Earth plastering, analysis and specification for conservation, repair and restoration works in Malton, North Yorkshire

Earth or loam plasters are commonly found within the buildings of Malton and neighbouring villages. These formed part of a traditional two-coat plastering system deployed locally until at least the mid-Eighteenth century and still into the earlier 19th C. They may be observed in timber-frame buildings, as well as within most pre-19th C masonry buildings, lest these be of brick, which display lime-sand mortars from the 16th and 17th centuries onwards. Stone buildings in the region were typically constructed using earth or earth-lime mortars, and this pattern of construction was all but universal across the UK, upon the limestone belt as generally as elsewhere. It was the general pattern of masonry construction in France, Spain and across Europe, subsequently carried from Europe to the Americas. The pattern is the same in all of these places: lime-lean earth bedding mortars pointed with – often lightly haired – lime-rich facing mortars, the exteriors typically limewashed; lime lean base-coat plasters within, surmounted by quite thick, hot mixed, lime-rich finishing plasters. This may also have been applied as an exterior finish, but was likely displaced during the 18th and 19th centuries by the use of thoroughgoing lime-sand mortars for exterior protection. This pattern of construction – and its particular demands for compatible repair and conservation – has been substantially ignored by the conservation industry and during the 'lime revival'. It has been barely noticed by advocates of earth building. It is essential for the appropriate performance of earth-built masonry structures that lime mortars used in association with them are eminently breathable. They must have a high free-lime content to deliver this breathability; they must be 'deformable', able to flex without cracking.

A normally one-coat base of earth plaster was followed by a finish coat rich in both lime and hair, and including lime stone or chalk aggregate. Many, if not most of the earth plasters contained up to 10% lime, added in the form of quicklime. During the 17th and 18th and into the 19th Centuries, variable volumes of quicklime were also added to bedding mortars for masonry construction, usually in the form of lump lime, probably mixed by the 'ordinary method', as also applied to lime sand mortars – the lump lime placed in a 'doughnut' of subsoil, improved as necessary by the addition of sand or limestone aggregate, and water sufficient to effect the slake added, either in one go or by sprinkling. More water would be added after slaking was generally complete. Alternatively, pulverised, but not necessarily powdered, quicklime might be added to an already wet-mixed earth mortar, the earth taken to a slurry to achieve maximum engagement of the clays before being brought back beneath the liquid limit by the slaking of the quicklime. The addition of quicklime already run to putty may have been practiced, but this would add to the water-load in the mortar, not reduce it and would mean the earth mortar being previously mixed quite dry, potentially leaving it lumpy. Such a mortar would then require extensive beating and tempering, which is much less necessary when the earth mortar has been already run to a slurry.

Throughout the medieval period and all of the Seventeenth century locally, this pattern of internal plastering was applied within limestone and calcareous sandstone buildings the mortar of which was also loam. Even after lime bedding mortars became the norm locally for particularly brick masonry structures, the use earth bedding mortars in association with stone, and earth plasters locally persisted well into the C18.

The relative slowness of the carbonation of pure lime mortars may have been a factor in the widespread use of earth backing coats – the stiffening and setting of these was much less dependent upon carbonation of the lime, and was a process of 'lime-assisted' drying. The laying on of subsequent coats would not inhibit carbonation of the deeper layers in the same way as occurs with 3-coat lime-sand plasters. Earth plasters were lime-lean, relying more upon the chemical interaction of clay and lime for their tenacity, less upon

the carbonation of the lime itself. This would allow faster working, therefore, with much reduced delay between the application of multiple coats.

The widespread survival of earth plasters in buildings of all status in Malton is an important element of the town's undoubted historic and cultural significance.

It is essential, therefore, that every effort is made to retain these mortars in situ wherever they are encountered; to repair them with like materials when necessary and to deploy plasters of similar character and composition during refurbishment and repair works as appropriate. Where harder, later plasters, clearly less compatible with a mud-bound substrate have obviously displaced earlier earth plasters and are themselves failing or causing damage, consideration should be given to the reintroduction of earth plaster.

Even when wholesale failure of an earth plastering system has occurred (usually because of recent interventions with incompatible and little-breathable materials), and especially when the masonry substrate is itself bound with earth mortar, loam plaster should be used to replace it. The old plaster is easily recycled and reapplied. All surface treatments, including paints, must be breathable.

Earth mortars regulate interior relative humidity, drawing moisture from the air when RH is high; releasing moisture when RH is too low. They provide an interior atmosphere of optimal human healthfulness. Interruption of their ability to perform this function will promote dampness and decay and will inhibit their otherwise excellent thermal performance. Internally, the walls may become too wet, or too dry. In the former situation, they may ultimately liquefy and lead to slump; in the latter, they may become brittle and lose bond.

The pattern of earth plasterwork locally:

The walls were pointed and dubbed out generally flush with earth mortar;

A basecoat of earth/loam plaster (with or without inclusions of hay; sometimes with ox-hair and/or quicklime) between 1/2" and 1 ½" thick was applied to either masonry or riven lath. This was laid on with a float.

Many – perhaps most – such earth mortars had a certain amount of quicklime added and were 'hot-mixed' therefore, particularly from the later 17thC onwards. Analysis of these mortars (see slide) shows that some contained nearly 50% calcareous material, but, of course, this is unlikely to be lime only as the local geology is calcareous itself – much of the aggregate content will be naturally occurring limestone and the volumes of this will have varied according to source.

A finish coat of lime mortar rich in ox-hair was applied over this. The aggregate of this mortar was typically oolitic limestone, or chalk, as well as residual grit and impurities delivered by locally made lime. This could be up to 8mm thick, but was typically around 4mm in thickness. This is typically thicker than a finish coat upon 3-coat lime plasterwork, but its composition was similar, if very rich in hair.

The base-coat contained hay (and sometimes also ox-hair) to reduce shrinkage and to improve tensile strength. Not all earth plasters observed in Malton contain hay, however, and slight shrinkage was not unusual.

The pattern when earth or earth-lime mortars were used for building was straightforward: the earth bedding mortar was struck at the face – not raked back – and the lime rich, often almost pure lime pointing mortar was laid over this, much like a localised finish plaster. This defies current conservation repointing practice, with the joints raked back 20 or even 40mm before being repointed with lime. The traditional pattern demands an eminently sticky, cohesive and adhesive mortar, which may have been applied wetter than typical lime pointing mortars to facilitate attachment. As with most lime pointing mortars, these were applied and left 'off-the- tool', or were, at least, pressed back to leave a tight, tooled finish – once more defying current conservation repointing practice. The objective was plainly to reduce the moisture uptake of

the pointing mortars themselves; to 'shed' as much as to absorb received precipitation. It was a common understanding historically that pointing mortars should be more durable and weather-resistant than the bedding mortars. This led to the ongoing adoption of harder and denser binders over time, as each appeared. Compatibility was never a consideration in the past, nor until really quite recently.

Sourcing of raw materials:

Earth was likely sourced much as it would be today – opportunistically. Soil is always a valuable resource. Some, at least, will have been won during the excavation of footings and cellars/undercrofts. The latter are very common in Malton. It is a measure of its local importance for construction, however, that the first right and privilege of the burgesses of New Malton laid down in the medieval borough charter was that to 'dig stone and earth for building and edification on either side of the town'.

Depending upon its source, the soil would have been more or less suitable and fit for purpose. The proportion and distribution of clays, silts and sand/aggregate in a soil will determine its characteristics and its utility for plastering. Clay content might range between 5% and 15%, with around 10% clay being optimum and typical in local plasters that have been analysed, producing a relatively strong and cohesive mortar. Most of the sand/aggregate observed in plasters locally has been limestone aggregate. This will be naturally occurring, not added. It is clear from the sheer variety of earth plasters locally that the soils were generally used as found, and improved only by the addition of hay, though the addition of sands and other aggregates as necessary cannot be ruled out.

In regions where arable farming predominated, hay is the typical addition to moderate shrinkage and to increase flexural strength. Where cattle were dominant, such as in the Lowlands of Scotland, ox-hair was more commonly used; reserved elsewhere for use in lime plaster and pointing mortars. In Spain, neither was common.

On analysis, sands found in earth and earth-lime mortars were predominantly very fine. In Malton, larger particles tended to be of oolitic limestone, not sand. This tendency was reflected in Georgia, USA, and is likely the norm in such mortars. Indeed, the high volumes of very fine material would indicate that silt content is as important to the proper performance of such mortars as is clay content. Such sands are typically found in rivers and streams, or beneath previously underwater landscapes (such as the Vale of Pickering, where the subsoils typically demand no great improvement before use).

Earth as a building material is eminently sustainable – it is carbon neutral and carries minimal embodied energy. It is also a significant contributor to healthy living – acting to effectively regulate the relative humidity levels of an interior, keeping these within healthy limits. Its durability and fitness for purpose is evidenced by its survival throughout Malton.

Earth plasters have rarely failed, but have been removed unthinkingly or in 'horror' by builders and others. Earth mortars sometimes attracted significant snobbery under the gaze of 'improving landlords'. The lord of the manor of Moffat, Dumfries, offered his tenants long leases in return for them demolishing their earth-built whinstone houses and rebuilding them with lime mortared masonry. Consequently, only two earth-built houses – owned freehold by merchants – survive in the town (Elliot).

Where the earth plaster has failed in situ: the lime top coat should be peeled away and set aside for disposal. The earth plaster may then be gathered from the wall and reused. It will be dry and lumpy and it will be necessary, therefore, to break it down, initially by stamping underfoot and then by submersion in water. This soaking should commence 24 hours before reuse. Preferably, mixing will be done in a pan/paddle mixer, but a drum mixer may be used. Water will be added until the mud is of a sloppy consistency – as wet as possible without its slumping upon laying up on the wall. If the material was especially sandy in situ, and was easily crushed to powder between the fingers, it

may be necessary to add a small proportion of clay. Hay in the original mortar will be recycled along with the earth during this process, or may be added during mixing.

Localised repairs should be carried out in a soil of similar character and appearance to the original. Ideally, with the same material recycled. If this is not possible, an acceptable alternative to sourcing a similar material would be to use a pre-mixed clay plaster from Womersley Associates, with hemp added. This is softer and less cohesive than earth plasters typical locally, but is compatible and reliable, as well as being an honest repair.

New work and restoration, however, should be executed in a locally sourced sub-soil free of vegetable matter of similar character and composition to typical earth plasters in Malton, or in the building being worked upon. Test panels with and without added hay or hemp shiv will demonstrate the suitability of the material as well as the necessity, or otherwise, of adding either to the mix.

Application:

Walls should be dubbed out as necessary, with all open joints pointed flush with either an earth or a soft lime putty or hot mixed air lime mortar, which should be allowed to cure.

Walls should be well brushed down using a stiff bristle brush.

Walls should be well moistened with a fine spray, avoiding water run off. This wetting should commence well ahead of plastering and be repeated regularly through the day before plastering begins and topped up shortly before the laying on of the base coat.

The earth should be well-prepared and well-tempered. It may be left outside exposed to the weather well before use to be broken down by frost and rain and should be free from humus or other growing vegetable matter. All lumps should be broken down, by stamping or other means, and then submerged in water at least the day before use and left to soak overnight.

Mixing will be in a paddle or roller mixer for preference. Roller mixers will produce the best-tempered material. Earth mortar should be brought to a sloppy consistency at the same time as hay is added as necessary. Hay should be well distributed through the mortar and may comprise up to 20% of the mortar by volume.

If lime is to be added, the earth mortar should be mixed wet and even beyond the liquid limit, after which it should be sprinkled with powdered quicklime and well mixed. Hay, hemp shiv or hair would be added after this.

Earth plaster should be applied with a wood or a steel float, as per lime mortar, in sweeping strokes, laid on, not overly compressed. Unlike for lime plastering, coats of 1" may be considered typical.

The plaster should be used at a consistency approaching the liquid limit of the material – we have found this to be the most successful method and shrinkage is generally minimal.

Typically, the surface was finished with follow-up strokes of an 'opened-up' trowel, which will leave drag marks from hay or larger aggregates across the surface. Scouring does not seem to have been common practice but should not be ruled out if minor shrinkage occurs. Nor should brushing or knocking back with a churn brush as appropriate.

No more mechanical keying of the surface was carried out traditionally, other than the above abrading of the surface and should not, therefore, be done today.

Earth mortars may take a month or longer to dry, depending on the time of year. Some fungal growth may occur when hay or under-ripened hemp shiv has been admixed, but this will fade and die as the plaster dries and should be brushed away before application of lime finish coats.

Although the lime finish coat may be applied to a previously fully dried (and then pre-wetted) earth base coat, it should normally be applied before full drying of the base coat has occurred – as soon, indeed, as any

shrinkage has occurred. This will reduce the need to rewet the surface, which can lead the earth surface to dissolve.

The lime finish coat will be 1 part partly sieved Portland (or other oolitic limestone stone dust) or chalk: 1 part putty lime or 3 parts limestone dust to one or 1 ¼ parts quicklime, hot-mixed. Goat or ox hair cut to roughly 1" lengths will be added as the mortar is mixed or knocked up for immediate use. As much hair will be added as will not compromise the workability of the mix. Typically, hair will comprise 15% of the mortar by volume (this equates to about 6 parts mortar to 1 part hair). The 'beard' that hangs from a trowel of this mortar will be dense and tightly spaced.

This will be applied to a previously moistened surface somewhat more thickly than a typical finish coat to 3-coat lime plasterwork. Scouring and brushing *will* be required, as per lime plaster finishing, to consolidate and level the surface and to take out any minor cracking or crazing. The quality of the finish required will determine the extent and frequency of this scouring, but two sequences will be the minimum at roughly 24 hour intervals.

There will be some advantage in 'feeding' the finished surface with one or two coats of limewash some several days or so after completion of the scouring process.

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