Lime Revival

It is clear from all of the above that the ‘lime revival’ comprises a catalogue of mis-steps, errors and misinterpretation. Some of these have been benign; some of them much less so. The fact that there had been a temporal rupture in craft practice with lime, in the UK, at least, may be offered as mitigation, but the almost complete absence of research into historic texts on lime and its manipulation (with some notable exceptions) and a general unwillingness by professionals to listen seriously to those craftspeople working ‘in the dark’ with these materials and yet discovering pockets and sometimes voluminous caverns of light and insight, may be seen as frankly inexcusable in an industry and an area of academic research not much older than the ‘lime revival’ itself, avowedly devoted to the compatible and like-for-like conservation and repair of historic fabric. This research should be just the beginning of the rectification of this fundamental deficit, which rectification will rely upon the empowerment of practitioners by both knowledge and experience and a recognition by conservation professionals that successful and non-damaging preservation of historic structures relies upon a mutual respect and cooperative working between all of those involved. Beyond this, and in keeping with the ideas and priorities of William Morris, John Ruskin, and others of their ilk, old buildings need to be valued more for their own sake than for their fetishized market value; and the owners of old buildings need to be educated in the usefulness and character of the traditional materials necessary not only for the health of these buildings, but for that of their occupants. Current legal protections, as well as current building regulations are wholly inadequate for this challenge. Finally, any serious endeavour to mitigate or to begin to reverse the progress of catastrophic climate change must include an appreciation and implementation of the logic that traditional materials, and traditional mortars, in particular, as well as traditional patterns of construction for domestic and less than heavily engineered structures, are inherently sustainable and of significantly lesser carbon footprint than their modern and frequently unhealthy or even life-threatening alternatives.

"The technical evidence does not point to short cuts in the achievement of good building; it points consistently to the discovery by scientific means of the rationale of established building traditions, which should be altered only with the full knowledge of the consequences…"
RIBA Committee (1946) – The Architectural Use of Building Materials - Post-War Building Studies No.18 London HMSO for the Ministry of Works.

In conclusion, the below is a list of key insights and areas of general consensus derived from old texts and building accounts. This represents an expansion of a text that forms part of HES Technical Paper 25, an edited selection of old texts and building accounts written and assembled by the author, to be published in 2019.

A SUMMARY OF CONSENSUS – AND OF SOME AREAS OF CONTENTION -WITHIN OLD TEXTS.

- Building mortars should be made and used immediately or within a few days, except for plastering, where 'ordinary method' hot mixed coarse stuff should be laid down for – usually – 2 weeks, or sometimes months, to allow for late slaking. Use within 5-7 days was typical for masonry construction.
- Although little documentary record from the medieval period is readily accessible, the evidence of numerous images of medieval building sites across Europe – some more naturalistic than others – is that mortars were mixed on site, immediately adjacent the works, and used immediately after mixing. Though some of the activity may be interpreted as the knocking up of previously slaked mortar, some images show steam rising from the mortar being mixed, as well as its being carried to the masons on the scaffold. Others show the mortar being mixed to have been cut from a larger pile of coarse stuff. Some show mortar boxes, where the lime might be slaked alone, to be mixed whilst still very hot with sand.

- This pattern is confirmed by surviving medieval building accounts, which show lime burning, lime slaking and mortar making going on at the same time as the building works proceed. Items paid for in some accounts include 'limesieves', indicating that the mortars were being dry-slaked and screened, at least on the sites in question. Lime kilns were frequently built on site, appearing early in account books. Pam White's research into the accounts of Corfe Castle during the time of Edward I show the lime-burners arriving on site the week before the masons at the start of the building season. Sand as routinely appears in the same account as 'lime from the kiln'.
- Although later, the 1616 building account for the Queen's House in Greenwich shows a very similar pattern. Payments for bricks, lime, sand, wheelbarrows, shovels, pails, 'lime sieves', hogsheads to make water-tubs, and significant payments to stonemasons and bricklayers is accompanied by payments to "Samuel Avery, William Browne and others for slacking, sifting and wetting of lime into mortar at 12d the hundred".
- Two of the three traditional methods of slaking aim to maximise the temperature of the slake, within certain parameters – and this is considered important for final performance. If sufficient water to effect the slake is added either in one go, or steadily by sprinkling, the temperature of the slake will be 100 Degrees C or a little more.
- The addition of insufficient water in the first instance will lead to significantly greater slaking temperatures, but will invite the risk of 'burning' the lime and then 'chilling' it when more, particularly cold, water is added before the slake is complete. This leads to unmixable particles and leaves the mortar 'short'.
- The addition of too much water too soon – or throwing lump lime into an excess of water – will 'drown' the lime, preventing its reaching the minimum necessary temperature of 100 degrees C. This was considered to lead to a weaker mortar, lacking in binding power and tenacity.
- Method of slaking has a material effect upon character and performance, though this was rarely tested. Early test results from Historic England confirms this. Hot mixed mortar used hot is the more

porous with the least (initial) compressive and flexural strengths. Mortar mixed to a dry-slake and knocked up when cold is the less porous and has the greatest (initial) compressive and flexural strengths. Hot mixed mortar used cold is between the two. These differences may equalise over time. Carbonation rates vary also – the more porous, the faster the carbonation.

- For all traditional methods, a minimum of water was added to quicklime, not the other way around. Adding quicklime to water is routinely counselled against. This was generally true also of limewashes and putty limes before the 20thC. Occasional criticism that masons added too much water in the first instance, to produce a thinner paste that was easier to mix with the sand – this practice always frowned upon.
- All lime mortars, fat and hydraulic, should be well-beaten during and after the making. One author indicates an optimum period of beating of a typical batch, by one man, to be 8 hours. Mortar mills - built or (later) mechanical made this process easier and more efficient and, once available, were always preferred to hand-mixing for works on any scale. Mortar mills and pug-mills reduce the necessity of extensive beating. Scott (1862) was certain of this. Beating was necessary to engage as much lime as possible and to reduce the proportion of lime lumps to effective binder. Roller mills continue to produce the 'best' mortar today; though mortar from pan mixers is also very good. Hand-mixing should not be ruled out, however.
- Lime run to putty was generally considered to produce a weaker mortar, with less bond, particularly if the lump lime was added to an excess of water, of which process Vicat seems the only occasional advocate, whilst at the same time condemning fat lime mortars for any purpose (and whilst acknowledging their universal use at the time).
- Putty lime was used for interior finish coat plasters and for high status limewashes, run to putty to facilitate the removal of lumps of under- or over-burned or otherwise slow slaking material. It was normally made by adding water to lump lime, diluted after slaking was complete and used, typically, within a few weeks. This was by far the most common

method from the late 19thC. Prior to this, putty might be made from previously dry-slaked hydrate, sieved and then run to putty.

- Putty lime was used alone as a mortar for gauged brickwork and sometimes for very finely jointed stone ashlar, situations where strength was of less importance, but the absence of lumps essential. It was typically mixed with a small volume of water to produce a dough-like putty and used immediately (hot) or soon after slaking (cold).
- Limewashes generally were made from quicklime and used immediately, whilst hot. This increases their bond to the substrates and hot lime has a high 'flowability' even whilst quite thick, with or without fine sand or chalk addition.
- Except for fine stuff – fine finish plaster – when it might be mixed 1:1 with very fine sand, lime putty was *not* used as a binder before the 20thC, when it became common to gauge lime mortars with either Portland cement or gypsum, depending upon use and geography (gypsum was more commonly deployed in Spain, eg), in response to the pressure for haste in modern building practice and the activities of plumbers, electricians and the like.
- It was commonly agreed in this latter period that a gauged mortar such as 1:2:9 had less 'tenacity' than a typical 1:3 fat or feebly hydraulic lime mortar, but that it reached an initial full-depth set much sooner.
- Any less than 40% of cement in binder proportion delivers a weaker, less tenacious mortar than if the same proportions were expressed in lime alone – but gain an initial set much sooner (US Building Codes Committee 1923).
- Even in the 1950s, 1:1:6 was suggested *only* for brickwork in the depths of winter and for chimney cappings and roof flaunchings; otherwise 1:2:9 for exterior works and 1:3:12 for interior brickwork partition walls (Ministry of Works Advice Note No.6 and various publications aimed at technical college and architects' education). The Ministry of Works Advice Note indicated pure or feebly hydraulic lime mortar at 1:2-3 for bedding porous limestone and sandstone, with 1:3:12 indicated only where a 'rapid set' was essential.

- Only once such gauging had become well-established did it become the norm to assume that fat and feebly hydraulic lime mortars were inherently ‘bad’ and gauged or more than feebly hydraulic lime mortars ‘better’. Both assertions may be seen as propaghandist in nature, encouraged by commercial interests. This trend has continued, with 1:1:6 commonly used all year round and 1:2:9 mortars rarely used by general builders.
- The move away from fat and feebly hydraulic lime mortars (which were variable and the proper mixing and proportioning of which relied upon the mason’s skill and experience) and towards hydraulic lime and gauged mortars made with industrially produced and ‘reliable’ ingredients which could be mixed by rote, coincides with the rise of architects and engineers and the undermining of the mason and bricklayers’ authority (and renumeration) within the construction industry, as also with the prevalence of competitive tendering, the contract usually awarded to the lowest tender.
- Putty lime – made by ‘drowning’ - only more commonly used for other than interior finishes after establishment of cement or gypsum gauging from earlier 20thC
- Military engineers, in France, the USA, the UK and Spain, had led the move towards using hydraulic mortars ‘in the air’ as producing stronger and faster setting masonry better able to resist heavy ordnance. Initially, they advocated the use of natural cements, gauged into common mortar. Portland cement only became the norm and preference over natural cement towards the end of the 19thC. US military engineers were the first to begin running fat lime to putty before gauging with natural cement. This practice then extended across Europe (and North America) using Portland cement. There was more focus in France upon the use of eminently hydraulic limes in this context, though some (Treussart, eg) continued to prefer fat limes plus pozzalans for water works, as well as advocating their use for above-ground construction. Vicat’s advocacy of (his own patent) artificial hydraulic lime never caught on amongst fellow engineers, but did contribute to the development of modern Portland cement.

- The trend towards harder and faster setting mortars for use in the air as well as in water was quickly embraced by architects keen to establish and assert their ascendancy within the construction process. This became the more so as industrially produced and 'reliable', 'idiot-proof' materials came onto the market. This was justified by assertions of a lack of durability in traditionally used mortars; by assertions of laziness and absence of integrity among craftsmen; and pretensions of scientific certainty. In fact, it might be argued (and with notable exceptions, of course), the decline in building quality and longevity; certainly of vernacular character and tradition, runs parallel to this shift away from craft tradition and the status of craftspeople within the building industry.
- Masons, bricklayers and plasterers had always chosen and preferred fat limes – whether pure or feebly hydraulic – before this shift, and even as it proceeded, until the earlier 20thC, at least – especially, but by no means exclusively, away from metropolitan centres. Lump lime was still commonly used in London after WWII, for example, and well within living memory in Yorkshire.
- Masons and bricklayers would use pozzolans as required. Many lime mortars in vernacular buildings show low volumes of brick or clay tile chips, even when no bricks were otherwise used in the structure, as well as added ash, whether of wood or 'smithy dust'. No mention is made in historic texts of this practice – when pozzolans are recommended to be used, it is always as a significant proportion and rarely less than 1/3 part of the aggregate. *This is 'secret' craft practice, therefore.*
- Despite the urgings of architects and engineers throughout the 19thC, hydraulic limes were rarely used in the air for domestic or ordinary construction before the tail-end of the Century. They were immediately displaced by cement-lime mortars.
- As late as 1946, a RIBA Committee was suggesting they might be usefully deployed for new build, but that they were very variable in quality and lacked a Standard – indicating that their use was not then common. Ironically, therefore, the first time significant demand for the

use of NHLs in the air was created, it was created by the Conservation industry.

- Quicklimes remained in common use even after WWII – especially in the case of hydraulic limes (particularly Blue Lias), which were preferred by many over the industrially hydrated versions of the same. High calcium quicklimes remained a common form of lime for the preparation of gauged mixes in the 1950s, though bagged hydrate was by then more common.
- Bagged hydrated lime should ideally be mixed to a putty 24 hours before use. The use of bagged hydrated lime became common for plastering in the first half of the 20thC, in the UK and USA. This could be readily mixed to traditional proportions.
- 'Hot Lime' grouting is frequently recommended – for brickwork and for stone core-work. A hot lime grout will penetrate deeper into the work and then stiffen through evaporation, suction from porous fabric and completion of the slake.
- Oft-quoted discussion by Vitruvius and Pliny of laying down pits of putty lime for periods of years (albeit made by the addition of water to quicklime and of dense, dough-like consistency) was demonstrably for use in high status finish coats (and is discussed by them in this context) and was not reflected in recorded craft practice after their time, though it did occur.
- Mention of the same is not uncommon in the 18thC – coupled with strong indications that this is not normal craft practice – but most authors are architects associated with the Palladian movement, referring back to Greek and Roman example and dismissive of more recently previous architectural style and, by extension, craft practice. Alberti in 1460 similarly looks back to a notional 'golden age'. He is the only author who specifically says (in the chapter on ornament) that lime putty should laid down for a minimum of 3 months, and is the only possible source for the lime revival's insistence on the same. Miller (1897) said the same, but on occasion, 2 weeks being more normal.
- Until the late 18thC in the UK and later in some parts, and into the 20thC in some regions of France, earth and earth-lime mortars were

the most common mortar of stone masonry construction and base-coat plastering. Pure lime, or very lime rich lime mortars were used mainly as finishes over these earth-lime mortars. Inevitably, this influenced their manipulation and accounts of the manipulation of lime for such purposes in contemporary texts. A typical pointing mortar over earth in Thornton Dale, North Yorkshire, which had survived in sound condition since 1656 was shown on analysis to have been 2 parts lime to 1 part fine limestone dust, with hair addition. It had been hot mixed or mixed with just-slaked lime putty, still hot, and then had been used after cooling (Bill Revie, analyst). Finish coat plasters over earth were of similar composition (but with more hair) or were of pure lime and hair.

- Vitruvius clearly discusses hot mixing for general construction and his specification of 1 part of *slaked* lime to 3 parts of aggregate – which contradicts all later texts and apparent practice - is probably a mistranslation made centuries ago, or refers to the production of fat lime: aggregate: pozzalanic concretes. He also recommends 1:2, however, for river sand mortars. Vitruvius's work survives only in medieval translation, with many inconsistencies and incongruities reconciled as possible in the 16thC. French, and probably Spanish, concretes ('beton') were made with already slaked lime run to putty, although – as in American military practice in the 19thC – still mixed whilst very hot. French and Spanish practice *may* more closely reflect Roman traditions. Hot mixing of concretes was the norm in the UK, however. Gillmore (USA 1864) describes it as the 'English Method'.
- The 'ordinary' or 'common' method was almost universal for fat limes, as well as for hydraulic – lump lime slaked with just enough, or a slight surplus of necessary water in a doughnut of sand, sand banked over to retain heat, and mixing done as soon as the slake was complete. Hydraulic limes would be slaked to a dry hydrate with just sufficient water to slake the free lime without initiating the hydraulic set and laid down to allow for typical late-slaking before use. This would be more properly described as 'sand-slaking'. Late-slaking was much less likely in a pure lime. Although the ring of sand method was common in

France and Spain, it was not uncommon to slake the lump separately in a mortar box or in a pit – but generally still mixed whilst very hot. Moxon (1703) considers this to produce a weaker mortar than when lime slakes alongside the sand.

- Fat or feebly hydraulic limes were the norm for work in the air until arrival of cement-lime mortars, though frowned upon by some engineers – particularly Vicat and those who followed his lead.
- In the UK, feebly hydraulic limes were considered common limes with slightly enhanced setting power. They expanded similarly and slaked as readily. They were preferred for exterior use where available – particularly in London and the South-East of England. They were generally frowned upon by engineers as being little better than pure limes. 'Fat lime' referred to both pure and feebly hydraulic lime, typically, with a clay content of less than 6%.
- Hydraulic limes and natural cements the norm for water or underground works – 'water limes', but pozzolanic fat lime mortars were generally preferred to NHLs, even for this. Blue Lias and other moderately to eminently hydraulic limes were often gauged with pozzolans for water works. The only purpose for which NHL was the preferred binder was for concrete, for building footings and for floors. These were mixed typically at 1:7. This function was displaced by Portland cement during the earlier 20thC.
- Hydraulic lump lime was often ground to a powder before slaking, to accelerate the otherwise tardy slaking time. This was noted as increasingly common for fat limes also by Pasley in 1826. Scott mentions it as a good option when mixing by hand in 1862, at the same time as revealing a hot mixing method: "When the lime is first ground to a powder, and is then partly mixed with the sand <u>before any water is added</u>, as is done with cements, it is probable that much better hand mixtures could be made, but there is danger in permitting lime to be ground before it is brought on to the ground (due to the risk of premature carbonation in the air) and it is essential that it should be finely ground, for the over-burned particles which generally escape grinding are precisely those which most require it."

- It is commonly asserted that limes used were often of poor quality. This may stem from frequent complaint in London about the poor quality of the lime – usually due to air slaking by the time of mixing. This was sometimes the case in London because the quicklimes, whether chalk lime or feebly hydraulic, was carried into the city from Kent or Surrey, along the Thames or other waterways. Smeaton built lime kilns at Mill Bay in Plymouth to provide the Blue Lias lime for Edystone Lighthouse, after observing that Blue Lias lump lime carried from Watchet, North Somerset by sea was too prone to air slaking in transit. Generally, however, most areas were served by local kilns and a customary limit of 12 miles was commonly understood to be the maximum distance it might be carried as unslaked lump (on waggons or by pack-horse) without detriment to its quality. Masons would judge this quality on mixing, and if it was too lean for some of the quicklime having air-slaked, more lime would be used to achieve the right 'feel'. In limestone areas, lime kilns are numerous; in sandstone areas, kilns tended to be built at road-sides, the limestone carried to them for burning. In Cornwall, where Plymouth limestone was widely used, lime kilns were common along the banks of the River Tamar, or other navigable water courses, the raw stone brought to them. For major projects, such as gentry house construction, lime kilns were built on site, if they did not already exist on larger estates. At Bolsover Castle in the 17^{th}C, building accounts indicate that the mortar was hot mixed at the kiln and carried to the work site after mixing, minimising the time between burning and slaking.
- All authors stress the necessity for quicklime to be used fresh from the kiln. Even when quicklime has not partially air-slaked before being fully slaked, there is a common notion that it loses some quality the longer it is out of the kiln before slaking. Oral testimony from masons and plasterers using quicklime in the second half of the 20thC indicates that the quicklime tended to arrive on site still hot from the kiln; or as still hot coarse stuff.
- Lime: aggregate proportions expressed in quicklime: aggregate, except where explicitly stated otherwise.

- Optimum lime:aggregate proportions for fat and feebly hydraulic limes 1 quicklime: 3 aggregate, or else 1:2; for hydraulic limes: 1:2, moving towards 1:1 the more energetically hydraulic the lime.
- The bulk density of the particular lime or form of lime is importantly considered, though mortar ingredients were mixed by volume, not weight. Scott – Royal Engineer, 1862 (a determined advocate of removing craft experience from the mortar mixing equation) spelt out the necessity of attention to the variable bulk densities of different limes when mixing by volume. He set a 'datum' that the volume of 50 lbs (22.68 kg) of a given lime should determine the volume of the aggregate, so that one volume of quicklime weighing 50 lbs (22.68 kg) should be the volume of each of the 3 parts of sand, measured as cubic feet, for a fat lime; of 2 parts for hydraulic. Most craftsmen would have achieved similar, but by 'feel'.
- Military engineers tested materials extensively. Most agree that the optimum sand mix is 2 parts sharp sand to 1 part fine sand.
- It is often asserted that 'dirty' sands were commonly used in the past. This has been sometimes (and illogically) used to justify the use of natural hydraulic limes. This is probably based upon a misinterpretation of earth-lime mortars. It is a common and routine demand of old texts that sands for lime mortars should be clean and washed – frequently accompanied by detailed descriptions of the methods for washing the sand. Marshall discusses the regular use of 'road scrapings' in the Cotswolds, and whilst this may well have been common, it would offer calcareous aggregates with some clay and earth in this and other limestone regions where earth or earth-lime mortars were the norm for stone buildings until the early19thC. Some suggest that road-scrapings give a good aggregate; others (such as Scott (1862) and Pasley) condemn the inattentiveness of many masons to the cleanness of their sand. Langley (1750) says that 'loamy' and less well-graded sand should be confined to internal use, whilst exterior mortars using the same lime should be made with clean, sharp sand and that the cleanness and sharpness of the sand was the key influence upon a

mortar's durability. Pozzolanic mortars he details were all for use underground or underwater.

- Many consider that the addition of certain stone dusts or clays to mortars promoted a strengthening reaction. This would be most pronounced when the mortars were hot mixed. Dossie (1771) considers that the heat of the slake of powdered quicklime whilst mixed with the aggregate promoted positive reactions between the two, as did Burnell (1857). Psammites – clayey, shaley sandstones – were oft-mentioned, particularly in France, as giving aggregates that offered a pozzalanic reaction. 'Growan' a degraded granite sand with around 18-20% clay content, traditionally used on Dartmoor, seems to offer a clear pseudo-pozzolanic set, as does the addition of slate dust, in our experience. The use of iron-rich limestone dusts seems to offer similarly accelerated set and has been shown to enhance and increase compressive strength (Lawrence 2006).
- Typical fat lime: pozzalan (true pozzalan, brick dust and other fired clays, forge scales, wood ash, calcined ironstone): aggregate proportion for water works: 1:1:2, with slaked lime; 1:3:1 with quicklime. Often 1:2 lime: pozzolan; sometimes 1:1.
- Concretes were typically hot mixed (when lime was the binder) and were surprisingly lean: 1:7 being typical for foundations and water works, the one being Blue Lias lime or (later) Portland cement. 1:8 or 1:6 opc:aggregate still common in 1950, depending on end finish.
- 1 slaked lime or other binder to 3 aggregate only became the norm with arrival of cement-lime mortars, eg 1:3:12; 1:2:9; 1:1:6. Reflects the extra setting power of the cement addition.
- The use of cement gauges was a conscious response to pressures of modern volume construction and time pressure – it was acknowledged that it did not give a 'better' mortar and that only the added cement or gypsum actually set, carbonation taking much longer (and perhaps inhibited, or even prevented by the fast-setting addition).
- Gypsum gauging of fat lime for finishes (to walls and to mouldings) had a long history – gypsum gauging of base and second coats only arose in earlier 20thC in response to similar time pressures. It was not

considered best practice – but pragmatic practice. Vitruvius said that gypsum gauging should not be done: "For these (ceiling finishes), gypsum is the last thing one wants to mix in; instead, they should be composed of marble sifted to a uniform consistency, so that one part will not anticipate the other in drying, but the whole will dry at a uniform rate…" and 20thC authors understood that only the additive set quickly – not the main body of the material.

- During 20thC industrially produced hydrated lime was commonly used – in cement-lime mortars but also for plastering, run to putty 24 hours before use to fatten for the latter purpose. Its ease of use, convenience of packaging, handling and transport and reliability were considered benefits, as well as its ' de-skilling' of mortar production, removing the skill and experience of the masons from the specification process.
- The first mentions of routine and absolutely necessary protection of newly emplaced mortars (other than the covering of wall-tops during winter) from sun, wind and rain, as well as of on-going wetting of new work are in association with the use of hydraulic limes in the air.
- Similarly, greater emphasis was placed upon the liberal wetting of building materials and substrates with the increased use of hydraulic materials.
- Building materials should be pre-wetted, although some engineers asserted the contrary on the basis of empirical testing. Essential for hydraulic limes; not always so for hot mixed fat limes, depending upon 'natural' moisture content, though generally to be recommended.
- No texts, with the exception of Burnell (1857), display any understanding of the principle of compatibility. The engineers' definition of the 'best' mortar was the 'hardest' achievable which would set most effectively underwater.
- It is a common assumption historically that pointing mortars should be tougher and harder and more weather-resistant than bedding mortars. This is reflected in the use of lime-rich pointing mortars over earth - or lime stabilised earth - mortars and carries on as lime mortars become routine for bedding, with the use of feebly hydraulic or natural cement pointing mortars over fat lime bedding mortars, at least once

repointing becomes necessary (eg Pasley 1826 and 1838). More normally, however, a pointing mortar might contain some element of pulverised brick or wood ash, whilst the bedding mortar would not. This continues into the 20thC with the repointing of lime-built masonry (and the over-laying of generally sound lime pointing with) cement or cement-lime mortars.

- Very few writers mention or discuss earth or earth-lime building or plastering mortars. Cato (160 BC) mentions earth, lime and sand as components of mortar; Vitruvius (20 BC) commends adobe construction (with earth mortar between the 'bricks'); Alberti mentions earth building, as well as earthen mortars for stone construction; Marshall notes the prevalence of earth mortars in the Vale of Pickering, North Yorkshire, as well as the routine use of road-scrapings in the Cotswolds. Neve details the use of loam for plaster basecoats, to be followed by lime finishes). Also in 1726, Bailey and Worlidge propose building and rendering with earth-lime mortars. This general absence contradicts the material evidence across Western Europe and indicates that earth mortars were very much hidden in craft and vernacular practice, or were considered unworthy of consideration by 'experts', a situation that persists today. It is likely that the friable and 'weak' fat lime mortars criticised by Vicat and others in the cause of promoting the use of hydraulic lime mortars in the air were, in fact, earth or earth-lime mortars for the most part. The sheer number of standing masonry structures
- Bricklayers began using lime-sand mortars sooner, in general, than stonemasons, although both had used lime-sand mortars as well – reflecting the relative 'thinness' of brick walls compared to stone – though some earth-built brickwork from the 17th C may still be found. Perhaps a majority of stone buildings across much of the UK – and on the limestone belt as commonly as elsewhere – built before 1900 were built with earth-lime mortars. Similarly across Europe and the Americas. In this scenario, lime mortars were used as finishes – either as pointing over earth-lime bedding mortars or as finish coat or limewash over earth plasters. This would affect the manner of their

slaking and processing. Lump reduction and removal will have been given a higher priority, though lime lumps are usually evident in both pointing and plaster finish coats or earth or earth-lime mortars, as well as in earth-lime mortars themselves, which were frequently less assiduously mixed than lime mortars. Sieving may have been more common for such mortars. They may have been mixed wetter in the first instance and used after a period of rest, rather than hot.