Soft Lime Mortars in a Cold Climate

Text of a presentation delivered to the Traditional Building Conference, Chicago, April 2006.
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I am a stonemason and building conservator and have been working with lime mortars for a little over twenty years, primarily in the context of historic building conservation, but also in association with new build projects. I do not use ordinary portland cement.

I have spent the last 5 summers working on building conservation projects in the state of Vermont and upon all of these—in southern, central and northernmost Vermont—I have deployed soft lime mortars as a matter of course.

Some of these have been putty lime mortars with added pozzalan, others hybrid mortars using putty lime guaged with NHL 3.5 or NHL 2.0. Others still have been mortars using NHL 3.5.

I have used English and French NHL, English putty lime and putty lime slaked on site from quicklime produced in Massachusetts.

I have used these mortars with 200-year old brick, with new brick, with granite, schist and slate, with West Rutland marble and Champlain Black limestone.

I have used them in a variety of locations, some more exposed than others, but all of them cold in the winter. In a VT winter, frost penetrates to 4 feet deep.

In a VT summer, however, the weather is frequently hot (in the 80s) and often humid. There is rarely any wind to speak of. I believe that the summer climate in New England (and elsewhere in the USA) provides optimum conditions for the curing of lime mortars, and that the secret of longevity in a lime mortar lies in its curing. Effective curing depends upon the weather conditions prevailing when mortars are used; upon the good practice of those that use them, as well as their use in the context of a proper and thorough understanding of how traditional buildings perform and why. These factors are much more significant for success with lime mortars than the severity of winter climate.

In the UK the relative mildness of the climate, the absence of unremitting cold; the sheer frequency of freeze-thaw cycles, coupled with driving rain and seemingly permanent wind can have a much more damaging impact upon lime mortars. But conservation and repair is successfully built around the use of softer limes, whether putty or 2.0 or 3.5 NHL.

The use of NHL 5.0 is limited to concrete floors or footings, or to particularly exposed, and flat, locations such as chimney flaunchings.

In Malton, North Yorkshire, where I am based, I have yet to find a stone building built before the mid-1800s the bedding mortar of which is not mud—earth, soil. Internal plasters as well are of earth. No lime was added, although the town itself is built on limestone and had quarries all around. All of these walls are sound. Some of them date from the 13th Century. The masons were highly accomplished. Mud was not used because they had no ready access to lime mortar: it was their material of choice. And their choice was informed. Where this mortar becomes exposed to the elements due to decay of the stone (decay most often induced
by the use of opc mortars over the last 50 years or so) and neglect, it survives very well—and so, crucially, does the stone. Mud mortars were used right across the UK far more commonly than is appreciated. They were used for their softness and their flexibility. They make even the softest lime mortars seem quite hard.

That New England masons’ slang for mortar is ‘mud’ (which it is not in England), tells me that this building tradition remained widespread in Britain during the 17th Century, and was carried - along with the craft understanding that went with the habitual use of soft mortars - to the New World.

It has become apparent to me over the course of the last five years, that - whilst there is a growing interest and awareness of the importance of using lime mortars in the USA - many of the people involved in the specification, supply and use of these mortars are inclined to assert that, such is the severity of the New England climate, only lime mortars based upon NHL 5.0 are appropriate or to be recommended.

Or worse still: that ‘conservation’ opc mortars should be used.

To me, as a soft-lad from the western extremes of Europe, it would seem that this logic would extend across huge swathes of the North American continent, since how much of it isn’t brutally cold in winter?

Most of Europe is colder than England, however. And the English climate was itself very much more extreme until 200 years ago, before which time the River Thames froze every winter, for example. Whilst many of our medieval buildings may bask today in mild winters, this has not been so throughout most of their existence.

Even much of southern Europe endures extremes of cold as well as of heat, especially at altitude. And most of central and northern Europe experiences extremes of summer heat along with bitter winter cold: The Czech Republic, for example. Throughout the towns and cities of this land-locked little country, the buildings are faced with lime stucco. Whole elevations; whole streets in Prague, as well as in the snowy mountain towns, that read as stone, are in fact rendered brick or brick-backed stucco mouldings. The bricks are soft, and so are the mortars. Most were limewashed in the past, and many are highly decorated with lime-based paints.

In Thailand, too, brick-backed lime mortar, both flat render and run mouldings, was the common finish for the temples and palaces built in the 1500s. There is no frost in Thailand, of course, but the patterns of decay and degradation of old and neglected lime mortars would seem little different from those in the Czech Republic.

Soft lime renders, finished with putty lime washes are a dominant architectural finish throughout central and eastern Europe and in Russia, of course. Exposed stone is relatively rare, and much rarer than in England, where dubious Victorian taste saw most of the lime renders swept away to expose stonework its builders never intended to be seen.

Returning to New England, why did we elect to use soft lime mortars?
Based upon my previous experience with lime, and upon a lot of received wisdom from the new wave of lime users in the conservation industry in the UK, as well as upon my growing theoretical and empirical understanding of why lime works, of why buildings of traditional construction need lime (or some other eminently porous material, such as earth) in order to perform as their builders intended, it seemed clear to me that the very harshness of the climate made the use of soft lime mortars absolutely imperative.

I would humbly suggest that those people who conclude that a relatively hard, relatively dense and relatively impermeable NHL 5.0 lime is appropriate, or even essential, risk falling into the same trap as those who so eagerly embraced the use of opc mortars in the past: the seductive notion that the exclusion of moisture is the best way to keep a building dry.

This is, of course, the basis of modern building technology. There is little continuity between traditional and modern building practice, however. The common sense idea that a modern builder or architect will automatically understand the needs of an old building leads frequently to disaster. There is scant continuity; we are not part of an unbroken craft tradition, however romantic and reassuring the notion might be. A rupture occurred; we are having to relearn what our fellow craftsmen and women took for granted. If we do not understand this, then more historic buildings than already have been will be lost.

The use of hard lime mortars ignores the requirement of COMPATIBILITY, and gives too much weight to modern laboratory testing (particularly of freeze/thaw cycling performance). The characteristics of a lime mortar that will lead to its rapid failure in a laboratory are precisely those characteristics that are essential for its success in the real world. The characteristics of an opc mortar that lead it to succeed in the lab are precisely those characteristics that invite disaster when it is used upon a traditional building.

The addition of opc to a lime mortar (which is, in reality, the addition of lime to a cement mortar) is not only unnecessary, it causes damage and is self-defeating. At 1:1:6, it is relatively durable in itself, but too hard and inflexible and will be destructive of historic fabric. At 1:2:9 or 1:3:12, it is still destructive and is at the same time less durable than an ordinary lime mortar. No mortar with opc offers the necessary characteristics of porosity and flexibility that are as important as compressive strength for its durability. In the context of old buildings, it is not high compressive strength that guarantees durability— it is the opposite.

Historic lime mortars have a typical compressive strength in the range of 0.1 to 3.5 Mpa (Hughes and Valek, 2003). The ultimate typical Mpa of a putty lime mortar, without pozzalanic additive, is around 1.0, which is adequate for the demands of most, traditional solid wall construction. An NHL 2.0: sand mortar at 1: 2 ½ proportion will achieve a compressive strength of 0.9 Mpa after 200 days and will have strengthened little more after 700 days. An NHL 3.5:sand mortar at 1:3 proportion will achieve a typical Mpa of 1.0 after 28 days; 2.2 after 365 days. At a more typical proportion of 1: 2 ½ an NHL 3.5 will achieve a compressive strength of 1.3 Mpa after 28, and 3.1 Mpa after 365 days. (Figures, Foresight Research Team, in Hydraulic Lime Mortars, 2003). A 1:1:6 opc:lime:sand mortar, however, delivers a compressive strength of 5.1 Mpa almost immediately - 40% greater than that of a typical historic lime mortar. A Type-M cement mortar, typically 1 lime: 3 cement: 12 sand delivers 17 Mpa—more than 5 times the likely maximum of an old mortar.
Crucially in this context, NHL 5.0 at a lime: sand ratio of 1:3 delivers an Mpa of between 4 and 7 after 65 days, strengthening to between 5 and 8 Mpa after 700 days. An NHL 5.0 mortar, therefore, is harder/stronger than even a 1:1:6 opc mortar, and will be significantly stronger than a typical historic mortar. It is likely to be incompatible in a way that an NHL 2.0 or 3.5 is not.

Soft lime mortars have a very low thermal or hygroscopic expansion: the harder the mortar, the greater is the potential for both. A new pointing mortar that is too hard compared to the old will loosen over time for this reason alone.

The key to healthy performance in a traditional building is for it to be allowed to perform as its builders intended (Oxley). Crucial to this endeavour is BREATHABILITY. That is to say, the gentle absorption and equally gentle release of moisture, however generated, whether from within or without the building.

Most of the problems people associate with old buildings are the consequence of inappropriate interventions using modern materials—cements, modern paints, resins, damp-proofing membranes, etc—both inside and out of the building.

The priority of our mortar designs, therefore, should be maximum vapour permeability consistent with durability, compatibility and, importantly, authenticity. They will use soft lime and sharp, well-graded sands that will deliver mortars of an open pore structure, promoting rapid evaporation of moisture from the fabric of the building and, particularly, from the masonry substrate—minimising the potential for damage to this substrate by either salts or frost action.

It is a fools errand to think that one may ever exclude moisture from a solid wall of traditional construction. The attempt leads only to the opposite effect: keeping that moisture in, with frequently damaging consequences.

It is important to say, however, that our Stateside analysis was not made entirely in a bubble. I have been delighted to discover that Vermont, western Massachusetts and Upstate New York are replete with 150 and 200 year old masonry structures the majority of which retain their original lime bedding and pointing mortars, often in as good a condition today as the day they were laid in, the original striking perfectly preserved.

The mortars used in these brick and stone buildings were soft lime mortars, produced in the simple kilns, fired by wood, rarely generating a temperature greater than 900 degrees centigrade.

That the original mortar of so many buildings survived intact gave me every reason to have confidence in my judgement. It is considered a truism in England that a lime mortar that survives a year will last a hundred years and more. None of our repair mortars have failed.

Lime mortars of any strength (remembering that weakness is frequently the greatest strength of a lime mortar) will fail under the influence of specific decay mechanisms and in the absence of complementary architectural detailing—if they remain too wet for too long, for example, because of poor detailing or defective rainwater goods. Or if they are regularly soaked with
salt laden water. By failing in these circumstances, however, lime mortars are only doing their job. They are intended to be sacrificial—decaying preferentially to far more expensively replaced stone or brickwork.

Hard mortars—particularly ordinary portland cement mortars, but also, I would contend NHL 5.0 mortars, reverse the equation: they make the masonry substrate the sacrificial element of the building. They have a much reduced vapour permeability; they are dense and brittle and are less able to accommodate the inevitable seasonal movement of a solid masonry wall. They will very likely be incompatible in strength with the bedding mortar and will promote unnecessary stress and strain within the structure. They will loosen quite early in life, but cling on stubbornly for years, allowing moisture in, whilst inhibiting its departure; trapping it and promoting its preferential evaporation from the brick or stone, where its passing will leave salts behind; keeping the masonry wetter for longer than is either necessary or desirable. The very use of opc introduces salts.

Few people can doubt the habitual bad practice that has developed under the influence of opc-use, or even the likelihood that even ‘soft’ conservation cement mixes will be habitually corrupted by the modern mason’s lack of belief in them (he will add more opc than specified). OPC is very forgiving of quick-fix working, in the short term. Most of the masons likely to use lime mortars will previously have been accustomed to the use of opc mortars. The rapid initial set of NHL 5.0 can—rather than helping a reluctant mason to make the transition to lime—incline him to think he can use it in the same way, encouraging a lack of attention to detail—insufficient pre-wetting; insufficient after-care. Drying is not the same as setting. When working with lime, one cannot effect a quick-fix and simply walk away. Lime demands the attentiveness and consideration of its users. It demands that they care.

Lime mortar demands good working practice; and soft lime mortars demand it more than harder ones—but both will fail without it. It demands engagement with and understanding of the building, its history and construction, and this in turn allows us, on occasion at least, to touch the hands and even the souls of its builders.

The guarantee of longevity in any lime mortar is good practice: soft lime mortars demand it more than harder ones— but both will fail without it.

- Understanding the history, construction and needs of the building as a whole;
- Attention to prevailing weather conditions;
- Good aggregate selection—sharp, and especially, well-graded sands and/or stonedusts;
- Ample pre-wetting of walls and substrates, before and during the work;
- Using mortar of the correct consistency and water content;
- Covering/protection of mortar from sun, wind and rain;
- Careful management of the curing process;
- Beating back to consolidate where necessary, and to expose aggregate, increasing the surface area of the mortar;
- Care and consideration and a modicum of sensitivity;
- The confidence that lime mortar will succeed.

Good practice, above all, will mean that even the softest lime mortar will have a long and successful life—whatever the climate. And so will the building it is part of.