HYDRAULIC LIME

BEST PRACTICE INSTRUCTIONS FOR GENERAL MASONRY, RENDER & PLASTER

For other applications consult the company before use

Contents:

IMPORTANT NOTICE

Continuous stringent monitoring of the manufacture and performance of the lime is carried out which ensures that the material will always perform in a satisfactory manner. However as with any material performance depends upon following the manufacturers instructions. The company can accept no liability for incorrect use or application.

Recommended 'best practice' must be followed and the lime must not be mixed with materials other than suitable aggregate without obtaining prior approval, in writing, from the company.

HYDRAULIC LIMES LIMITED
Tel/Fax: 01935 815290
e-mail info@hydrauliclimes.co.uk
www.hydrauliclimes.co.uk
The Lime Loft, Preistlands Lane, Sherborne, Dorset, DT9 4RS

GENERAL GUIDANCE FOR MIXING AND USE OF Hydraulic Limes

Introduction

The purpose of these notes is to provide readers with adequate information to ensure hydraulic lime is used correctly in all but the most arduous conditions. It is not intended to provide comprehensive information on performance for which specifies and contractors are advised to study the following books.

1. 'Building with lime' by Stafford Holmes ISBN 1 85339547/1 Revised 2001. Published by Intermediate Technology.
2. Hydraulic Lime for Mortar for Stone Brick and Block Masonry. Published by Donhead ISBN 1873394640

In 1998 UK Government funded research into hydraulic limes began at the University of Bristol resulting in the publication of the second book listed above in 2003. To date this book remains the definitive reference to the performance of most hydraulic limes.

General

To obtain the best performance from lime mixes it is essential that the correct sand and lime to water ratios are used. This will include assessment of the masonry units, and in the case of mortars, assessment of the engineering design strengths required for the structure. For local building works when the same sands, stone or bricks are repeatedly encountered this should only take a few minutes. The factors which affect the strength of a mix are:

1. The type of sand. Soft sands with fine circular grains make weak mixes. Sharp sands with angular particles including some 3 –4mm grit produce the strongest mixes.

2. The water content. Too much water will decrease the mixes strength by holding the grains apart thus leaving an open structure when dry .This effect can be dramatic.

3. The amount of binder. Generally the purpose of the binder is to hold the sand particles together and to fill the voids between the grains of sand.

4. The type of binder. The strongest binders are those using Portland cement. The weakest are those made from high calcium lime. In between are the hydraulic limes categorised into three groups: HL2: HL3.5: HL5 - prefixing the category with N (ie NHL2 or NHL3.5) indicates a natural hydraulic lime with no additives.

Storage of Lime & Aggregate

Our Hydraulic Lime is supplied in 25kg paper bags which must not be allowed to become wet opened the exposure to air will start to weaken the hydraulic set. As a result any opened part bags left at the end of the day should be carefully folded over at the top and put into a dry store. In this state the lime will remain useable for a further 2 or 3 days. Thereafter it should be discarded. For larger orders the individual bags will be supplied with up to 40 on a pallet.

Aggregate should also be covered since if left exposed fines can be washed out and the material as a whole .can gradually separate. The result will be to make the aggregate less well graded and this may impair durability of the mortar. Covering the aggregate will also stabilise the water content and make mixing more consistent.

Aggregate

There are many poor quality sands on the market. In most cases for good quality lime work -which is about better building, these soft fine sands, frequently containing clay, are not acceptable. Clean sharp, well graded sand should be specified. A good supplier should be able to provide a sieve analysis against which the sample sieve analysis provided (see page 8) can be compared.

Sand Void Percentage

If you find a good local sand which you may use repeatedly, establishing a void percentage is a very worthwhile exercise. Working with unknown materials is not a good idea. Knowing the voids in the sand tells the user how much binder is required in order to fill the voids. Insufficient binder to fill the voids will weaken the material and make it vulnerable to frost damage. The procedure to find the void percentage is as follows:

1. Take a container of known volume (a one or two litre jug or jar is ideal) and fill it level to the top with the selected sand.
2. Remove the sand and dry it completely in an oven on a tray.
3. Replace it in the container to a level top.
4. Take a measured jug of water and gradually add the water until bubbles stop rising and the water has saturated the sand.

5. The void ratio is then:

$$\frac{\text{volume of water added} \times 100}{\text{volume of sand}}$$

say for example the answer is 30%
Then a 1 lime to 3 sand (by volume) will fill the voids

In general the type of sands suitable for lime work will have a void ratio in excess of 30% probably 35-40%. Therefore our general advice is to use a mix ratio of 1:2 or 1:2½ in order to ensure adequate frost resistance.

Water Content and Masonry Units

The more water remaining in the mortar or render, the weaker will be the final result. However too little water will also prevent necessary chemical processes taking place and weaken the material. The water absorption of masonry units with which the mortar/render is being used has a considerable bearing upon the final strength by altering the amount of water left in mortar.

Bricklayers and masons will normally add sufficient water to obtain adequate workability However if the tradesmen are not used to mortars with sharp sands it is possible that too much water may be added.

IT IS STRONGLY RECOMMENDED that either:
Manufacturers absorption figures are obtained for the masonry or ~. The following test is carried out:
a) the brick/stone is oven dried and weighed
b) the brick/stone is then placed in bucket of water for 2 hours and then re-weighed

Water percentage in the masonry can then be established. Optimum strength is likely to be achieved with a final mortar water content of around 15% by mass after suction of water by the masonry using a typical sharp sand with 36% voids.

Mixing Technique

A conventional cement mixer can be used although for larger projects a roll pan or paddle mixer is preferable. These are becoming more readily available on the market with the renewed interest in lime products. Measuring of material must always be with a gauging box or bucket. A shovel is not acceptable since quantities are too inconsistent.

Lime mortars mixed in drum mixers can be prone to balling use of particular mixing techniques can reduce this. It is therefore recommended that a small quantity of water is put into the mixer while not rotating and then the appropriate quantity of lime added. When the mixer is switched on the lime should be turned into a wet slurry .The sand is added to the slurry with more water and mixed for not less than 15-20 minutes. Do not overfill the mixer as this will prevent proper mixing.

The mix, to begin with, should appear rather dry but as mixing time increases the render will become much 'fattier'. At the end of 20 minutes the final water can be added to obtain the correct workability if required. If too much water is added the risk of shrinkage will increase and the final strength will be reduced

Use of Air Entrainment Agent

Use of air entrainment agent 3 is not recommended.

Additional Pozzolan

In cold weather and for certain other applications it may be advantageous to add additional pozzolan in order to increase the speed of set and/or increase strength. The company has full confidence in the use of either Bulmer Brick Dust or Metastar for this purpose. It is recommended that the company be consulted as to the quantities of these materials to be added since the amount may vary depending upon the work being undertaken.

Addition of Hair or Fibreglass to Renders

Addition of natural hair or fibreglass will improve the strength and durability of render. It can be added to our Hydraulic Lime based renders during mixing in accordance with accepted practice.

Other Applications for Lincolnshire Hydraulic Lime

There are a number of other applications for which the company's limes are suitable. The techniques and mixes will vary considerably. Below is a list of some:

Sea Defences : Canal Works : Grouts : Foundations : Flooring

It is essential that the company is consulted if the best results are to be achieved.

TECHNIQUES FOR EXTERNAL RENDER

Selection of Aggregate and Mix Ratio

The finer the aggregate particles the less porous will be the render. A balance' must be struck when selecting the aggregate between protection of the underlying masonry and providing for adequate evaporation of moisture. Annual weather conditions on site will have a bearing on the best aggregate and mixes. The standard mix for a render should be 1 lime to 2 sand by volume. It is important to follow the advice concerning mixing given in the above section.

Generally for render, a washed sharp well graded sand containing a proportion of 3-4mm grit will prove most satisfactory. If the level of fines is too high porosity of the render will be reduced and durability impaired. However shortage of fines will dramatically reduce workability and it may be necessary, if this happens, to add a little fine sand. Clay content in aggregate can cause shrinkage and will impair durability. Sands with over 1% or 2% clay should be avoided. In addition fine soft sands should also be avoided although the addition of a small proportion of fine sand for the final coat may improve the finish and workability. For an example sieve analysis of suitable sand see attached at page 8.

Assessing the Site

The location and layout of the site will have a bearing on several factors regarding the application of hydraulic lime. The main considerations are:

1. Exposure to drying winds
2. Height of the site above sea level -the higher it is the lower the temperatures likely to be encountered.
3. Some elevations will be more exposed to wind and sun and therefore prone to rapid drying. If possible leave south facing elevations for cloudy days.

If undue work is to be avoided running water must be available to all parts of the site especially those elevations likely to need damping down. Adequate length of hoses and on site availability of covers will ensure work can be completed successfully and with the minimum of fuss.

Surface Preparation

Whether the render is onto new work or restoration, surface preparation is vital for a successful job.

The main points to ensure are:

1. A good keying surface for the render
2. Removal of loose material
3. A moist surface to prevent rapid suction of water from the render.

The first two should be tackled in the same way as any render but point 3. requires special attention. Some masonry, especially blockwork and porous bricks, can suck water from the render very rapidly; it is essential to prevent this by adequate damping down -without saturating the wall.

Application

If there are large voids in the wall these should be filled first to within not less than lOmm of the wall surface. This is called "dubbing out".

After damping the surface (on very porous walls several applications of water in the hour or two before render is applied may be required) render can be laid on using the normal technique. The first coat (scratch coat) will normally require two skins of around 6mm each in rapid succession. The first coast should be left to stiffen up and then a float used to compress the render over the whole area. Undertaking this second pass too early before the material has stiffened can weaken the render by squeezing fines of sand and lime to the surface. The result may be voids deep in the render which make the render vulnerable to frost damage. Finally within an hour or two the surface is then scratched over using a suitable comb.

Once the first coat has hardened enough a similar technique is used for the second. The time interval between the two will vary depending upon the temperature as little as 24 hours in warm conditions but several days if cool. A fine spray of water should be applied beforehand. If a third coat is required proceed as above. If a fine surface is required for the last coat a finer sharp sand may be used and 'floated up' as the surface stiffens, in a similar way to the previous coats.

Rendering should not be attempted at temperatures below 5°C. Render must be used within one hour. The company does not recommend rendering in hydraulic lime between late October- end of February due to the risk of frost damage.

After Care

The render must be kept moist for several days after application of the final coat. Water will tend to drain down from the top of the work and therefore particular attention must be given to spraying the upper sections. Remember water is essential for the hydraulic set. It is important while maintaining the moisture to prevent rapid drying from wind and bright sunlight. Covering the work with damp Hessian is the best procedure.

If there is a risk of frost Hessian covers should again used. Bubble wrap can also be used. However a circulation of air must be maintained between the cover and the render. Do not use anti-freeze additives. For more detail on after care please read the paragraph after Techniques for Mortars.

Subsequent Painting

With lime renders it is recommended that lime washes are applied. The use of synthetic paints is not recommended since they will prevent subsequent carbonation. Curing of the render takes many months and if such paints .are applied they should not be applied until carbonation is complete. Normally allow one month for every 3mm of render.

To summarise it is essential to ensure that:

1. The mortar is very well mixed -balling must be avoided. Use a gauging box or bucket to measure -not a shovel.
2. Do not put too much in the mixer at anyone time as this will reduce the quality of the mix.
3. The wall is well wetted before rendering commences.
4. Render must be used within two hours and then left to stiffen. A second pass must be made to compress the render but only when it has stiffened.
5. Do not apply if the temperature is too low i.e. 5°C or below. Be prepared to protect from frost, excessive sunlight and drying wind for up to 7 days. Protection may include hessian sheets, bubble wrap or sheets of polythene. In very warm weather wetting of hessian will help to reduce rapid drying. In the winter do not add antifreeze agents designed for use with portland cement.
6. Keep render moist for 7 days. The chemical set can only complete in the presence of water. The need to keep render damp is best achieved by the availability of a hose with a fine spray. Not only will this ensure even coverage but the time taken will only be a few minutes each day (if indeed conditions require damping down).

Bear in mind the render will continue hardening for many weeks and final strength will not be achieved in less than one year.

TECHNIOUES FOR INTERIOR PLASTERING

Techniques for interior plastering using hl2 are the same as for exterior work with the following exceptions:

1. For base coats a sharp sand is still recommended. Depending upon final finish required however finer sands can be used at that stage. Use of finer aggregates will reduce the porosity of the plaster and therefore if dampness in the masonry is a problem careful consideration should be given to choice of sand. Interior plastering is the only occasion when a fine sand needs to be used in order to obtain a smooth surface. However even then a fine sharp sand will provide a stronger surface.

2. The upper sections of plaster will dry very much quicker then the bottom metre. It is important that these upper sections should be kept damp in the first few days so that there is no apparent difference in colour, due to drying. In normal ambient temperatures over 12°C this practice should be maintained for three days on each fresh coat.

3. The plaster will generally carbonate, after the initial hydraulic set, at the rate of approximately 3mm per month. During this period it is not advisable to decorate the surface especially with paints that do not breathe. A good air flow in the room will help to speed this carbonation process. Heating rooms will not speed up the process, indeed it may damage the final result.

TECHNIOUES FOR MORTARS IN WALL CONSTRUCTION AND POINTING

Mortar Strength

The principles outlined previously for rendering apply equally to mortars. For exterior work, when mortar joint size permits, the sand should contain a small proportion of 3 -4 mm grit.

Mortar designations are contained in BS5628 Part I, Section 2 Page 9, Table I. A summary of B.S. mortar designation is included on page 9 of this best practice guide. For the majority of conventional construction a type (iv) mortar will be adequate. A 28 day compressive strength of 1.0 newtons/mm2 should be attainable with an NHL 3.5, provided average ambient temperature exceeds 10^0C. Below this, the rate of strength build up may slowdown work. Generally a I lime to 3 sand ratio by volume will be sufficiently strong to provide a type (iv) or (v) mortar. Additional strength requiring a I: 2 mix will be needed for the following areas of exposure:

1. Chimneys 2. Parapets 3. Copings 4. Splash areas at base of walls 5 .Below D PC

The following points need highlighting for all mortar work:

1. The mortar should be very well mixed -balling must be avoided. Always measure using a gauging box or bucket.
2. Mortar must not be allowed to dry out too quickly. This is especially important with porous masonry that may require wetting before construction.
3. Mortar must be used within two hours and then left to set. It may be advantageous to brush the surface later the same day to expose the grit.
4. Do not use if the temperature is too low i.e. 5°C or below.
5. Be prepared to protect from frost, excessive sunlight and drying winds.
6. Pointing is kept moist for 7 days. The chemical set can only complete in the presence of water.

It should be possible to build at about the same rate as with Portland cement mortars but bear in mind the mortar will continue to gain strength for some weeks

PROTECTION & AFTERCARE FOR LIME MORTARS/RENDERS

Effects of Rain and Temperature

Without doubt often the most significant difference to the user between OPC and lime based mortars and renders is the rate of strength build up in cold weather. This can result in:

1. Slower rate of laying
2. Requirement for protection against water saturation and frost

This notwithstanding in mild winter weather work with hydraulic lime mortars can proceed normally provided there is provision of immediately available protection in the event of rain and/or frost. Lime renders are more vulnerable

than OPC. Unless sheeting and heaters are in situ rendering work should not be attempted in the UK from October to mid March. Possible exceptions are the warmer centres of large cities such as London.

In order to understand the need for protection specifiers and contractors should appreciate that the rate of set of hydraulic lime is more dependant on temperature than cement. While mortars and renders laid in the summer months may achieve frost resistance in a month, work done at cooler times of the year will undoubtedly take much longer and will therefore require protection from frost longer too -perhaps for the remainder of the winter. Without doubt the worst combination is heavy rain followed by clear skies and a frost. Saturated walls with under-strength mortars will suffer frost damage much more easily than walls protected from the rain. Driving rain poses less of a risk than rain entering from the top of the wall. As a result covers on the top overlapping, say 300mm each side will do much to keep the wall dry thereby reducing the risk of damage.

Another factor to bear in mind relates to porosity of masonry units. Porous materials hold very large quantities of water. Lime mortars are designed to aid evaporation. This process of evaporation causes a drop in temperature, so the mortar in new walls holding large quantities of water will set slower because of this drop in temperature. A great deal of the water in the masonry units will evaporate out through the mortar joints. This effect will ensure a permanently low temperature in the lime mortar until the whole wall begins to dry. Cement mortars are much less permeable and a high percentage of water will have to evaporate from the face of the masonry units.

Frost Protection

As stated previously wet masonry is much more vulnerable to frost. Frost protection of masonry is best achieved using hessian or bubble wrap. During daylight hours if warming winter sum is available, covers should be lifted to allow heat to be absorbed and then replaced during late afternoon. Even under these conditions a circulation of air is advisable between covers and masonry.

IMPORTANT NOTICE

Continuous stringent monitoring of the manufacture and performance of the lime which ensure that the material will always perform in a satisfactory manner. However as with any material performance depends upon following the manufacturers instructions. The company can accept no liability for incorrect use or application.

Recommended 'best practice' must be followed and the lime must not be mixed with materials other than suitable aggregate without obtaining prior approval, in writing, from the company.

HEALTH & SAFETY INFORMATION

Hydraulic Lincolnshire Lime is manufactured by Singleton Birch Limited in Lincolnshire.

Characteristics

In its hydrated form the particle size is generally very fine at 30 microns or less. The powder is non poisonous but mildly irritating especially to the skin and eyes. Because of it's light weight and small particle size it makes airborne dust easily if agitated. Repeated contact will produce dry skin. If dust is inhaled it may produce coughing.

Handling

hl2 should be handled in the same way as non hydraulic hydrated lime or cement powder.

Safety Precautions

- .Avoid contact with the skin.
- .The powder should be washed off with liberal supplies of cold water and soap (not detergent).
- .If the powder comes into contact with the eyes it should be washed out immediately with copious supplies of water.

Avoid creating airborne dust which can be inhaled or wear a dust face mask to Occupational Exposure Level (OEL 12) in the open or in confined very dusty areas OEL 50.

A detailed Health & Safety Data Sheet is available by clicking on Health & Safety on our web site ‘www.hydrauliclimes.co.uk’

MIXED SHARP SAND -TYPICAL VALUES

PRODUCT NAME:	MIXED SHARP SAND TO BS882:1992.T.4 GRADES 'C' & 'M'

PETROLOGICAL NAME:	FLINT/QUARTZ

MECHANICAL ANALYSIS:	B.S. SIEVE (pm + O.OOl mm)	% PASSING	BS 882 'M'
	10mm	100	100
	5mm	100	89 – 100
	3.35mm	95	
	2.36mm	90	65 – 100
	1.18mm	76	45 – 100
	600µm	51	25 – 80
	300µm	26	5 – 48
	212 µm	17	
	150 µm	8	0 – 15
	75 µ m	1.5	0 - 4

SPECIFIC	Passing 2.36 mm – Retained 212 µm	73.0%
	Passing 1.18 mm – Retained 212 µm	59.0%
	Passing 212 µm - Retained 150 µm	9.0%

CHEMICAL ANALYSIS:			
	SILICA	SiO_2	97.39%
	ALUMINA	Al_2O_3	0.20%
	IRON	Fe_2O_2	0.81%
	TITANIA	TiO_2	0.05%
	CALCIUM OXIDE	CaO	0.26%
	MAGNESIUM OXIDE	MgO	0.30%
	POTASSIUM OXIDE	K_2O	0.14%
	SODIUM OXIDE	Na_2O	0.02%
	MANGANESE	MnO	0.05%
	LOSS ON IGNITION		0.67%

PHYSICAL PROPERTIES:	RELATIVE DENSITY (OVEN DRIED)	2.54
	RELATIVE DENSITY (SAT. SURFACE DRY)	2.57
	RELATIVE DENSITY (APPARENT)	2.60
	WATER ABSORPTION	0.99%

BULK DENSITY:	Uncompacted	-
	Compacted	-

Requirement for mortar		Mortar Designation	Type of Mortar (proportion by volume)			Mean Compressive strength at 28 days	
			Cement: Lime: Sand	Masonry Cement: Sand	Cement: sand with plasticiser	Preliminary Lab Tests (N/mm^2)	Site Tests (N/mm^2)
↑ Increasing Strength	↓ Increasing ability to accommodate movement eg. due to settlement, temperature and moisture changes	(i)	1 : 0 to ¼ : 3	-	-	16.0	11.0
		(ii)	1 : ½ : 4 to 4 ½	1 : 2 ½ to 3 ½	1 : 3 to 4	6.5	4.5
		(iii)	1 : 1 : 5 to 6	1 : 4 to 5	1 : 5 to 6	3.6	2.5
		(iv)	1 : 2 : 8 to 9	1 : 5 ½ to 6 ½	1 : 7 to 8	1.5	1.0
← *Direction of change in properties is shown by the arrows* →			Increasing resistance to frost attack during construction				
			Improvement in bond and consequent resistance to rain penetration				

Though Hydraulic Limes are not mentioned in the above extract from BS5628 Part 1 (This standard is currently being rewritten into a more comprehensive EU standard), in general terms a 1:3 mix [NHL3.5:Sharp Sand] would be designated as type iv, and a 1:2 mix [NHL3.5:Sharp Sand] would be designated as type iii.