Lancaster Lime Works
NATURAL LIME FOR PRESERVATION AND BUILDING
1251 BEAVER VALLEY PIKE, WILLOW STREET, PA 17584

Selecting a Sand

Sand and larger sized aggregates make up the larger proportion of most mortars. Color, texture and overall strength of the mortar are all strongly affected by the choice of aggregate.

The aggregates most commonly used with hydraulic lime meet ASTM C144, although for the purpose of matching historic mortars various inclusions and pigments may have to be added. A good sand should be a washed sharp sand with angular grains to ensure good bonding qualities. Soft building sands should be avoided as their rounded grain shape can result in excessive shrinkage.

Larger sized aggregates may be used in some mortar or pointing work. As a rule of thumb for pointing, the maximum size of aggregate should be no bigger than one third of the joint width. Sands, which contain a clay or silt content of more than 4% should be avoided, as these will inhibit the contact between lime binder and aggregate.

Sands which have a high fines content also be avoided as the larger surface area of these will require more water to be used in the mixing. This higher water content will induce shrinkage and can affect flexural and compressive strengths. Monogranular sands should be avoided as they will possess poor workability qualities and will inhibit good vapor exchange i.e. the ability to breath.

Sand:Lime Ratios

For general pointing, bedding, stucco and plaster work we suggest mixing the NHL and sand together at a ratio of 2 ½ parts of sand to one part of NHL. This ratio can be altered according to certain needs and requirements of the project. Please consult with us to discuss.

Sand Void Percentage Once you have identified a good local sand, it is worthwhile to establish its void percentage. Knowing the void space in the sand tells 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 is simple:

1. Take a container of known volume (a one-gallon pail 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 can then be calculated from the amount of water used. If for example the amount of water used was approx. 30% of the total volume, then a mix ratio of 1-part lime to 3 parts sand (by volume) would fill the void

Mixing your Mortar

A conventional cement mixer can be used, although for larger projects a vertical shaft mixer is preferable. Lime mortars mixed in drum mixers are prone to balling. However, the following mixing procedure can reduce this problem. It is vital to ensure that when measuring materials this is done by volume. A measuring container or bucket will be necessary for this task. Measuring by shovel is not acceptable since quantities will be inconsistent:

1. Start with an empty mixer or mixing pan.
2. Add 1-part sand
3. Followed by 1-part lime
4. Followed by the balance of the sand needed for your mix.
5. Mix dry for at least 5 minutes or until thoroughly mixed.
6. After 5 minutes slowly add water until the desired consistency is reached
7. It is very important not to drown the mix by adding too much water.
8. Once the desired consistency is reached mix for a further 20 minutes

At the beginning, the mix will appear dry but as mixing time increases the mortar will become much ‘fattier’. If too much water is added the risk of shrinkage will increase and the final strength reduced. Do not use any plasticizers. To improve workability, allow the mortar to rest for a while before using. This will allow the water to fully saturate the sand particles and allow better hydration of the free lime that is in the NHL. It will result in a more workable and “fatter” mortar.

Water Content

The addition of water should be considered carefully, as it will directly affect the ultimate strength and durability of a mortar. The more water introduced into the mortar mix, the weaker the final result. However, too little water will prevent the chemical processes taking place and weaken the material. Generally, water should be added sparingly, until a useable consistency is achieved.

The masonry background may also affect mortar strength. Dry backgrounds can quickly ‘suck’ moisture from newly applied mortar. This should be controlled by dampening down the background prior to mortar application.

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Pointing

Analysis of Original Mortar
Before carrying out re-pointing work on Historic buildings or structures, determine the type of mortars used in the original building phase. Make sure when removing samples for analysis that they are from an original phase of work and are not from later remedial repairs/repointing. The samples should be representative of the bulk of the remaining material. Analysis is needed to determine correct binder, aggregate size, color and type.

Inspection of existing conditions
Carefully survey the wall to determine the pointing style and condition of the mortar. Notes should be made of open joints, decayed mortar, vegetation and general extent of re-pointing required.

Protection
Before cutting out of defective mortars, windows, doors, drains, vegetation etc., should be covered and protected. Special care should be given to friable cut masonry and other special features such as antique glass etc.

Cutting out of Defective Mortar
Considerable care must be taken when removing decayed mortar from historic masonry. When the mortar being removed is decayed or crumbly its removal can be carried out using hand tools. Plugging chisels, masonry chisels and old hacksaw blades used in conjunction with a club hammer will easily remove the mortar. Never use chisels that are wider than the mortar joint as this may result in damage to the adjacent masonry. The removal of cement pointing will require greater care if damage to the adjacent masonry is to be avoided. If wide joints exist, a series of holes or a single narrow cut may be made through the center of the joint, which will allow the joint to break inward when tapped with a chisel. On finer joints a tap with a sharp masonry chisel on the top and bottom of the joint will help to break the bond to the masonry at the edge of the joint.

After removal of the mortar, the back side of the joint must be squared off rather than rounded. The use of power tools or air chisels should only be carried out under strict supervision and by experienced personnel. Remember that the percussion action of these tools may loosen masonry as well as cause irreparable damage to historic masonry units. When used carelessly and improperly, masonry saws and grinders will cause irreversible damage to the masonry units.

Where the original lime mortar requires a chisel to remove it, it should be questioned whether its removal is necessary.

Depth of Joint

As a general rule the joints are cut out to a depth of twice the width of the joint, quite clearly this rule applies to brickwork, but in the case of rubble masonry this could result in overly deep joints, which may de-stabilize sections of masonry. Generally, a minimum depth of one inch will allow a good body of re-pointing mortar but common sense from a skilled craftsman must be used. The principle that applies here is that the mortar joints be deep enough to “grab” some of the weight of the building.

Notes should be taken if pinning’s are removed in the cutting out process and these should be retained for re-use.

Cleaning the Joint

Once the joints have been cut out, they should be thoroughly cleaned. Brushing out with a small brush will remove loose mortar and dust, once this has been carried out, the joints should be flushed out with water. This must always proceed from the top, working down the building, ensuring all traces of debris are cleaned down. Where there are deep joints or voids, care must be taken not to flood the core of the wall.

Applying the New Mortar

Before applying the re-pointing mortar, ensure that the joint is well damped down. The new mortar should be stiff and not sloppy, as this will result in shrinkage and leave a smudged and dirty finish. The new mortar should be placed into the joint using a pointing slicker/tool or a plasterer’s small tool and well packed and compressed into the joint. Pointing trowels should be avoided, as this will not allow pressure to be applied across the whole of the joint.

Deep joints must be built up in consecutive layers with a minimum of 4 days between coats otherwise cracking may occur.

Where there is evidence of stone pinning’s or wide joints, the pinning’s (small stone chips) should be packed into the new mortar. These will help to avoid overly large joints, which may result in shrinkage. Pinning’s will also support weak areas of masonry.

Finish Style

The style of finish will depend on personal preference, or direction from building owner or architect. On brickwork, struck, weather struck, weathered, flush finish and tuck, are all common. On rubble masonry, it is unlikely to have been a distinct style, as the remains of the mortar are likely to be nothing more the struck off bedding mortar. Therefore, a joint, which is flush or slightly recessed, will blend with the masonry. The finished joint should be finished by beating the wall with a stiff churn brush once the mortar is stiff. This process also compacts the mortar and leaves an open texture, which will aid evaporation of moisture.

Aftercare

New pointing work should be protected from frost, rapid drying and direct rain for a minimum period of 7 days. See 'Aftercare' section.

Exterior Stucco

Preparation of the Wall Surface

The successful application, bonding and correct hardening of hydraulic lime mortars, requires that the background should be clean, free from vegetation, free of containments and reasonably dry (not wet from water issues) throughout the wall mass. The wall should be structurally sound and the masonry and bedding mortars in good condition.

Where natural weathering or incomplete repair works have previously been carried out, new repair work will be required to correct these defects. In masonry the natural weathering process can result in the loss of small stones. These stones are known as pinning's, which are traditionally placed into wide bed joints between larger stones. When these are missing their replacements should be carried out with any general repointing work which needs to be undertaken. (See repointing)

Where walls are covered in vegetation, algae or moss, these should be removed by treatment with appropriate biocides, and soft power washing. Any remaining biological growth can retain water and may in time grow back through the new lime coatings.

The application of various coats of hydraulic lime is not a way to repair unstructurally sound masonry backgrounds and walls. The replacement of loose or defective mortar, replacing missing stone pinning's, repairing damaged brickwork or stonework are distinctly separate operations and the eventual outcome should be to present a reasonably flat and even surface, which is structurally sound, cleaned, and ready for the rendering application.

Suction Control and Bonding

Before the application of any new lime coatings it is vitally important to check the degree of suction within the background. Poor or excessive suction can result in a weak bonding with the substrate caused by rapid de-maturing of the newly applied render. This will result in a weak and powdery interface which could lead to later failure and separation.

In situations where suction needs to be controlled, wetting down will be required. On dense blocks or near impervious masonry, simply dampening the surface with a mist spray may be all that is required.

On very porous surfaces such as old brickwork *considerable* wetting will be required. Wet the wall with a hose, working from the top of the structure, downwards, this may need to be carried out the previous day and several times on the day before rendering commences depending on the substrate.

The objective of the suction control is to achieve a thoroughly damp surface, but not wet, i.e., the surface must not have running or standing water remaining on the masonry or brick, this could form a barrier between the coating and substrate.

A certain amount of suction is required for lime mortars to adhere and stiffen so the exact amount of wetting down is decided by the plasterer's experience.

Salt Contamination

Where new lime coatings are to be applied to masonry, which is salt contaminated, the masonry should be allowed to dry fully before applying new renders. This will allow salt to be detected on the masonry and mortar joint surfaces. If excessive salt is identified clay or lime mortar poulticing may be required. Specialist advice should be sought.

Salt contaminates should never be washed from the surface, as this will result in the crystallized salt returning to a soluble state and reentering back into the pores of the masonry or brick. Where detected on the masonry surface, the salts should be brushed from the surface and vacuumed away from the structure.

All salts must be removed from the surfaces to be covered with lime mortars before installation.

Base or Keying Coats

Techniques or render application (2 or 3 coat work)

The techniques employed in the application of hydraulic lime plasters should be to ensure a correct bonding with the background while striving to minimize shrinkage and rapid drying. These techniques should be followed throughout the plastering process.

Lime plastering is generally applied in 3 coats, but it is common to find 2 coats or even single coat work in vernacular or early structures. In 3 coats work the first coat on masonry or brickwork is generally known as the scratch coat or render coat. This coat is applied at a maximum thickness of 3/8" and is applied by use of a steel trowel or thrown onto the wall by use of a harling trowel and then flattened in by the steel trowel.

When the coat has firmed up but has not gone hard, the plaster is keyed or scratched up to produce a key for the following coats. The keying up is carried out by use of a lath scratcher or similar toothed instrument and care should be taken not to cut through the plaster coat back to the background.

The keying up is generally in the shape of diamonds of approximately 1” spacing. This coat should be allowed to harden for 72 hours minimum before further coats of plaster are applied - thicker coats will take longer. Before applying the second coat the first coat should be checked for shrinkage cracks, and these should be filled with plaster before proceeding with further coats. The first coat should be brushed down to remove any dust, which may have blown onto the surface.
The first coat should then be damped down to ensure that the second coat is applied to a damp but not wet surface.
This second coat is called the floating coat and is the coat, which is straightened to ensure a flat and even surface, after this coat has been straightened, the surface of this coat is scoured up with a wood float.

Surface Finish

Where possible the texture of the finished surface should be left slightly open or coarse, as this will allow better evaporation of moisture from the surface, the finished work should not be closed or “troweled” up with a steel trowel.

Day-Joints

Where day joints are unavoidable, they should be hidden wherever possible behind down- pipe runs or over the shortest possible areas. When working with NHL2 or NHL3.5 mortars the reworking of the joint is usually achievable the next day by lightly spraying the surface with water and rubbing up the joint with a wooden or polyurethane float. If this process proves difficult cut away approximately 2” of the previous days render. It is this perimeter zone which is most open to the air and will therefore dry first.

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Aftercare

Protection and Curing
After the application of lime renders, plasters and stucco, controlled curing and protection will be needed to ensure maximum strength and durability are achieved.

The chemical reaction which gives hydraulic lime its long-term performance is known as the 'hydraulic set'. A second set known as carbonation also takes place. Carbonation is when the lime reabsorbs the carbon dioxide that was driven off during the firing of the lime.
The setting process is best achieved in warm and moist conditions, which allows the new work to dry and set slowly. Therefore, during and after completion of the work, it is essential to ensure ambient conditions.
Rapid drying by the sun, wind or artificial heat will all have a detrimental effect on the outcome of the lime finishes.

Temperatures below 41 degrees F will slow the carbonation and hydraulic setting process and frost conditions before the NHL has totally set will damage un-carbonated areas, through the action of freeze-thaw (expansion/contraction) resulting in feeble and crumbly finishes.

Excessive shrinkage is a result of rapid drying, and this can lead to separation between coats and background. Rapid drying of the surface of new mortars, can also lead to the pores of the mortar becoming blocked with fine material, transported to the surface by the passage of water evaporation too quickly from the mix, this will inhibit the carbonation process taking place deeper into the new mortar.
The best way to control and protect the carbonation process is to form a microclimate for the new work. Where the new work is scaffolded, this can be a reasonably simple job. Scaffold netting is especially useful for reducing the effects of wind. In addition to this in warm or hot conditions, damp hessian can be placed against the new work and then covered by sheeting to stop rapid drying.
New work should be damped down for a minimum period of 10 days after completion and longer if possible. The emphasis should be on damping down as opposed to saturating new work. Provision should be made for damping down over weekends, holidays etc. In cold weather, the work must be protected from frost attack, by using thermal blankets e.g. polystyrene sheets. Hydraulic plasters/mortars will stand up to cold conditions after 3-4 weeks of hardening. It should be remembered that prolonged periods of cold temperature will slow the overall hardening process and extended periods of protection will be called for.

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Storage of Lime & Aggregate

Natural Hydraulic Limes are supplied in water-resistant paper bags. If the bags get wet, they may be irreversibly damaged. Also, once 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 dry storage.
In this state the lime will remain useable for a further 2 or 3 days. Thereafter it should be discarded.

Aggregate should also be covered, if left exposed fines can be washed out and the material can gradually separate.