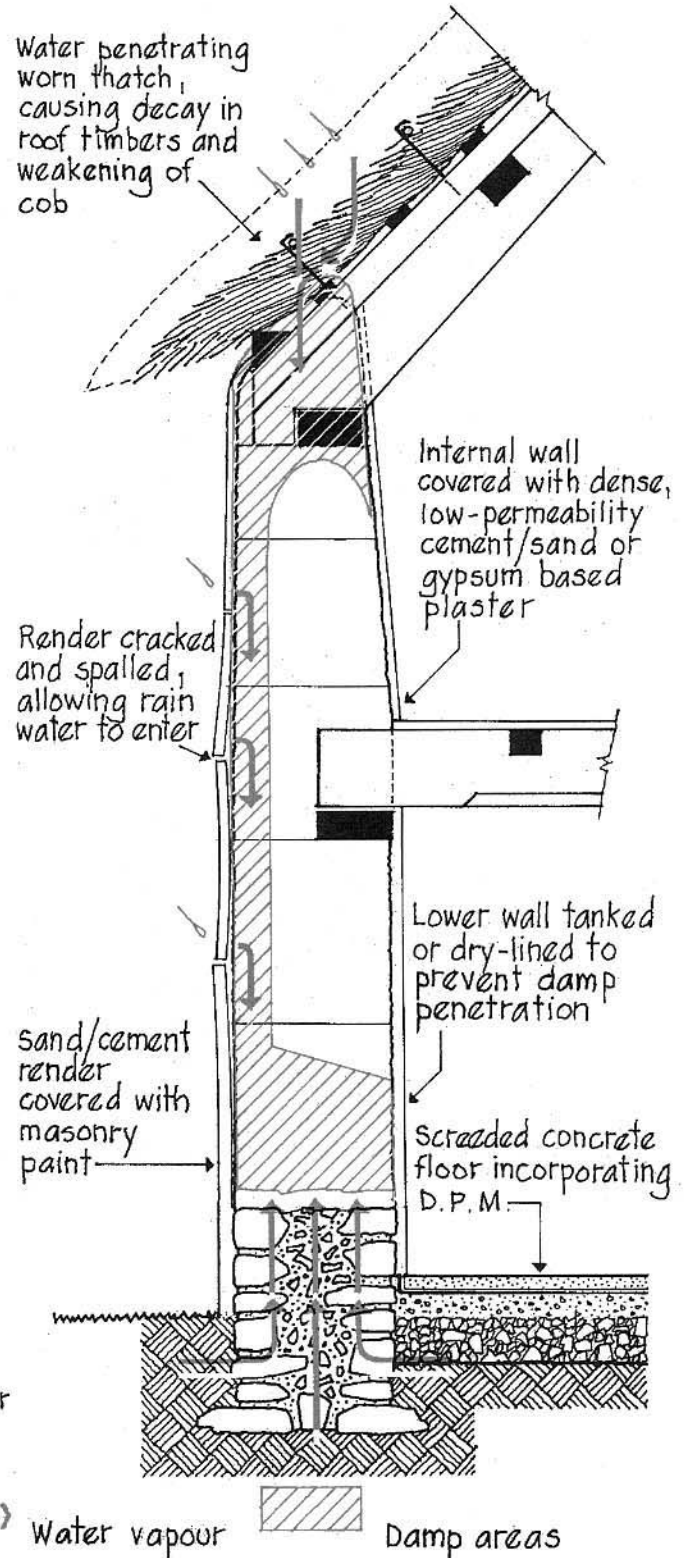
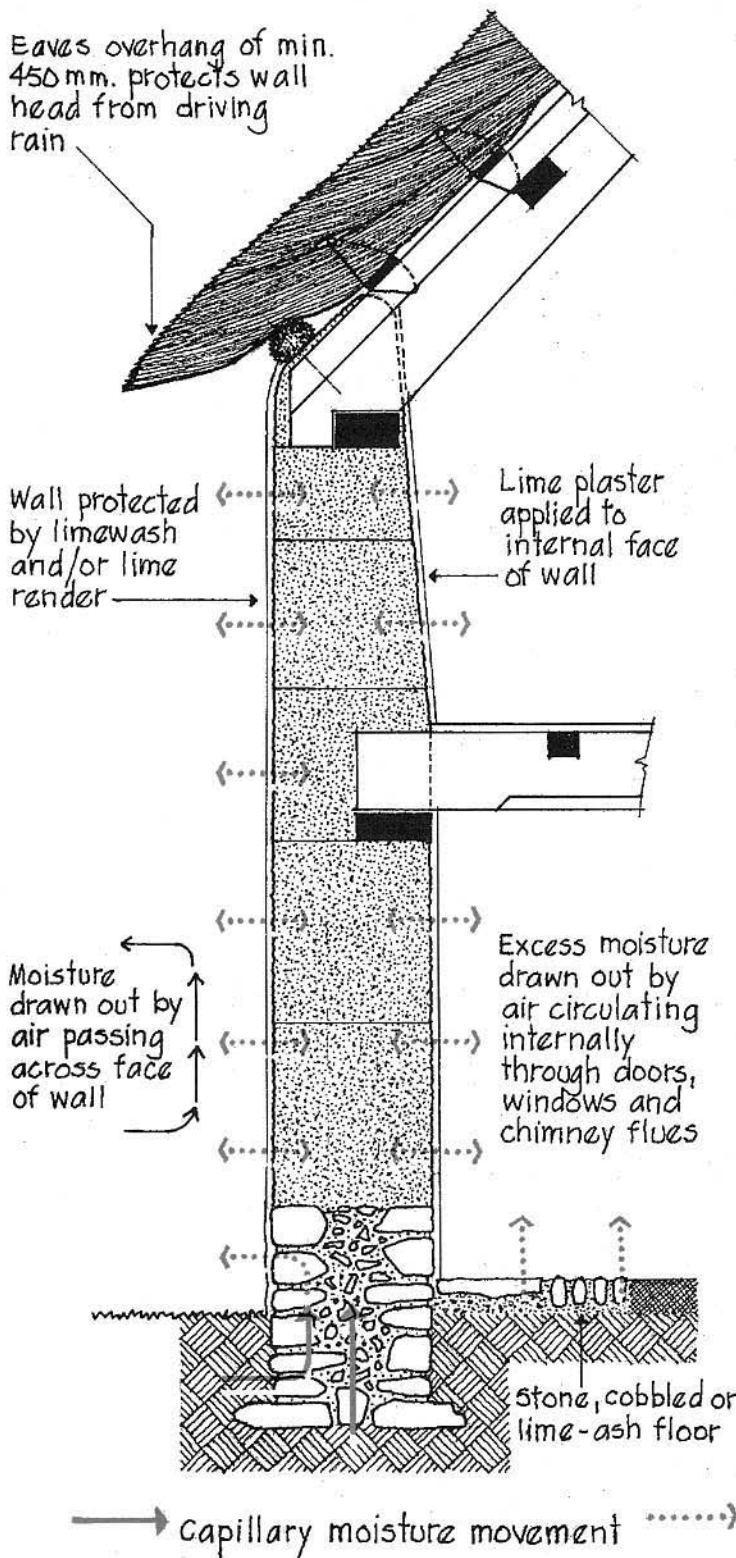


Fig. 1A Wall of unaltered cob building showing how a state of moisture/air equilibrium is achieved.

Fig. 1B Neglect combined with inappropriate repair/maintenance can upset the balance and lead to rapid deterioration.

The effectiveness of injected damp proof courses (DPCs) in rubble masonry is doubtful, and the internal 'waterproof render' they are typically coupled with, is almost always harmful to walls of cob and masonry. For these reasons the Association considers their use, either singly or in combination, wholly inappropriate.

When building new walls, or rebuilding existing ones from ground level, a proprietary sheet damp proof course can be incorporated 6" (150mm) above ground level in the conventional manner. It is, however, seldom necessary to install a damp proof course in walls of solid construction which have the benefit of breathable finishes and decorations.

REPAIR OF EXISTING RENDER AND PLASTER

Renders and plasters can often sound hollow when tapped because they have separated from the wall behind (often identified in buildings of cob construction). Traditional mixes of render and plaster generally include hair, which holds them together, and keeps them serviceable even when they have separated from the wall. It is a matter of judgement whether wholesale replacement is necessary; repairs in such areas will often provide sufficient strength to allow retention of the loose material. Grouting behind loose areas may be a solution, however this is a specialist technique. Further information can be found in 'Mortars, Plasters and Renders', English Heritage Technical Handbook, Vol. 3.

Where the majority of the wall finish is sound, areas of missing or worn render/plaster should always be carefully patched. This is essential if the original material is of some antiquity. It is always worth taking photographs as a record before and during any work.

RE-RENDERING

Surface Preparation

- A. Carefully remove failed renders using hand and power tools that do not disturb the substrate through vibration.
- B. Because cement-based renders tend to come away in heavy sheets and sections, protect yourself and areas on and around the building that might be damaged in the process of removal and by the application of the replacement render (i.e. drains, windows, doors etc.). Masking which uses polythene and tape is very effective.

- C. Where walls are made of brick or stone they should have their joints raked back 1/2" (13mm). Do not hack the surface to provide a key for the renders.
- D. Removal of failed renders/plasters often exposes other problems. If rebuilding or crack stitching is necessary this should be carried out using lime mortar, and not cement. As noted above hard, cement-based plasters, renders, waterproofing materials and tanking applied internally and externally trap moisture; as a result cob walls invariably become saturated (see Fig. 1B). In such cases the cob deteriorates to the point where it loses much of its strength, the consequence of which may be serious structural failure. Recent experience suggests that the removal of renders from saturated cob walls can precipitate such a failure. For this reason it is recommended that if high moisture levels are suspected, especially in the area of the wall just above plinth level, then expert advice should be sought before starting any work.

If uncertainty exists concerning the state of cob walling it is worth removing small areas of render near the base of the wall in order to ascertain its condition.

(NB See Devon Historic Buildings Trust pamphlet *The Cob Buildings of Devon, 2: Repair and Maintenance*.)

- E. Cob walls are not always straight and level. No attempt to improve on their general line should be made when preparing them for plaster and render. However, walls may have small depressions in their surface where an area of the material has fallen away. These "hollows" may be anything from 4" to 9" (100-225mm) across and as much as 3" (75mm) deep. Without changing the general line of the wall these should be filled out. Recent experience in Devon has shown that a mix of subsoil, screened through a 3/8" (10mm) mesh sieve, and chopped hay is suitable for dubbing out cavities up to 4" (100mm) in depth. The material should be rammed or beaten, preferably into squared off and undercut cavities, in a fairly dry plastic state in order to avoid excessive shrinkage. The cavity having first been thoroughly dampened, wedge-shaped shards of slate may be driven into the wall at an angle to provide a key for the new cob infill material. It may be necessary to repair larger cavities with cob block and/or tiles - (See Devon Historic Buildings Trust pamphlet *The Cob Buildings of Devon, 2: Repair and Maintenance*).

Alternatively the advice given in the first edition of this leaflet, as described as follows, is still employed by some practitioners. The material to be a mix of 3: 2: 4: 2 lime putty: sieved subsoil: sharp sand: fine gravel of 3/16 - 3/8" (5 - 10mm) diameter with chopped straw or hay added, and no water. Hammer in 4" (100mm) long galvanized slab nails, lengths of riven oak pegs or riven hazel spars (one every 2" (50mm) - or as necessary - across the surface) at angles, to provide a key for the filling material. Wet the existing cob surface and fill up the hole, pushing in the mix in layers if necessary. Put in no more than 1" (25mm) thickness at any one time, waiting for that to dry out and then wet the surface again before adding the next layer. The amount of time the material takes to dry out depends on the air temperature and humidity.

- F. Apply a gentle spray to the area to be rendered/plastered using a pump-type garden sprayer. In the case of cob walls each part of the wall may be worked over for 2-3 minutes at a time about 3-4 times (leaving 10 minutes between each spraying - thereby allowing the water to soak in) so that the wall is thoroughly dampened. The wall can never be too damp. This process is most important to prevent the render/plaster drying out too quickly and cracking. Do not use a garden hose as this will, most likely, erode the surface of the wall.

MATERIALS AND MIXES

Lime Putty was traditionally the basis of all lime renders, plasters, mortars and washes.

Ready-made Lime Putty (matured for a minimum period of six weeks) is the easiest, safest and most effective way to buy the material - see list of suppliers.

Quick Lime (lump lime), can be slaked to produce lime putty. This process involves some danger and requires experience for successful results. Seek advice before slaking your own lime.

Natural Hydraulic Lime (see Supplement)

Bagged Hydrated Lime Powder is a poor substitute for either of the above. Even when soaked in water to produce a putty, performance is noticeably less good. If the bagged material has stood at the builders merchants or their suppliers for some time it loses strength. For this reason bagged lime powder is not recommended.

Sands and Aggregates

For all mixes other than limewash, sands and/or aggregates will be required. These provide bulk at low cost, and control shrinkage. If shrinkage cracking is a problem, get advice on the sand/aggregate that you are using. Limestone aggregate is particularly recommended. Sea-dredged sands will need washing several times in clean water to remove salt.

Grading of Aggregate

For all mixes - mortars, plasters and renders it is essential to have a range of particle sizes from the smallest up to as much as 3/16" (4mm) in the case of roughcast renders.

Hair

All plasters and renders on cob or stone walls work well with hair in the mix. Some minor shrinkage cracking often occurs with mixes containing lime, the hair helps control the shrinkage.

The hair should be clean, neither too short nor springy (see Sources of Materials). Cow hair was used traditionally and is to be preferred. However, this is sometimes difficult to obtain; imported goat and yak hair is now frequently used.

Setting Additives

Avoid the use of cement. Other 'pozzolanic' material such as brick dust and fired kaolin may be used - see supplement

Mud Plasters - see supplement

Binders in Limewash

Tallow, linseed oil, casein powder or skimmed milk can be added to limewash. They make more durable, but less breathable, paint. Too much tallow or linseed oil will make a waterproof oil based paint

Pigments

These can be obtained as a dry powder or in concentrated liquid form

Blending the Materials

For mortars, plasters and renders the lime putty has to be pre-mixed with the sands and aggregates to make coarse stuff. Mix the putty thoroughly with the sands and aggregates, turning, beating and chopping the coarse stuff. This can be done in a mortar mill, pan or drum mixer (the latter is often known as a cement mixer). Do not add any water.

Store the coarse stuff under wet carpet underlay felt, or wrapped in polythene, or wet sacks in bins with airtight lids for at least two weeks. Remove only enough coarse stuff for one day's work, onto a

clean board. Mix again chopping, beating and ramming - this will make it more 'plastic'. Extra water should not be needed. At this stage add the setting additive and/or hair if they are required.

Mortar producers can provide a very economical alternative to this DIY method. Commercially produced mortars should still be allowed to stand for at least two weeks after delivery (see 'Sources of Materials' below).

Suggested Mixes for Mortars, Renders and Plasters (measured by volume)

Roughcast Render: Backing and Finish Coats.

2 x coarse sand

1 x grit - up to 3/16" (4mm) dia. or if obtainable 1/4" (6mm) (preferably the grits should be rounded not crushed)

1 x lime putty

1 x bucket of the mix to 1/2 bucket of teased* hair (omit hair in final thrown coat).

**Hair must be teased out with, for example, carding combs to remove the large clumps - a tedious but worthwhile process.*

Smooth Render

1 x coarse sand

1 x grit (up to 3/16" (4mm) diameter)

1 x fine sand

1 x lime putty

1 x bucket of mix to 1/2 bucket of teased* hair.

Mortar for Bedding

12 x coarse sand

3 x lime putty

gauged with 1 x pozzolanic additive

Mortar for Pointing

3 x coarse sand

1 x lime putty

Limewash

Limewash is composed of lime putty and water. It is available ready-made (see Sources of Materials) or can be made up as briefly described below. Mix the putty and water together to a consistency of skimmed milk. Sieve through a fine kitchen sieve. If pigment is required ensure it is thoroughly premixed by adding it to a little warm water in a jam jar, seal the jar's lid and shake vigorously. Add to limewash, stir and sieve limewash again.

For limewashes on external walls (only) tallow or linseed oil can be added. Warm the limewash in a metal container, add the oil and continue heating until it has blended with the mixture. Use no more

than 1 walnut-sized lump of tallow or 2 dessert spoons (1 tablespoon) of raw linseed oil to every 2 gallons of limewash. Pumice may be added to limewash to encourage faster curing, thereby permitting its application in harsher weather conditions. Use pumice in the ratio 1 part to 12 parts of lime putty.

SOME SOURCES OF MATERIALS

| | | |
|-----|---|-------------------------------------|
| NHL | - | natural hydraulic lime |
| L | - | lump lime |
| LP | - | lime putty |
| Po | - | pozzolanic additives |
| p | - | pumice |
| RM | - | ready mixed coarse stuff & plasters |
| EP | - | earth plaster |
| H | - | hair |
| C | - | casein |
| T | - | tallow |
| LW | - | limewash |
| D | - | distemper |
| Pi | - | pigments |

The letters after each stockist's name indicate availability of the materials (*at time of going to press*).

A.R.C. Southern - L

Battscombe Quarry, Cheddar,
Somerset BS27 3LR Tel 01934 742733

Back To Earth - LP, Po, RM, H, LW, PI

Jubilee House, Cheriton Fitzpaine,
Crediton EX17 4JH Tel 01363 866999

Blackfriar, E. Parsons and Sons Ltd - D (known as paste whitecoat sold for use on ceilings only).

Blackfriars Road, Nailsea, Bristol BS19 2DJ
Tel 01275 854911

Brodie and Middleton Ltd - Pi

68 Drury Lane, London WC2R 5SP
Tel 0207 836 3289

Cob Construction Co - L, LP, RM, H, LW, PI

Station House, Station Yard,
Exminster EX6 8DZ Tel 01392 834969

Cornish Lime Co. - NHL, L, LP, Po, p, RM, H, T, LW, D, Pi

Brims Park, Old Callywith Road, Bodmin, Cornwall
PL31 2DZ Tel 01208 79779

H.J. Chard and Sons - LP, RM, H, T, Pi

Albert Road, Bristol BS2 OXS
Tel 0117 977 7681

also at: Springfield Lane, Weston Zoyland,
Bridgewater. LP (for collection only)

Tel 01278 691193

Dulux Decorator Centres -

some lime materials available to order

Farrow and Ball (Southern Ltd) - D

Uddens Trading Estate, Wimborne,
Dorset BH21 7NL Tel 01202 876141

Fiddes and Sons Ltd - Pi

Florence Works, Brindley Road,
Cardiff CF1 7TY Tel 0292 034 0323

HL2 Ltd - NHL

Tout Quarry, Charlton Adam,
Somerset TA11 7AN Tel 01458 223179

Limebase Products - NHL, L, LP, Po, p, RM, H, T, LW, D, Pi

Walronds Park, Isle Brewers, Taunton TA3 6QP
Tel 01460 281921

Kevin McCabe - L, LP, RM, H, T, LW, Pi

Lower Tricombe, Northleigh, Colyton,
Devon EX24 6DA
Tel 01404 871487

Nutshell Natural Paints - C, Pi

PO BOX 72, South Brent, Devon TQ10 9YR
Tel 01364 73801

Potmolen Paint - LP, Po, H, T, LW, D

27 Woodcock Industrial Estate, Warminster, Wiltshire
BA12 9DX Tel 01985 213960.

Rose of Jericho St Blaise Ltd - LP, RM, LW, D

Westhill Barn, Evershot, Dorchester,
Dorset DT2 0LD Tel 01935 83662

J & J Sharpe - NHL, L, LP, Po, RM, EP, H, LW, Pi

Woodside, Merton, Okehampton,
Devon EX20 3EG Tel 01805 603587

Tamar Trading - NHL

15 Bodmin Street, Holsworthy,
Devon EX22 6BB Tel 01409 253555

Twyford Lime Products - NHL, L, LP, RM, LW, Pi

1 Twyford Place, Tiverton EX16 6AP
Tel 01884 255407

Mike Wye - NHL, L, LP, Po, RM, H, T, LW, Pi

Glebe House, Buckland Filleigh, Beaworthy, Devon
EX21 5HY Tel 01409 281644

APPLICATION

General Notes

Always make up some small sample areas (about 1'6", (450mm) square) and leave them to cure before starting to do the whole job to ensure that the method and finish are satisfactory.

Never apply any of the mixes for renders or plasters thicker than 3/8" (10mm) per coat; any thicker will tend to cause shrinkage cracking.

Do not try to achieve a perfect level and true face - let the render/plaster follow the major undulations of the wall beneath it.

Do not overwork the surface of floated renders as this action causes segregation of the mix, thereby weakening the material. When segregation occurs the binding material (i.e. lime) is drawn to the surface leaving a weak sandy residue in the body of the mortar.

Put a board against corners of the wall to render against. Do not use galvanised or stainless steel beads at corners of the wall, at window and door openings, or at the foot of the wall above stone plinths.

Only apply render to walls when the full strength of the sun has gone from that elevation and/or place wet screens of hessian around the new work.

Avoid cracking and weakening the render due to rapid drying out during windy or hot weather by hanging wet hessian sacking covered by polythene sheeting about 2" - 4" (50 - 100mm) away from the wall surface. Keep the hessian wet as best you can - in extreme cases the surface of the wall can be mist-sprayed (using a garden sprayer) to slow its drying.

The new work should be protected from rain by using just the polythene sheet (no mist spraying, no wet hessian).

Never render if there is a risk of frost.

The amount of time taken for each coat to dry sufficiently before laying subsequent coats can vary from hours to more than a day (when ready it should feel firm to the touch but not 'bone dry').

Roughcast on Cob

For new work on cob an absolute maximum of two coats of render will suffice (not including the filling out of hollow areas as preparation), giving a total thickness never more than 3/4" (19mm). Some practitioners in Devon are experimenting with renders of one coat only on walls of both cob and masonry. When repairing roughcast, build up the



Fig. 2 Roughcasting a cob wall

render in coats to match the thickness of the original. (*N.B. Coat thicknesses should be no more than 3/8", (10mm) thick.*)

We recommend that the render be applied by hand-casting using a harling or dashing trowel. A small coal shovel with the first 2 - 3" (50 - 75mm) of the scoop cut off will do - see illustration. Never apply roughcast with a Tyrolean render machine - these cannot provide the essential bond to the backing that render surfaces require, which the force of hand casting provides.

The finished work shows how it was applied, and therefore it is important to use a regular rhythm to achieve an even texture. Stand about 2ft (600mm) away and side-on to the wall and flick the mix off the shovel or trowel with a backhand stroke. Applying the backing coat will give you time to develop the regular rhythm which is necessary to achieve an even texture on the final coat. When the first coat is 'green hard' (i.e. firm to the touch but not bone dry) rub over it with a wood block (this should be a 6" (150mm) length of 4" x 2" (100mm x 50mm) softwood).

Use a circular motion as this process knocks off high grits and pushes others back into the render. When the backing coat is still green hard, wet it and apply

the final coat. It may be necessary to add a little water to the mix of this final coat to ensure that it spreads evenly.

When rendering onto a wall made up of different materials (e.g. masonry, cob, embedded timbers, concrete), the amount of time taken by the render to go green hard may vary dependent on the backing material. In such cases wait for the slowest area to be ready before applying subsequent coats.

Smooth Render on Cob

For the backing coats the technique is the same as that described above. The top coat, however, should be applied with a wood float to achieve the smooth finish. Do not polish the surface of the render and always follow the major undulations of the wall.

Roughcast and Smooth Render on Stone

Masonry with raked out joints gives a better key than cob, so it is not essential to hand cast the mix on to the wall. As for cob, two coats should suffice. They can all be applied with a wood float. Floated coats must be given a 'scratch' to provide a key for the next coat. Scratch diagonal lines in two directions to give a pattern of 4" (100mm) squares. Use a length of timber 9"x 1"x 1/4" (225mm x 25mm x 6mm).

Applications of the roughcast and smooth render top coats are as for cob.

Plaster on Cob and Stone

As for render on stone above.

Limewash Applied Directly on Cob and Stone

This is generally only encountered on internal wall faces, on external walls of houses sheltered from the force of the weather and on non-domestic buildings. When redecorating existing walls ensure that lichens, mosses and any loose material are removed from the surface of the wall. Wet the wall and apply limewash as described below.

DECORATIONS

Limewash

Immediately before using limewash, pass it once more through a sieve (a domestic kitchen sieve will suffice) otherwise the finish will be gritty.

Mask all surfaces not to be limewashed using polythene sheets and tape.

Wet the wall surface thoroughly then apply the

wash with a stiff bristle brush 4"-6" (100-150mm) wide. The wash will appear transparent at first but soon turns opaque as it dries.

Externally a minimum of three coats can be applied but as many as five is recommended. Allow the previous coats to dry before applying the next (this may take up to one day). Internally three coats will most likely be sufficient.

It is important to re-wet the surface of the previous coat, with a fine mist spray, before applying the next.

Distempers

Apply these products as recommended by the manufacturers' or suppliers' instructions.

Advice

Devon Earth Building Association through -
Devon County Council

Historic Buildings Section,
Environment Directorate, County Hall,
Exeter EX2 4QW. Tel 01392 382261

Local Authority Building Conservation Officers

At the local District Council Offices

Society for the Protection of Ancient Buildings

37 Spital Square, London E1 6DY,
Tel 0207 377 1644

English Heritage

29 Queen Square
Bristol BS1 4ND. Tel 0117 975 0700

SUPPLEMENT TO THE 2ND EDITION

PERMEABILITY OF APPLIED FINISHES

It has been accepted for some years now that low-permeability finishes can affect the performance and durability of earth walls.

One recent study of major structural failures in cob buildings, carried out at Plymouth University, showed that in 18 of the 22 buildings examined (82%), the observed failure could be partly or wholly attributed to the presence of cement based renders or plasters. The fundamental difference between cement and lime based renders and plasters is that the former are intended to provide an impermeable 'weatherproof' outer skin and the latter a 'sacrificial' coating designed to prevent erosion and abrasion of the substrate while allowing the free passage of water and a degree of thermal and moisture expansion to take place. Cement based materials are brittle, whereas lime based materials are relatively flexible. Although the types of aggregates used and their proportions are similar in both cement and lime based finishes, the nature of the two binders is quite different. Unlike lime, which acts in a similar way to clay binders in soils, cement paste, when it cures, develops fibrous shoots of calcium silicate hydrate which expand to fill the pores between the aggregates, thus significantly reducing their porosity.

Laboratory tests, which have been carried out in both Britain and the USA in order to compare the water vapour transmission characteristics of lime based materials with those of other products, have shown that lime renders have a permeability two to three times greater than those based on Portland cement. Comparison of traditional limewashes with acrylic resin based exterior emulsion paints have given similar results.

Clearly therefore, a cob house whose walls are covered with a cement based render, to which two or three coats of a proprietary masonry paint have been applied, will be at considerably higher risk of structural failure, through the presence of excess moisture, than one which has been finished using traditional lime based materials.

NATURAL HYDRAULIC LIMES AND POZZOLANIC ADDITIVES

Lime Putty and Natural Hydraulic Limes: a Comparison

On the basis that finishes for the walls of traditional buildings should be weaker than the substrate to which they are applied, lime putty based renders and plasters, which have been in use for least three to four hundred years, would appear to be the most appropriate solution, for both aesthetic and technical reasons. Because great care is needed in the mixing and application of these pure lime finishes in order to achieve a satisfactory result, labour as well as material costs are higher than those associated with the use of cement and gypsum based materials. The use of natural hydraulic limes is on the increase, perhaps for the reasons that they are somewhat easier to use and may be more appropriate when the substrate (cob/masonry) of a building is insufficiently dry to permit the use of a lime putty mix and/or when the climatic conditions are less favourable.

Pure or 'fat' limes (lime putty or hydrated lime) are comprised of at least 94% calcium hydroxide - $\text{Ca}(\text{OH})_2$. Mortars and renders which use pure lime as a binder will only set if exposed to the air. This process, known as carbonation, takes many weeks, or months in the case of mortars, to reach the point where the material has completely set, or hardened, and been converted back to calcium carbonate - CaCO_3 .

Hydraulic Limes

Limestone is sometimes found in natural combination with clay and silica. When it is fired and slaked in combination with these minerals, a chemical reaction between them results in the formation of what are known as cementitious compounds. These blends can be manufactured; however only those which are found naturally should be employed.

It is this process which changes the nature of pure lime and forms the basis for the production of both natural hydraulic lime and, when fired at much higher temperatures, that of Portland cement, which, as already noted, is considered entirely unsuitable for use in work on old buildings.

The essential difference between pure and natural hydraulic limes is that the former need to be exposed to the air in order to achieve a relatively slow set, whereas the latter, whilst also subject to carbonation over a prolonged period, achieve a

chemical set ('hydration') that is both faster and can also take place underwater, which is why it is known as hydraulic lime. Home-produced natural hydraulic limes, obtained mainly from the blue lias limestones of southern England, were in widespread use up to around 50 years ago, but have now been largely supplanted by Portland cement. Most natural hydraulic limes in current use are imported from Europe, mainly France and Italy. Natural hydraulic limes are manufactured from limestones that contain impurities, mainly silica, alumina and small amounts of haematite, and are classified according to the amount of these impurities present, which will vary from around 8% up to 25%. The only natural hydraulic limes that DEBA consider suitable for plaster and render mixes are those containing less than 12% reactive clay-sized particles, the European standard classification for which is NHL-2.

The qualities that make lime based renders and plasters particularly suitable for conservation work are (1) good adhesion to weak substrates (2) high water vapour permeability and (3) good flexural (as opposed to compressive) strength. Natural hydraulic limes may differ from pure limes in respect to 'fatness' i.e. they are less sticky and therefore less cohesive, and to permeability - in general, the greater the hydraulicity (percentage of clay present) the lower the permeability, though their permeability is still significantly higher than that of cement based renders. Mix proportions: 2 to 3 parts of well graded, sharp sand to one part of natural hydraulic lime (generally, the higher the porosity - in fine sands for example - the greater the proportion of lime required).

As with any form of lime-based mortar or plaster, work should not be carried out if the air temperature is below 5°C; in excess of 10°C is best. In fact, the higher the temperature the faster the material will achieve a proper set, but it must be kept moist for five to seven days.

Pozzolanic Additives

With regard to pozzolanic additives described below, it is considered that more data derived from laboratory and field-testing needs to be made available before the Association is able to offer any definitive guidance concerning their use and effectiveness.

Pozzolanic mortars were first developed by the Romans, who added either naturally occurring volcanic ash or crushed pottery to pure limes in order to make strong mortars that would set underwater.

Pozzolans are basically fired clays, having a similar chemical composition to that of the impurities found in natural hydraulic limes, which are supplied in bagged, powder form. When added to pure limes they have the effect of imparting hydraulic properties to the mortar.

Tests carried out by English Heritage have shown that soft bricks - fired at a temperature of less than 900°C and then crushed, have two advantages. First, the smaller particles, <75 microns, will react with lime to form cementitious compounds and second, the larger particles will act as porous aggregates, increasing the overall porosity of the mortar. A serviceable render mix would be 1 : 2 : 5 brick dust / lime putty / sharp sand.

Fired Kaolin (marketed as Metastar or Polestar) is made up of smaller particles and is, therefore, more reactive, so that a lesser amount is required to achieve the same degree of hydraulicity; the mix proportions in this case being 1 : 3 : 9 fired Kaolin / lime putty / sand. It is claimed that higher porosity, and therefore greater permeability, in lime mortars can be achieved by including, as part of the aggregate, crushed oolitic limestone (Bath, Portland or Ham stone, for example). Care must be taken because large amounts of stone dust (particularly if ungraded) can cause problems; in preference small amounts should be employed, preferably well graded (a range of particle sizes) or if that is unobtainable, medium grain size only. - mixes consisting of too much fine material or dust should always be avoided.

Conclusion

It should be noted that pure lime putty based mortars and renders, which have been used successfully in traditional building for several centuries, are, if correctly applied, ideally suited for their purpose. Currently DEBA has insufficient experience of the use of natural hydraulic lime based mixes on cob. For this reason and because of their greater strength and reduced permeability, these materials are not considered suitable for application to cob walls. Their use for repairs to random stone and brick masonry may however be justified in certain cases which might include all or some of the following circumstances. Firstly, where buildings or parts of buildings are very exposed to the weather. Secondly, where repair work has to be carried out in cold, damp conditions. Thirdly, where due to lack of time available following the removal of impervious render, the wall is not sufficiently dried out, and remains too wet to permit the application of a lime putty based mix; however walls which have remained damp for a long period may

contain salts which, as they evaporate from the wall surface, often 'push off' applied finishes, whether they be lime putty based or contain natural hydraulic lime.

MUD PLASTERS

Loam/hair and, to a much lesser extent, loam/ chopped hay plasters were applied mainly to internal walls and ceilings of both cob and random stone buildings from the earliest times up to the end of the 19th century. It is the hair (normally cow hair) combined with the clay binder that gives the material its considerable tensile and flexural strength, as well as its strong adhesion to earth substrates. A typical traditional mud plaster will vary in thickness from 3/16 - 1/4" (5 - 6mm) in early buildings up to 3/8 - 1/2" (10 - 12mm) in those of the 19th century. Often it will be finished either with a pure lime or 1:1 lime/fine sand skim coat, 1/25 - 1/12" (1 - 2mm) thick, or with numerous coats of limewash. Mud plasters seem usually to have been applied in one coat.

There is some evidence of mud plasters having been applied externally in the South West, probably prior to the general adoption of lime based renders during the 19th century, and it is hoped to carry out some field trials in order to assess their performance and durability. Mud plasters are used in the renovation of cob buildings in Normandy. They are usually stabilised with 10% pure lime and are mixed and applied mechanically, being projected onto the wall in the form of a slurry, using a compressed air hose, then floated by hand to control shrinkage.

Tests to measure the adhesion of various plasters to an earth substrate, carried out at Pennsylvania University, showed mud plasters to have an adhesive strength over four times that of lime plasters. Tensile strength at breaking point was 172 kN/m² for mud and 38 kN/m² for lime. (Cement based plasters have no adhesion to cob walls, which is why they require a mechanical key, usually chicken wire or metal lathing).

Mixing and application

As with lime based plasters, it is always best to make up two or three experimental mixes, containing variable amounts of water and, if necessary, added sand, and apply these to 1'6" (500mm) square trial panels so that drying, shrinkage and adhesion can be monitored and measured. Local subsoil or reconstituted cob is first dried and pulverised, then passed through a garden (3/16" (5mm) mesh) sieve. Subsoils containing more than about 40% to 50% of fines (clay and silt) may need

to be gauged with coarse to medium sand, as otherwise they may be too sticky to be workable and may develop shrinkage cracks too wide to be controlled by subsequent reworking.

Mud plasters and mortars may be mixed manually on a hard, smooth surface - a sheet of exterior grade plywood, for example. It is important to ensure that the large quantity of hair required should be incorporated in such a way that it is evenly distributed throughout the mix.

Mud plasters, like lime plasters, should be applied to a thoroughly pre-wetted surface. In cob walls, which have hollows and cavities, these should first be 'dubbed out' with a subsoil/chopped hay or straw mix, keyed into the cob. Mud mortars are very cohesive and, in order to be workable, may need to be fairly wet, with a water content of around 20% or more. Unless gauged with sand, clay-daub plasters may be almost impossible to apply. (Plasters containing chopped hay are easier to apply than loam/hair plasters, but are probably less durable).

Mud plasters may be either applied with a trowel or float, using a normal lime plastering technique, or thrown on to the wall (by hand) then levelled off with a steel float. If timber or glassfibre floats are employed for the purpose, they would need to be kept well wetted. Being applied to internal walls, surface cracking is usually less of a problem than it is with externally applied plasters. Repeated reworking of the material should be avoided, as this will bring the coarse aggregates and hair to the surface. Surface cracks can be filled with limewash or an applied lime based skim coat (1:1 lime putty/fine sand <1.0mm). A serviceable mix would contain the following proportions (by weight): fines (silt and clay) - 40%, fine to coarse sand - 40%, grit (1/12 - 3/16" (2 - 5mm)) - 15 - 20%, and cow hair or chopped hay - 3 - 5% (note that this is equivalent, by volume, to a mixture of subsoil and organic matter in more or less equal parts).

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FURTHER READING

(all titles are available from SPAB, London)

'The Need for Old Buildings to Breathe'
SPAB Information Sheet No. 4,
Phillip Hughes

'An Introduction to Building Limes'
SPAB Information Sheet No. 9,
Michael Wingate

'Rough-cast for Historic Buildings'
SPAB Information Sheet No. 11,
Andrew Townsend

'Building with Lime'
Stafford Holmes and Michael Wingate

'Lime in Building'
Jane Schofield

'Earth - The Conservation and Repair of Bowhill, Exeter'
Ray Harrison
EH Research Transactions, Vol. 3. 1999
(Chapter Six deals with plasters and renders)

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AIMS AND OBJECTIVES OF THE DEVON EARTH BUILDING ASSOCIATION

To provide a forum for the discussion of issues relating to earth building in Devon and the south-west of England.

To provide advice on the repair and maintenance of earth buildings through an information service, the publication of technical guidance and the organisation of practical demonstrations, exhibitions/displays and seminars.

To encourage and support training in the field of earth building and associated skills.

To establish and maintain mutually beneficial links with groups and individuals working with earth buildings in other parts of Britain and abroad.

To encourage the revival of earth building techniques for new building construction and to investigate the potential of the material for low-energy 'appropriate technology' building.