the earth stone and lime company

building conservation consultancy and practice

Thirley Cotes Farm, Harwood Dale. 29.03.2019

Brief analysis of mortars and pattern of construction and method statements for the mixing and use of earth-lime and hot mixed lime mortars.

The barns which are the subject of this report are of squared and coursed Jurassic sandstone, locally sourced. The longer barn was built using earth-lime bedding mortars, pointed with lime rich, hot mixed lime mortars; the smaller barn at right-angles to this and closer to the main farmhouse, appears to have been built throughout with hot mixed lime mortars.

Internal, cross-walls which have been required to be rebuilt were constructed using earth-lime mortars.

Internally, earth-lime mortars were left full and limewash was applied over. This will have been freshly slaked from quicklime and applied hot, maximising coverage and minimising necessary coats for being thicker than modern limewashes.

Earth-lime mortars were the most common mortars of construction for stone buildings in the region and across the UK until at least 1800. They were cheap, the raw material sourced close to the buildings; they were eminently workable, with excellent cohesion and adhesion, as well as having very good water retentivity and bond. The lime addition was typically low – around 5% quicklime addition by volume, doubling to 10% lime addition after slaking. They set by feeble pozzolanic reaction between the clay and the lime, as well as by slow and steady drying. They are of generally low compressive strength, displaying good deformability as well as a pore size distribution that facilitated the capillary movement of liquid-phase water from the fabric. It is essential to the proper performance of such mortars and such buildings that the pointing mortars and plasters applied to their fabric are of similar effective porosity. Vapour permeability alone is insufficient to maintain such traditional fabric in a dry condition – capillarity is essential. Vapour permeability alone does not deliver breathability.

Effective porosity in a lime mortar relies upon a high free lime content – which is reliably and easily delivered by the use of a hot mixed lime mortar mixed at 1 part quicklime to 3 parts aggregate. Such lime rich mortars are entirely durable, so long as the building retains its original pattern of weathering detail.

I have been using such mortars across North Yorkshire as well as further north for 13 years. Frost damage to these projects has not occurred and the buildings have become dry, which is to say, thermally efficient and safe from the decay of embedded timbers and from frost damage.

The policies and guidance of Historic England and Historic Environment Scotland have shifted recently away from the use of NHL mortars and strongly in favour of like-for-like repair of traditional buildings and the mortars of which they were built. The North York Moors National Park has embraced this shift in guidance.

In the case of the barns at Thirley Cotes Farm, like-for-like will require the use of earth-lime and hot mixed lime mortars, though this should not be seen as onerous – the prevalence of these mortars before the 20thC illustrate the fact that until this time, mortar design was the province not of architects, but of the craftsmen themselves – masons chose to use earth-lime and hot mixed lime mortars because of their workability and usefulness and because of the properties they possess, as listed above.

Beyond this, it should be stressed that lime-rich, typically hot mixed lime mortars represent an active, dynamic system for the promotion and preservation of dry fabric, actively poulticing liquid-phase moisture, as well as water vapour, from the fabric of the wall. This process is primarily wind-driven, and the necessary capillarity works from the inside out, not from the outside in. Porous mortars do not absorb received rainfall to great depth and they very quickly exvacuate such received moisture once the rain stops. Porous mortars do not lead to wet buildings – non- or little-porous mortars do this – but to dry ones.

Cement and NHL mortars are harsh-working, of poor workability, poor water retentivity and deliver poor and defective bond with the stones or the bricks; they are minimally breathable – and an NHL 3.5 mortar mixed at 1:3 has only marginally greater effective porosity to a 1:3 CEMII: sand mortar. Both will entrap moisture within the fabric and lead to its progressive accumulation.

Recent NHL research commissioned by Historic England has shown that these of very variable strength, not only between brands but within brands; they continue to gain in strength for an indeterminate period, but for at least 3 years and will have a compressive strength at 2 years typically 3 times more than their strength at 28 days. To reach expected tenacity, they require ongoing hydration – spraying with water – for the duration of their set. In the absence of this, the resultant mortar at depth will be either a mush or a powder, not a suitably tenacious mortar. Other research into historic texts has demonstrated clearly that NHLs have no historic precedent for use in above-ground construction before the last decade of the 19thC, and into the first decades of the 20th. This use was quickly realised to have been a mistake, and such use was displaced by the use of cement-lime mortars. A 1:3:12; even a 1:2:9 cement lime mortar will have a higher free lime content than any currently available NHL and will possess more effective porosity. Both, however, will be weaker and less tenacious than a fully cured 1:3 hot mixed lime mortar – though this curing and carbonation may take months, or even years at depth. In the meantime, however, such mortars are load-bearing and flexible, allowing for an even settlement of a traditional wall without cracking.

From the point of view of masons and plasterers, hot mixed lime mortars, as well as earth-lime mortars are a pleasure to work with.

Traditionally in this region, the base-coat plaster would be of earth-lime, with hay added in short lengths to counteract shrinkage. A 4 – 8mm thick, haired lime rich finish coat would be applied over this and subsequently limewashed.

Repointing mortars of similarly lime-rich composition would also often contain small volumes of ox-hair for similar reasons.

For structural and performance reasons, as well as for reasons of compatibility, these mortars should be used for the repair and restoration of the barns at Thirley Cotes. Listed Building protection is much more importantly about proper and compatible performance than it is about appearance. Applying the technology and materials of modern construction to traditional fabric will inevitably cause problems for the health of the building, but also for the health of its occupants. All materials must be porous and effectively so, including insulation materials, in order for a traditional building to perform as its builders intended – which is to say, to perform properly.

It is strongly recommended, therefore, that the following methods and materials are applied:

Cross-wall rebuild. Where no solid footing currently exists, a trench at least 6 inches wider on each side than the wall should be excavated to 12 inches. This should be back-filled with crusher-run limestone hardcore and compacted – in 4 inch increments, with either ramming tools or plate compactor.

The mortar should be made from sub-soil available on the site. This would ideally be screened – thrown through an angled screen to remove larger aggregates, or passed through a ½ mesh garden sieve.

The available sub-soil would appear very similar to the original earth of the mortars – it is sandy and of relatively low clay content and will probably not require improvement with sand addition. This will be established during a proposed training day. The sub-soil should be mixed to a wet state in a mixer (a pan mixer, ideally), before around 5% powdered quicklime by volume is added. The slaking of this quicklime will stiffen the earth mortar to a plastic state and it should be used immediately. If not used immediately, it will stiffen somewhat and require re-tempering before use, with the addition of more water. For the internal walls, this mortar will be struck at the face of the wall to receive lime plaster. No voids should be left within the wall, as such voids will interfere with capillary movement.

Earth-lime mortars for deep packing of open joints will be the same, but of a stiffer consistency.

All stonework to be repointed with either earth-lime or hot mixed lime mortar will be wetted before pointing to control suction. There should be no need, however, to pre-wet stones for building with earth-lime mortars. Some pre-wetting would, however, be advisable before bedding stones in lime mortars (see general method document attached).

If already installed stud walls are to remain, insulation within these must be effectively porous. Kingspan-type insulation materials will cause major negative issues for traditional fabric. The space between the kingspan and the wall will have a permanent relative humidity level of 100%, promoting the premature decay of even preservative-rich timbers, as well as a dramatic increase (2000%, typically) in dust-mite and mould populations. Suitable insulation materials in this scenario would be wool or hemp fleece. No vapour-barriers should be introduced.

It will not be unreasonable to increase the thermal performance of the walls by the use of an insulated lime plaster. This would contain hemp shiv, as well as sand, in the base-coats. A typical mix would be 4 parts of hemp shiv: 5 parts of sharp sand (such as that sold by Jewsons): 2.5 or 3 parts powdered quicklime, all mixed hot and used the day after mixing. This coat may be applied up to one inch in thickness. The second coat might also contain hemp shiv, but this would be less – 2 parts in 9 and a typical mix would be: 2 parts hemp shiv: 4 parts sharp sand: 3 parts Cook's sand. This would also require ox or goat hair addition to control initial shrinkage and should be applied in a ½ inch coat – certainly no thicker than ¾ inch. A thin finish plaster coat would be applied over this, followed by 3 coats of hot limewash. Ideally, several weeks will be left before first and second coats; the final coat may be applied as soon as the second coat has reached leather-hardness.

If the base-coat is of earth-lime: hay (or hemp shiv), the delay would not be so long, as the base-coat would not need to carbonate as fully as possible before application of the second coat. Earth plasters are very efficient at maintaining an ambient internal humidity of around 40%, the optimal level for human health.

In all coats, but especially in the base-coat, there may be some initial shrinkage overnight. This should be rubbed back and closed using a plastic float, which will also open the surface somewhat. No keying between coats beyond this opening of the surface should be necessary.

Within the barn, a concrete floor has been laid. A six-inch margin between this concrete and the wall should be cut out. This will be back-filled with a breathable lime concrete – typically 1 part quicklime: 1 part pulverised (softer) brick: 2 parts sharp sand: 10% meta-kaolin (as a proportion of the quicklime), mixed to a stiff consistency and laid hot or warm.

External repointing should be performed only where necessary – all surviving hot mixed lime pointing mortars should be left in situ; all cementitious repointing mortars should be removed and replaced with a matching hot mixed lime mortar. The precise mix will be refined during a training day, but this will be something like ¾ part powdered quicklime: 1 part 5mm down quicklime: 2 parts sharp sand (Jewsons); 1 part plastering sand (Jewsons), with a small addition of ox or goat hair cut to ½ inch to 1 inch lengths.

The joints should be wetted before pointing. There will likely be some slight initial shrinkage overnight. This should be closed up the following day using pointing irons or plastering lath 'sticks', and the pointing should be beaten with a churn brush. No spraying or misting of the knocked-back pointing should be done – the mortar has all the water it needs to set. Once the surface of the pointing has hardened, the elevation may be rinsed down.

As will be demonstrated on the proposed training day, pointing mortars should be quite stiff, not unlike molasses or soft brown sugar in moisture content; bedding mortars will be wetter.

At this stage, a concrete ring-beam has been installed around the wall-tops in response to concerns about outward wall movement; gable walls have been raised in concrete blocks bedded in 1:5 cement: sand mortars. Whilst not ideal, consideration might be given to leaving these elements in situ. Earth-lime mortars are weak in tension, so that a ring-beam might be seen as a legitimate strengthening of leaning walls; the gable raisings were not a replacement of existing fabric, but a closing of previously open internal gables. All will be encapsulated in a porous lime mortar, which will manage internal condensation sufficiently for this not to cause damp or mould issues.

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Some buildings locally repointed with hot mixed air lime mortars:

Barns, Swallowhead Farm, Fylingdales, 2012:

Immediately after repointing:

1 year after repointing:


Scampston Hall, 18thC horse shelter and cart-shed, 1 months after repointing:

Nawton Towers, Pockley. ! year after repointing:

Hall Farm, Maltongate, Thornton Dale, Pickering, North Yorkshire YO18 7SA