Earth Mortars and Earth Building as Referenced in Old Texts

That earth buildings are widespread across the world – whether of rammed earth, cob, mud and stud or adobe construction – is widely acknowledged and understood. Less widely appreciated is the enormous geographical and historic spread of earth built masonry structures. It would seem fair to assert that the majority of masonry buildings constructed across the UK and Ireland before the 19thC were built with earth or earth-lime mortars and generally pointed with lime rich mortars and that they were originally plastered within with a simple system of earth-lime backing coats overlaid with quite thick haired lime finish coats. In the earlier period, similar was probably applied to the exterior walls. This system of masonry construction was likely introduced into the British Isles by the Romans, continued after their departure and was reasserted by Norman builders. The use of earth mortars in masonry construction was almost certainly the pattern in the UK during Neolithic times, however.

This pattern of masonry construction is evident also in Spain, France, the Czech Republic and across Europe and Asia and, if it did not exist there already, was carried to the Americas by European settlers.

Only during the 18thC did it become more common to use lime-sand mortars for masonry construction, although these had been used in some – but by no means all - high status buildings during all periods and were adopted earlier by bricklayers than by stonemasons in the British Isles.

Until very recently, the prevalence of earth and earth-lime mortars in masonry structures has been substantially ignored by the conservation community, as well as by the 'lime revival', as has their demand for the use of truly compatible and eminently breathable lime mortars for their repair and conservation. Whilst the use of putty lime mortars for this can do no harm to the fabric of such buildings, the use of cementitious or even hydraulic lime mortars may be seen as offering essentially incompatible options. There is increasing evidence that NHL mortars, low in the free lime content necessary to achieve effective porosity (Wiggins 2016) with much greater compressive strength than was possessed by the typically hot mixed lime mortars traditionally used in association with earthen materials, lead to an ongoing accumulation and entrapment of received moisture.

This is to the detriment of appropriate thermal performance, will lead to the unnecessary decay of embedded timbers and may ultimately lead to collapse or other less exaggerated structural failure.

Putty lime mortars, mixed at 1:3 are breathable and workable, but are less durable than hot mixed lime mortars. Before the 20th C, when lime run to putty was expected to be gauged with either Portland cement or gypsum, depending upon location, they were not used as binders, but alone as mortar for fine plaster finishes, high end lime wash or for the very fine joints of gauged brickwork or the most precise stone ashlar. They lack the durability of hot mixed air lime or feebly hydraulic fat lime mortars. Used today, putty lime mortars used in the weather should be enhanced by the small addition of pozzolans. Hot mixed air lime mortars tend to have appropriate durability without such pozzolanic addition; though pozzolans may be necessary in more exposed or especially damp locations.

As the routine modern use of around 3% quicklime addition for soil stabilisation during road construction demonstrates, a small volume of quicklime has a disproportionately efficient effect upon the tenacity, cohesion, water management and load-bearing capacity of clay-bearing subsoils. Whilst carbonation of the lime addition will occur, it is primarily the chemical interaction of the clay and calcium oxide (or calcium carbonate) ions that offers this improvement in performance. Observation would suggest that quicklime was the most common form in which lime was introduced into otherwise earthen mortars, but this may have been 'hot lime' run to putty just prior to addition on occasion and depending upon customary lime slaking procedures locally.

There are real practical advantages in adding quicklime, however, as the earth mortar – improved as necessary by the addition of sands – may be mixed beyond the liquid limit to fully engage the clay content and then brought down below this limit by the addition of a small volume of quicklime. This addition also improves the workability and 'elasticity' of the earth mortar.

Many earth mortars contain a multitude of 'lime lumps'; others far fewer and with streaks or swirls of carbonated hydrated lime.

Analysis of these mortars – particularly where no obvious under- or over-burned, or simply carbonated lime lumps are present – may misleadingly indicate the use of putty lime, as quicklime added to a very wet earth or earth lime mortars will slake to 'putty' during mixing. Even where lime putty may have been used, it will have been slaked traditionally – the water added to the lump lime, not the other way around – and will have been mixed immediately after slaking was complete, whilst still very hot. Alternatively, and particularly when the lime addition was significant, the mortars will have been made by the 'ordinary method': a basin formed of the earth aggregate, the quicklime placed within this and then just sufficient water or a slight excess of water added to the lump lime to effect the slake before earth and slaked lime were mixed together to form the mortar.

Mention or discussion of this universal craft practice in historic texts on lime or construction is rare. More so than with lime, these mortars were hidden in craft practice; guarded by the masons and plasterers themselves, and the many 'experts' on lime writing particularly during the 18th and 19th centuries seemed to see no reason to write about them, let alone explore their properties or potential. They are mentioned in Roman texts; acknowledged by Alberti; identified in several 17th and early 18thC Century texts. Their manipulation is discussed even less – with only Henry Best describing this in 1641. Several authors during the 19thC promote earth construction – as Clough Williams Ellis does again in the early 20th C – as a means of constructing comfortable but easily affordable homes for the rural working classes, but there is little technical detail given. Loudon (1833) is the most encouraging of the use of earth, often presenting it as an equivalent alternative to stone. Very few discuss earthen mortars in masonry construction, and yet earth mortared buildings are everywhere in the British Isles – as commonly in limestone districts as in regions that had little or no easy access to lime.

In North Yorkshire, churches and buildings of very high status from the 16th, 17th and 18th centuries were constructed of earth-lime mortars, finished with lime rich mortars. In Lincolnshire, mud and stud houses were typically plastered inside and out with earth-lime mortars and lime washed rather than lime plastered.

It will be, perhaps, in building account books that the written evidence for earth and earth-lime mortars will be discovered, and several examples are transcribed below, from the 15th and 16th centuries. 18th century contracts between masons and the Fitzwilliam Estate in Malton, North Yorkshire - a town built mainly of limestone upon foundations of limestone bedrock - offer invaluable insights. The mason themselves designed the mortar and specifications called simply for the 'best mortar' in their judgement and according to the materials available. No proportions were ever spelled out, as they were not for lime mortars until the mid-19th C, when architects were becoming more involved in the construction process locally. Lime was supplied from Estate quarries.

On analysis, earth mortars in Malton and elsewhere have a predominance of very fine sands and silts. Larger aggregates tended to be calcareous inclusions, which were most likely present in the subsoil, though some may have been deliberately added. This contradicts the modern specification of earth mortars (for eco-build) to include plentiful sharp sands. It would suggest that silts play as important a role in performance as clays. Clay content is typically 12% by volume, though some plainly successful earth plasters have as little as 5% clay along with a lot of fine sand and silt.

In North Yorkshire, hay was a common addition to counteract shrinkage and to increase flexural strength, although hair is found on occasion and oftentimes no organic addition at all; elsewhere, such as Moffat in Dumfries and Galloway, ox hair was most common. In Spain, organic addition is rare in earth mortars (pers comm Santiago Gonzalez, Asturian stonemason), although common enough in adobe blocks.

Most earth mortar design was accomplished by 'feel' and experience. Testing will have been simple and straightforward, as it remains today where earth building persists. For plasters, trial panels provide the most effective means of assessment – different earths plastered upon a wall with and without hay or hair addition; with increasing volumes of sand addition and/or increasing volumes of quicklime addition. The mortar that shrinks the least and enjoys the necessary workability and tenacity will be selected. This is especially important for plasters; less so for bedding mortars which the evidence suggests could tolerate more clay content and were used in a sloppy consistency.

The qualities and character of a good earth mortar is very similar to those of a 1:3 quicklime: aggregate hot mixed lime mortar. It is not difficult to see why masons in the past assumed that these materials 'liked' one another.

Lime rich pointing mortars – often with hair addition – were laid over the earth bedding mortars almost like a localised render. The bedding mortars were typically struck at the face of the work before pointing with lime, not raked back as would be the norm today. In Yorkshire, in coursed stonework, the stones were tipped slightly forwards, leaving a slight step between courses – the lime pointing was laid over the earth bedding mortars and weather-struck across this step. The lime rich pointing is somewhat deeper-seated in earth-lime mortared brickwork of the 15th and 16th centuries in urban Valencia, the bricks being very thin and with mortar beds often thicker than the bricks themselves. Such brickwork in Spain may be reasonably characterised as forming part of an unbroken Roman tradition of building.

As Niamh Eliot's research into the buildings of Moffat has shown, there was significant pressure from 'enlightened' 18th C landowners, educated in Edinburgh and other cities, to demolish 'inferior' and 'embarrasing' earth built masonry houses on their estates, for them to be rebuilt with lime mortar. Earth mortars survived more easily when unnoticed or ignored and in Malton, once more, are frequently discovered beneath 3 coat lime plaster work from the 19th C.

The use of earth mortars persisted into the 19thC in certain situations – for the parging of chimneys, for the mortars of furnace (and kiln) masonry, both stone and brick and sometimes for plaster base-coats, in the latter case, reducing the delay between plaster coats, the set being less dependant upon complete carbonation of the base coats and allowing sooner application of subsequent lime coats.

Earth and earth-lime mortars have proven to be remarkably durable. Earth-lime mortars abound in the roofless clearance houses of Caithness and elsewhere in the Highlands and survive well in North Yorkshire long after the lime pointing mortars have fallen away.

As the work of Tom Morton and Becky Little in Scotland have demonstrated, earth mortars exposed to the air are surprisingly frost and rain resistant – in the former case, they will freeze but consolidate once more after thawing. That said, good detailing is essential to the longevity of earth as well as air lime mortars, as important as their inherent breathability and as the necessity that all lime mortars applied to them are as eminently breathable as this.

Earth mortars, with or without lime addition – are sustainable and were always locally sourced, as their variation and compositional similarity to immediately local sub-soils indicates. Their use involves a minimum of embodied energy. They are easy and economic to make; they are easy and pleasurable to use, enjoying high workability and good bond strength.

In summary, earth and earth lime mortars – as earth buildings in general - must be taken seriously and afforded the cultural and technological significance merited by so widespread and long-term use. It is essential that lime mortars used (as before) in association with these mortars is as compatible as possible. Historically, the lime mortars thus used were hot mixed air lime or, sometimes, feebly hydraulic limes with a high free lime content. Just as earth and earth-lime and hot mixed air lime mortars worked together in the past and in the buildings we aim to conserve, the hot mix revival should go hand-in-hand with a revival in the appropriate use of earth and earth-lime mortars and the thorough appreciation of their needs.

Cato (c160 BC) De Agricultura

If you are contracting for the building of a new steading from the ground up, the contractor should be responsible for the following: All walls as specified, of quarry-stone set in mortar, pillars of solid masonry, all necessary beams, sills, uprights, lintels, door-framing, supports, winter stables and summer feed racks for cattle, a horse stall, 2 quarters for servants, 3 meat-racks, a round table, 2 copper boilers, 10 coops, a fireplace, 1 main entrance and another at the option of the owner, windows, 10 two-foot lattices for the larger windows, 6 window-shutters, 3 benches,

5 stools, 2 looms, 1 small mortar for crushing wheat, 1 fuller's mortar, trimmings, and 2 presses.

The owner will furnish the timber and necessary material for this and deliver it on the ground, and also 1 saw and 1 plumb-line (but the contractor will fell, hew, square, and finish the timber), **stone, lime, sand, water, straw, and earth for making mortar….**

In a steading of stone and mortar groundwork, carry the foundation one foot above ground, the rest of the walls of brick; add the necessary lintels and trimmings. 5 The rest of the specifications as for the house of rough stone set in mortar. The cost per tile will be one sesterce. The above prices are for a good owner, in a healthful situation. The cost of workmanship will depend upon the count. In an unwholesome situation, where summer work is impossible, the generous owner will add a fourth to the price.

Vitruvius (30-20 BC) *Ten Books on Architecture.* Translated by Rowland I D; eds Rowland I D & Howe T N (1999) Cambridge University Press.

Book 2 Building Materials

Chapter 3; Mud Brick Masonry

1. First, therefore, I shall discuss mud bricks, and from what type of earth they should be created. For they should not be made from sandy or pebbly clay, nor from loose sand, because if they are made from these types of earth, they will be heavy at first, and then, as rain spatters against the walls, they break down and dissolve, and the straw mixed in them will not hold together because of their unevenness. They should be made from whitish clay or red earth or even coarse sand. For these types of earth, on account of their lightness, have durability without weighing the building down, and they are easily piled together.
2. The bricks should be made in springtime or autumn, so that they dry at a uniform rate. For those prepared in midsummer are defective because when the sun has baked the outermost skin, harshly and prematurely, it makes it so that the brick looks dry when the interior has not yet dried. Then, when it later contracts in drying, it will shatter what has already dried. Thus these bricks are rendered cracked and weak. They would also be most serviceable if they were made two years earlier, as they cannot dry thoroughly before that time. If they are laid new and not entirely dry, then, when the plaster has been laid and remains there solidified, the mud bricks themselves, as they subside (in drying), cannot maintain the same level as the plaster, and as they contract they no longer bond with it, but instead pull apart at the join. Therefore the plaster, split away from the masonry of the building, can no longer stand by itself because of its flimsiness, but shatters, and the walls, having settled haphazardly, are themselves flawed. For this reason, the people of Utica would use a mud brick in the construction of walls only if it were fully dry and made five years earlier, and approved as such by judgment of a magistrate.

3. Now there are three types of mud bricks. One, which is called 'Lydian' in Greek, is the one which we use, 1 ½ feet long and 1 foot wide. The Greeks construct their buildings with the other two types. Of these, one is called *pentadoron*, the other, *tetradoron*. For the Greeks, called a palm a *doron*, and that is always done by the palm of the hand. Thus whatever is five palms long in every direction is a *pentadoron*, and what is four palms long is a *tetradoron*, and public works are constructed with *pentadora*, private works with *tetradora*.
4. Along with these bricks, half-bricks are made, which are laid like this: rows of bricks should be laid on one side, and rows of half bricks laid on the other. Therefore, when they are laid on the level on each side, the walls will be tied together with alternating surfaces, and the half-bricks placed over the joins lend a durability and an appearance on each side that is not unattractive.

Book 8 Styles of Concrete Masonry.

Brick Masonry.

16. If, therefore, kings of such immense power did not disdain structures with mud brick walls, kings for whom it was possible, thanks to tribute money and the booty of war, to have buildings in rubble work, or squared stone masonry or even marble, I do not think it necessary myself to look down on buildings made of (mud) brick masonry, so long as they are roofed correctly. I shall, however, describe that type of structure which it is not right for the Roman people to have made in the City, and I shall not neglect to mention what the causes and reasoning are for such a phenomenon.

17. The law does not permit greater thicknesses than 1½ feet to be reached in a party wall. All other walls as well, except on the narrowest of sites, have been laid to the same thickness. However, brick walls at (this thickness), unless they are going to consist of two or three layers of brick, cannot carry more than one story, whereas in a city of this grandeur and such endless density of population it is necessary to put up houses beyond number. …the problem itself imposed arriving at the expedient of tall buildings. By the use of stone piers, tile masonry and rubble work walls, heights could be built up and layered (p42) with multiple stories…(restrictions of space therefore lead to an absence of mud brick buildings in the City)…
If the plan is to use them outside the City, this is how to make them flawless even into great age: On the tops of the walls tile masonry should be put under the roof tiles to a height of about a foot and a half, and let it project like a cornice. In this way one can avoid the usual defects that occur in this type of wall, for when roof tiles are broken on the roof, or blown down by the wind, in those places where ater can pour down from the tiles, the terracotta armour will not allow the brick to be harmed. 19. Instead the projection of the cornice will cast the dripping water beyond the plane of the walls, thus preserving whole the brick masonry.

Pliny the elder (23-79 AD) The Complete Works of Gaius Plinius Secundus Delphi Classics ebook (2015) Hastings. Delphi Classics Publishing

BOOK XXXV

Chapter 48 (14)

…Have we not in Africa and Spain walls of earth, known as 'formaeoan' walls, from the fact that they are moulded, rather than built, by enclosing earth within a frame of boards, constructed on either side. These walls will last for centuries, are proof against rain, wind and fire, and are superior in solidity to any cement…what person, too, is unacquainted with the fact that partition walls are made of hurdles coated with clay and that walls are constructed of unbaked bricks?

Chapter 49

Walls of Brick, the Method of Making Bricks

Earth for making bricks should never be extracted from a sandy or a gravelly soil, and still less from one that is stony; but from a stratum that is white and cretaceous, or else impregnated with red earth. If a sandy soil must be employed for the purpose, it should at least be male sand, and no other. The spring is the best season for making bricks, as at midsummer they are apt to crack. For building, bricks that are two years old are the only ones that are approved of; and wrought material of them should be well macerated before they are made.
There are three different kinds of bricks; the Lydian, which is in use with us, a foot-and-a-half in length by a foot in breadth; the tetradon and the pentadoron…These last two kinds…are named respectively from their being four and five palms in length, the breadth being the same. The smaller kind is used in Greece for private buildings, the larger for the construction of public edifices….the Greeks have always preferred walls of brick, except in those cases where they could find silicious stone for…building, for walls of this nature will last forever….At Rome there are no buildings of this description, because a wall only a foot-and-a-half in thickness would not support more than a single-story; and by public ordinance it has been enacted that no partition should exceed that thickness…

Sextus Julius Frontinus (40-103 AD) De aquaeductae Urbis Romae Translation Bill Thayer

http://penelope.uchicago.edu/Thayer/e/roman/texts/frontinus/de_aquis/text*.html

Also Rogers B (2003) Sextus Iulius Frontinus On the Water-Management of the City of Rome University of Vermont

123. Repairs that should be executed without cutting off the water consist principally of masonry work (*Rogers says 'concrete work'*), which should be constructed at the right time, and conscientiously. **The suitable time for masonry work is from April 1 to November 1, but with this restriction, that the work would be best interrupted during the hottest part of the summer, because moderate weather is necessary for the masonry properly to absorb the mortar, and to solidify into one compact mass; for excessive heat of the sun is no less destructive than frost to masonry.** Nor is greater care required upon any works than upon such as are to withstand the action of water; for this reason, in accordance with principles which all know but few observe, honesty in all details of the work must be insisted upon.

125. "The consuls, Quintus Aelius Tubero and Paulus Fabius Maximus, having made a report relating to the restoration of the canals, conduits, and arches of Julia, Marcia, Appia, Tepula, and Anio, and having inquired of the Senate what it would please to order upon the subject, it has been RESOLVED: That when those canals, conduits, and arches, which Augustus Caesar promised the Senate to repair at his own cost, shall be repaired, **the earth, clay, stone, potsherds, sand, wood, etc., which are necessary for the work in hand,** shall be granted, removed, taken, and brought from the lands of private parties, their value to be appraised by some honest man, and each of these to be taken from whatever source it may most conveniently and, without injury to them, remain open and their use be permitted, as often as it is necessary for the transportation of all these things for the purposes of repairing these works."

Turton R B (1895) The Honour and Forest of Pickering Vol I London North Riding Record Society

Cost of the New Hall. (within Pickering Castle) Clearing, digging and levelling the place within the castle where the bakehouse was burnt to build there a Hall with a chamber—**building the stone walls of the Hall and chamber, getting and carrying 400 cartloads of stone, digging and carrying soil for mortar, buying 27 quarters of lime**—contract for joiners' work, wages for those employed to saw planks and joists, 152 planks for doors and windows, 80 large spikes, 600 spike nails, 1000 broadheaded nails and 20,000 tacks, 22 hinges for the doors, 28 hinges for the windows and 2600 laths with carriage for the same—lid-roofing the buildings with thin flags by piece-work, collecting moss for the same, **plastering the floors of the upper room and several walls within the chamber, making a chimney piece of Plaster of Paris,** together with the wages of the chaplain who was present at the building —

1313-1314 Duchy of Lancaster Records MINISTERS' ACCOUNTS, Bdle. I. No. 3

Ibid Vol IV

Cost of the Houses within the Castle. A carpenter 4 days mending the wind-battered roof of the old hall with old shingles—1s; 300 nails for that purpose—9d; a man 10 days roofing with tin the small kitchen, the garderobe at the corner of the kitchen, the cellar [?], outside the new hall, within the tower and porter's lodge—2s 6d ; **2 men the same time carrying straw and old hay, and serving him and making mortar to smear over the said houses — 2s 6d** ; hire of cartage to carry 6 cartloads of old hay from the Marsh to Pickering for roofing the said houses with the service of 2 men carrying the hay outside a house in the Marsh and loading the carts —2s 4d.

Malton, North Yorkshire. Medieval Charter. C15thC version.

These rights and privileges persisted until the time of James I.

Thes ar the Customys and Libertes, the qwhyche was concest and graunted to the Burgeses of New Malton; at the fyrst Fundacyon of the said Malton, be the Lord of the same: and in all the tymes hydyrward hath ben usyd.

Fyrst, it was graunted to the forsayd Burgeses, a Wast, of ather side of the Town of New Malton; **that the Burgeses and thare Successors, shall in the sayd Wastys, gett stone, and fro thens, stone and Erd take and cary, to the Edyficacyon and Beyldyng, within the sayd Town; whensoever they Wyll, and als ofte as they wyll, without Impediment of any man.** And thay shall haffe iiii Ports, that is to say, iiii Yatts. And the Walles of the said Burgage, undyr thayr own kepyng, with fre entre, and goyng out, within the said Walles of the Burgage; with All the Proffets of the said Walles, to the mendyng of the said Walls, and also the said Yatts: And the sayd Burgese e'r more hathe usyd for to pastur and to fede the Bests in ye foresayd Wasts.

All Thyse Lyberteis and Customes above wrytyn , with many othyr moo Liberteis, the qwhyche unto the Liberty of the Burgage perteyns; the fore sayd Burgeses claymes for to haffe: the qwhyche thay and thayr Anteassors liberally hafe usyd before tyme;the qwhyche tyme is withowten Mans Membrance or mynde; the qwhyche stonds now in the Clayme of ye sayd Burgeses, And also in tyme coming, for to be Claymed.

Salzman LF (1952) Building in England Down to 1540, a Documentary History Oxford. Oxford University Press.

Wattle and Daub

'Torching' is one of the terms applied to this plastering with mud; as for instance at the Tower in 1278 - '*in arcillo empto ad torchiandum'* and in 1337. 'for torching the penthouse beside the smithy, with mud, laths and nails of the King's finding, 10s' *[this may be roof-work, of course]*. Sometimes other terms are used, as at Cambridge in 1486 - '*pro (4) bigatis de clay, 16s, item pro claying murorum 19s'*, or at a lodge the New Forest in 1368, where two men were employed digging red earth *pro parietibus plastrandis'*, though 'plastering' is usually applied to the finishing of a wall with plaster. The expression used at Bath in the 15th C was 'rudying' - as, for instance, 'for riding the old walls of the chancel' and '*pro casting de terra et rudyng'* of a house for which wattling had been made *[ruding is more likely to refer to the painting of the walls with raddle, it should be said, red pigment]*. At Penshurst in 1470 there is a reference to radelyng and daubing the walls of the barn; and carriage of clay called '*lombe'* for the said work'. More often the word used is, in Latin, '*terrand'*, which simply means earthing. For walls in Cambridge Castle, in 1267, we find 'splenteware' and ;batthes' bought, and wyttthes for binding them, and a payment 'to daubers for making the said walls and tearing the kitchen'. And in 1454, when a gable was made to a stable in Stamford, there were payments 'to a man 2 days teryng ye same gavel xd; for 2 lodes of earth to ye same warke 6d'. The common term, however is 'daubing'. As this is latinised indiscriminately as *dauband and dealband* and the workmen *as daubatores or dealbatores*, it is often impossible to be certain whether the process alluded to is daubing or whitewashing…At York in 1423 we find 200 stoures (stakes) provided for daubing over the kiln house, and also

rods, templis, which are also rods, and withies, and similarly in 1531 at Durham rods and 'dalbyngstours' were bought for daubing above four fireplaces in St Giles Street. At Clarendon in 1480 payments are made for collecting rods and shredding them to make the walls in the new chamber, and for bredyng and dawbyng the same walls…'bredyng' is the braiding or wattling between these. Often in later times, laths rather than wattles were employed, as at Sutton in 1402, when Henry Dauber was paid 113s 4d for the lathing and daubing of the walls of certain houses re-erected there, or at Clare in 1347, when money was paid for the daubing of the countrelatthynge of a room, possibly implying laths on each side of the wall. …In 1341, there is a charge for daubing the king's room at Clare, on the outside and plastering it and for stopping cracks round the queen's room.

To make the earth, or mortar, adhere properly it was customary to mix with it some fibrous material such as hair, straw or hay. Palsgrave, writing in 1530, says that 'daubing may be with clay only, with lime plaster, or lome that is tempered with heare or strawe'; and two years later we find lxx stone of heare provided for the plasterers' at Westminster, and also 'cowheare to make mortar for dallbyng of walls,. In 1286 'white straw' was bought for plastering the walls of the hall in Cambridge Castle in 1375 at Leeds Castle, 8 cartloads of straw were bought for daubing the floors and walls of various buildings. In Ripon in 1454 we have 3 wagon-loads of mud for a room, 2d spent on litter and water for the same mud, and 20d paid for two men for the daubing of the same room and the making of its floor. The churchwardens of St Michaels, Bath, used hay and straw for daubing in 1477, and those of St Mary-at-Hill, London, provided 'strawe to make mortere with to the dawbere' in 1491.

Closely allied to daubing was pargetting or rough-casting, the chief difference…being that in pargetting, mortar or a coarse form of plaster was used instead of clay or loam. The surface of the parget might refinished either smooth, with a coat of lime wash, or as rough-cast with sand or small stones. For work at Launceston in 1469 'six dozen seams of sand called roughcasting sonde and helynsonde (= covering sand) were supplied, and Thomas Lucas in the accounts for building his house at Little Saxham in 1507 distinguishes between the two types of finish: 'for lathing, row and white casting of part of my kechen range': 'for lathing, par getting, tiring and white casting of all my roves, walls, partitions and staires': 'for lathing and laying with here (=hair) and mortar of 4 chambers, with par getting and white casting thereof.' As early as 1237 we read of the par getting of the wall behind the leaded chamber' at Marlborough; and at Corfe in 1285 there is reference to Stephen the Dauber who pargetted the long chamber…daubers and pargetters are identified at Wallingford in 1390: 'for 8 casters of walls and party-walls…otherwise called daubers…lathing and daubing a great gable at the west of the hall and newly lathing, daubing and par getting a party wall of the Almerhouse - and completely casting with rowe mortar a great portion of the castle wall'…. A variant form of the word occurs in the north, as at Finchale in 1488, 'for the pargenyng and weschyng of the church', for which chalk and lime were bought; and at Durham in 1531: '*in le pargenyng et emendation foraminum'*.

Earth Mortar *[extrapolated from chapter below, p152]*

In Collyweston accounts for 1504: 'for sifting or mortar earth owt of the old walls'. The expression mortar earth occurs again in 1367 in the account of some repairs to the lodge of Beaumont in the Forest of Rutland: 'for digging earth for *mortarherthe'*

for the said lodge'. **Apparently when lime was not available ordinary soil was sometimes used instead** *[!!!]*. So at Clarendon in 1363 we find mention of 'digging and carriage of 2 cartloads of white earth for making mortar' and at Oxford in 1453, 'a cartload of red earth for making mortar'.

Walker S (2010) Oxford Historical Society. Building Accounts of All Souls College Oxford 1438-1443. Oxford. Boydell Press.

1438

Lime, sand and red earth

224 quarters of (quick)lime, price per quarter, including carriage 20d. £17 13s 4d
And for 42 quarters of (quick)lime at 19d per quarter
And for 23 quarters of quicklime, at 18d per quarter.

And for 312 loads of sand, 2d per load
And for red earth with sand for making mortar

(Similar 1439)

1440

For lime. Bought this year 56 quarters of (quick)lime, price per quarter 16d.

And for 246 quarters 4 bushels of lime bought, price per quarter 17d.

Dawbers

To John Mirthe, dawber for 6 days at 5d a day and his assistant for 6 days at 4d.

(Numerous further entries for daubers).

1441

For lime.

64 quarters 1 bushel at 18d per quarter; 112 quarters and 1 bushel at 17d per bushel; 6 quarters at 16d per bushel.

For sand.

For carriage of 158 loads of sand from Brokenheys (gravel pit in Oxford) at 2d per load.

For clay

For 36 loads of clay bought for the interior walls of the College at 4d per load

1442 More lime purchased.

Still daubing.

Alberti L B (1460) On the Art of Building in Ten Books. New York. Dover Press.

…There are other kinds of masonry construction – some where **mud, not lime,** is used in the joints, and still others where the stones are fitted together without the support of any mortar….

Any stone to be smeared with a **mortar of clay** should be cut square, but **most importantly it must be dry;** the bricks most suited to this are fired ones, or even better, unfired ones that have been well dried out. **A wall of unfired brick is very healthy for those who live within,** completely impervious to fire and little disturbed by earthquakes; on the other hand, unless it is reasonably thick, it will not be capable of of bearing the weight of the flooring. For this reason, Cato recommends that we incorporate masonry pillars in the structure to support the beams.

Some assert that mud, if it is to be used as mortar, should be **like bitumen, and they consider the best mud to be that which dissolves slowly in water, is difficult to wash off the hands, and contracts markedly on drying. Others prefer it to be sandy, being easier to mould. This sort of work ought to be coated on the outside with lime, and on the inside, if you wish, with gypsum, or even silver clay.** In order to make it adhere better, fragments of earthenware should be inserted occasionally into the cracks between the blocks during construction, so that they project like teeth and support the rendering more firmly.

Where the masonry is left uncovered, the blocks must be cut square, and they ought to be larger than usual, as well as being solid and extremely strong. There must be no infill, but the courses should be absolutely even and the joints continuous, and frequent use should be made of cramps and pins. Cramps are devices to fix two blocks together on the same level to form a continuous row. Pins…fix two blocks together one above the other, so as to prevent any rows being pushed out of line. There is little objection to cramps and pins of iron, although if we inspect the works of the ancients, we will notice how iron rusts and does not last, in contrast to brass, which lasts almost forever.

Throughout the buildings of antiquity extremely strong walls are to be found built of nothing but rubble *[concrete]*. These are constructed in the same manner as the mud walls common in Africa and Spain: a temporary form, of panelling or wickerwork, is set up as shuttering to contain the material as it is poured in, until it has hardened. The only difference is this: with the former they pour in an almost liquid dough made of aggregate; with the latter they make the mud pliable by moistening and kneading it, and then pummel it down with beetles and their feet. The ancients would insert a rubble-like layer every three feet as bonding…In Africa, they mix the mud of their earth with Spanish broom or sea rushes; the resulting work has a remarkable resistance to wind and rain.

…Walls consisting of 'shell' – as I prefer to call it…- should be constructed of seasoned wickerwork and reed matting; this is not a work of any distinction, but was

often used by the plebians of ancient Rome. The wickerwork is smeared with a mixture of **mud and straw** which has been kneaded for three days. It is then dressed…with either lime or gypsum, and finally adorned with pictures or reliefs. If you mix your gypsum two to one with crushed tiles, it will have less to fear from being splashed. If mixed with lime, its strength will be enhanced. In the damp, frost or cold, **gypsum will be entirely useless.**

Summary of contract for building at Wynyard, Stockton, County Durham. 31st January 1415. Source DCRO D/LO/F 322.

This indenture between Thomas de Langton of Wynyard and Thomas Rose, Vicar of Merrington on the one part and John Todd, wright, Robert Todde of Lanchester and Nicholas Hayforth of Durham on the other, witnesses that John Todde has undertaken to make anew, well and sufficiently, with sawing and all manor of work and things to wright-craft pertaining, except timber and carriage of it, and ironwork, a cross-chamber to the hall of Thomas de Langton at Wynyard with **6 couple of posts, each couple bing from the other 11 feet, with an entry underneath to the kitchen, with an entry closet athwart, in the middle of the said chamber above and two privies to the said chamber…which chamber be sufficiently set in ground-sills ('sole trees'), wattled and daubed ('rabet and dight') in all parts to be plastered…ready for theaking by August 1st next.**
Payment of £6 by instalments.

Nun Stainton 1392.

Lease by monks of Durham to the Prioress of Nun Monkton of the whole of their estates at Nun Stainton for 200 years of one messuage and two bovates of land (24 acres). The Prioress and Convent (shall maintain etc all buildings)…- one house called Le Firehouse, containing five coples of syles and two gavelforkes; one small house…containing three coples of syles and two gavelforkes. (from Surtees Society Vol 58 p167).

Cront 749 Delaps around Northallerton c1450

The hearth-house of John Copsy needs rybbes and walplats for four rowmes, one pair of crippils, 40 tignis (rafters) and 400 lattes with clav (nails) to the value of one carpenter for 6 days found by the Lord.

Cront 753 From ZBA/11/8/1/3

Mich 1426-27. Repair of tenements. Bedale.

8 cart-loads of stone from the Park of Bedale to tenement of John Watson in Ayscogh 4/-
3 cartloads of wattlyng to same 1/6
Stipends of 2 carpenters carrying stone and clay for the same for 1 day 2/4

6 cartloads of timber for repair of house of John Clay 2/6
1 cartload of spars from Frithbylund to the same
1 cartload of stone

600 sclatestane from quarry of Hernby *(Hornby, Bedale)* to manor of Bedale at 9/- per 1000 6/3
4 cartloads of lime from Cracall to the Manor 2/8
2 cartloads of sand for the same 3/-
stipend of the carter carrying 10 quarters of lime of Burton on Yhore to Bedale 2/6
2 cartloads of clay for the Lord's house once of John Caterik in Emgate 6d
3 cartloads of old timber from the tithe grange of Ayscogh to the Manor of Bedale
2 cartloads of old timber from the tenement of Wm Walker to the Manor
2 cartloads of spars and watlyng from the Park for the repair of the tenement of Thomas Rudd in Burrell.
2 cartloads of timber for the Manor Gate from the wood
Stipend of John del Cote tiling (tegen) on the Grange, 9 days at 8d
Bread and ale for raising the house of John Watson in Ayscogh…
2 cartloads of clay for daubing (riggat) a grange.

5 cartloads of clay for repairing a wall within a tenement 1/3
carriage of lime by a hired woman 2d
4 cartloads of straw brought from the Rectory to the tenement 8d
2 cartloads of straw to the tenement of John Watson.

ZBA/11/8/1/4. Michaelmas 1429-30

Repair of the tenement of Thomas Vale
Stipend of John Thirn for cartload of timber for the buildings of one house of Thomas Gale, erected anew 19/-
Stipend of Simon Wade for the carpentry of the same…in gross 100/-
Sawing of 'tubularum' and timber 20/-
Stipend for carrying stones for walling, clay and sand 17/10
1000 laths bought for the same 10/5
4000 lathnayles bought for the same 6s
400 medilspykyngs 20d
iron bought for making chains, crokes, hasps and staples ¾
12 quarters of lime (calceto) 10/8
stones bought for roofing same house 21/6. Carriage 14/10
bread and ale at the raising 2/6
total; £11 – 14 – 5.

ZBA 11/8/1/6

Mich 1431 – 32

Repairs
Symon Ward the carpentry of a tenement lately in the tenure of Thomas Chandelier 21/4
To Thomas Felett and his mate for carriage of timber of the same 2/8
Thomas Harpour for daubing walls 11/9
Stone bought for roofing of the same, of which 9/6 for carriage.
Laths bought for same 5/10
10 quarters of lime bought for same at 9/4 for 7 quarters and 3/- for 3 quarters and for carriage.
4000 brodes 5/2

iron of Laurence Spicer for John Hamsthwayte for crokys, chains and nails 2/5
Bread, ale and cheese at the raising ¼
Roofing.
Total 116/5 ½

(lime for finish coats over earth plasters)

ZBA 11/8/1/7 Mich 1432-33

John Pygot for walling le Yatehouse of the Manor 10d
Thomas Harpur hewing and 'stauryng' the same 4/-
6 cartloads of earth for the same 18d
1 quarter of lime (calcet) 8/-
3 cartloads of sand
Schlatstanes bought at Langthorne for roofing the same manor 6/-
Carriage of the same by two mule-drivers 2/2
To Thomas Schlater for roofing 3 roods of a chamber called Dungron and another called Yatehouse 15/-
Same for mending great chamber on east side 4/-
Paid for carriage of baysestanes for the grange in the tenement of John Chalenor 10d
2 cartloads of wood for the same for wattling and daubing the same 12d.

ZBA 11/8/1/8 Mich 1433-34

Carriage of 19 cartloads of stone for the grange of John Hampthwayte 4/9
Carriage of 11 cartloads of earth and clay to the same 2/9

ZBA 11/8/1/10 Mich 1442-43

Excerpts.

To Wm Godale, carpenter. For making anew a small house in the said messuage
To the same for soleing (soland) lez Stothis et postis within the said house
Collecting several stones called baystonis and carrying
Cutting stoups and carriage from the Lord's wood to said house
Digging and laying in the cart **7 cartloads of clay** with carriage from le stonecannse to said messuage
To Robert Morland hired for 'peyntyng and betyng 7 rood in said capital house
3 quarters of burnt lime at 16d per quarter
2 cartloads of sand.

To Cole and Clapham, labourers, hired for mending walls of (John Burrel) in places
Carrying 2 cartloads of clay from le stonecannse to said house

Carrying 5 cartloads of sand
6 quarters of lime.

John Punderson hired for making anew one wall of a house within the manor called le Carthous
1 quarter burnt lime for same
1 cartload of sand.

To John Hamswayt hired to cut and carry from the wood to (Wm Coltonn) house one cartload of 'dowbynstawris'
To Thomas Clapham constructing and daubing the wall of said house
To John Cartere of Harnby for 2600 slatstonis for roofing said house
…**To Wm Symondeson for 7 quarters of burnt lime for the said walls**
To John Hamswey carrying lime from Ffrtheby to said house
To same for digging, laying and carrying 13 cartloads of calay for said house
To same for 3 cartloads of sand.

To John Hamsweyt for cutting and carting 1 cartload of underwood to said grange (of Robert Medilton) for walling the same
To same for digging 3 cartloads of clay for said grange
To Thomas Clapham for mending and daubing walls and for roofing the same.
Thatching.

2 cartloads of timber from the Lord's wood for the messuage of Wm Smyth.
John Hamsweyt for 4 cartloads of clay for the same

…one sieve for sifting burnt lime
one vessel called a 'bolle'

ZBA 11/8/1/11 Mich 1443-44

To Robert Morton, Parson, for 60 threaves of rye straw for roofing of a capital house in the tenure of Wm Smyth at 2d a thrave
To Margaret Hoddeson for drawing said straw for roofing
To John Hamsweyt for 6 cartloads of stone from the field of Brell to said house
To same for digging 12 cartloads of clay from the stonycawnsey for same
2000 lathnayle
3 cartloads of underwood called wattelyng from the Lord's wood
7 cartloads of clay and carriage from Crynggilgate to the house
To Richard Durrell and Rob Medilton for 60 thraves of barley straw for roofing
To John Webster for 20 thraves of wheat straw.

ZBA 11/8/1/19 1454-55

To Simon Bynkes, carpenter, for one pair of mylletrendles bought for the water mill
To Wm Smyth for a new loop of iron bought for the mill
To John Lofthous for planks bought for part of the millwheel called lez almes mending

To Thomas Herryson for one piece of timber called walplate lying on the wall of the mill, defective, with carriage from the Lord's mill
To Wm Slater of Exylby for roofing the mill house in various places with burnt lime and le slatestones and mending the roofing of the Town Hall
Thomas Cole for mending the wall of the mill in places with clay.

Welch E (1967) Plymouth Building Accounts of the Sixteenth and Seventeenth Centuries. Devon and Cornwall Record Society.

The early Guildhall was a stone building, of immediately local limestone and of 'moorstone' brought down from Dartmoor. Moorstone was the softer, more weathered and tractable granite that might be won from the surface, rather than deep-quarried; the roof was stone slated. Deliveries of sand and lime, but not of earth suggest lime-sand mortars, lest earth was being won on site. For the new, later Guildhall, however, lime, sand and earth is carried to site, suggesting earth-lime mortars improved before use by the addition of sand. The evidence of the Shambles and later Guildhall accounts is that the mortars were both earth-lime and lime – the former probably forming the bedding mortar; possibly the base-coat plasters, although when plasterers are being paid, lime, lime-ashes, sand and hair are also listed. It may be that the interior plastering was effected with haired earth-lime and then haired lime-sand finish mortars; with the exterior plastering haired lime and sand mortars throughout. The Orpanage accounts show lime and sand for the moorstone masonry, though earth may have been won in situ. Towards the end of the project, payments are made for 'white hair', as well as the first specific payments for 'quenching' and sifting lime. This would indicate that the finish plasters are being made from dry-slaked and sieved lime to facilitate the removal of lumps. The finish coat almost certainly comprised lime and (white) hair only. By implication, all other mortars, of both earth and lime, were being hot mixed. The lump lime for the Guildhall is being carried and stored in canvas sacks, not by the load or in barrels, at least to the site itself. There was a kiln close to the site, but carriage costs for burned lime to the site are high. Stone, although quarried only a mile away, was loaded onto boats which brought it within ¼ mile of the site; the same seems to have occurred with the lime, hence the need for limesacks. Sand was drawn from the rivers. Lime ashes are as commonly delivered as lime. Lime ashes are a mixture of fuel ash and quicklime, but would make a pozzolanic mortar slaked together on their own or as a gauge for clean lime mortars. Lime ashes likely preferred for the below-ground masonry, laying floors upon; perhaps in the roof works, perhaps as a general pozzalanic addition. Plymouth limestone, as Smeaton demonstrated in 1756, produces a fat lime for all that it is hard and dense and will take a polish.

At the Guildhall, lime is being burned in the 'town kiln' – associated payments are for burning and carrying the lime, not for the limestone or lime itself. There are entries for sand and for earth. Most payments to day-workers do not identify the work for which they are being paid. Generally, three trades are using lime – masons, plasterers and roofers.

The Shambles and the Guildhall 1606-1607

The Shambles

July 1606

The first weeke

To the Masons:

Thomas Creese 3 dayes 3s
John Werye 3 dayes 3s

To Lawrence Hunne for carieng 1 bote (boat) of Stones 2s
To Thomas Skorye for 2 doss of earthe 3s *[''doss' is an unknown measure, the author thinks a small amount, which seems most unlikely, as it costs 3 times the cost of a quarter of sand]*
Paid for 1 quarter of sand 1s
To Alse Jory for bearinge 1 quarter of sande, 1 quarter of Lyme ashes and 1 quarter Lyme 1s 6d

The seconde weeke

To Richard Shepheard for 4 doss of earthe…
To George Palmer for 6 botes of stones at 4s per bote…
To Thomas Nyle for 5 botes of stones…
To Phillip Tookerman…in parte of payment for paving

Item to Alice Joyce for carienge of 12 bushels of Lyme and 4 quarters of Lymes Ashes…
To Lawrence Hunne for carienge 4 botes of stones…
[£2 4s 6d paid to the Masons this week and £2 8s 8d the following week].

August

Item for carienge of 1 doss of earthe 1s 6d…
[15s paid to labourers for 18 man days]…
To Alice Jorye for carienge 3 quarters and 6 bushels of Lyme Ashes and 2 bushels of Lyme 2s.

[Significant payments to carpenters, masons, labourers, sawyers, helliers (roofers) and Pavers]…

To Walter Symons for carieng 20 doss of Ruble…
To Alice Jory for caryeng of 2 quarters of lyme more to her for 14 bushels of sand and the carryage…

The fifth weeke
For 4 bushels of heare (hair) at 8d per bushel
For 2 doss of earthe caryeng away…
For 6 bushels of heare at 9d per bushel…

Item to Alice Jory for carieng 22 bushels of lyme and 8 bushels of sand, and for the sand…

[Payments to the above trades *and* to Plasterers for the first time]:

2 labourers **beating mortar** eache 3 days at 8d per day….

Sixth week

Item to Alice Jory for bearing 1 quarter and ½ of Lyme, 2 bushels of sand and 1 quarter 2 bushels of Lyme Ashes and for the sand…
12 bushels of heare…

[Payments this week to Helliers, Sawyers, Plasterers, Pavers, but *not to masons*]

Seventh week

To Alice Jory for caryeng 1 quarter and ½ of Lyme

[payments to carpenters, sawyers, plasterers, roofers].

Eighth week.

[Payments to plasterers, roofers, carpenters]

To Alice Jory for carieng 1 quarter 7 bushels of Lyme
More for carieng 1 quarter of Lyme Ashes

Best H (1641) Rural Economy in Yorkshire, Being the Farming and Account Books of Henry Best. Published 1857 George Andrews.

When they are to make a new barne floore, they grave it all over, and then rake it all over with hey rakes or iron waine rakes till the mowles be indifferent small; then they bringe water in seas and in greate tubes or hogsheads on sleddes and water it till it bee as soft as morter, or almost as a puddle; then lette it lye a fortnight, till the water bee settled in that it beginner to waxe harde again, and then beate it downe smooth with broad flatte peeces of wood. When a floore is decayed , that there are holes worne, they usually leade as many coupe loades of red clay, or else clottes from the faugh field, as will serve, but they must not leade theire clottes from such places where the clay is not mixed with sands; and then when it commeth, theire manner is for one to stand will a mell and breake the clottes small, another hath a showle and showleth the mowles into the hole, the third and all the rest have rammers for ramming and beating the earth down into the hole….then they water it, and lette it lye three or foure dayes to mawme, for if they shoulde ram it presently it would cleam to the beater: we use to digge and leade clay for our barne from John Bonwickes hill.

P145 In summer-time wee usually fetch clottes out of the field to make morter on, but in winter wee eyther shoole up some dirte togeather, in some such place as is free from gravle and stones, or otherwise wee digge downe some olde clay or mudde-wall that is of noe use, or else grave up some earth, and water it, and tewe it. Morter neaver doeth well unlesse it bee well wrought in, viz.; except it bee well watered and tewed; and it is accounted soe much the better if it bee watered over night, and have nights time to steepe in. In makinge of morter, yow are first to breake the earth very small, and with your spade to throwe out all the stones yow can finde, and then to water it and tewe it well, till it bee soe soft that it will allmost

runne; then lette it stande a while till the water sattle somethinge from it, and it will bee very good morter….

They that make the morter have allwayes by them an olde spade to tewe it with, and a little two gallon skeele to fetch water in, and two olde scuttles to carry up morter in, viz.; one for the server, and another for the thacker-drawer, if occasion soe require; and theire manner is to putte an handfull or two of dry-strawe into the bottomes of the scuttles to keepe the scuttles cleane, and that the morter may goe readily out and not cleave to the scuttles.

A thatcher hath usually to folkes to waite on him, viz. ; one to drawe out the thatch and make it into bottles, and the other to make morter and serve him ; unlesse it bee when they come to morter the rigge of an howse, and then the thacke-drawer giveth over (p146) clrawinge, and worketh amongst the morter, and filleth the scut- tles as the thatcher throweth them downe; and the other doth nothinge but carry up to the toppe….

The mudde-wall, that goeth from the ende of the West- howse to the Gardens bricke-wall-side, served George Wise two whole dayes afore hee got it eized, and the eize cutte; it was eized with stubble and haver-strawe mixed togeather, and wee had three folkes imployed aboute it beside the thatcher, viz.; a woman that drewe thacke constantly, a boy that did nothinge but tewe morter and carry it up, and the third did sometimes help to drawe thacke, and otherwhiles make morter, and helpe to tewe it…

att the last of all, hee taketh a girlinge of stubble, and lyeth over thwart the other strawe; for it is layd eaven forwards as a wall goeth; and thereon hee lyeth his morter: hee standeth upon the wall himselfe, and carryeth up aboute halfe a yard, or betwixt a foote and halfe a yard, att a course, to which hee constantly useth three scuttles full of morter; and in layinge on of his morter, his manner is to take the strawe that is in the bottome of the scuttles, and thrust the morter downe as lowe as hee thinketh good, and then to plaine it with his trowell.

The History of the Royal Society of London Vol 4 (1872) A Millar London.

P363.

A letter of Mr Musgrave to Mr Aston, dated at Oxford, January 31 1684/5 was read, containing an answer to Sir William Petty's query about mortar and plaister, as follows….

Clay mortar, or loam mortar is made with clay and as much chopt straw as the clay will take in, by the help of water.

Mortimer (1708) The Art of Husbandry; Or the Way of Improving of Land.— Book I.

If you design to make your Cisterns under your House, as a Cellar, which is the best way to preserve it for culinary Uses, you may lay the Brick or Stone with Terrace,

and it will keep Water very well; or you may make a Cement to join the Bricks or Stones with, with a Composition made of slacked sifted Lime and Linseed Oyl tempered together with Tow or Cotton-wool. Or you may lay a Bed of good Clay, and on that lay your Bricks for the Floor, then raise the Wall round about, leaving a convenient space behind the Wall to ram in Clay, which may be done as fast as you can raise the Wall: so that when it is finish'd, it will be a Cistern of Clay walled within with Bricks, and being in a Cellar, the Bricks will keep the Clay moist (altho' empty of Water) that it will never Crack.

Or you may make a Cistern or Pool to hold Water by daubing of it with Clay and Mortar, and after draw it over with Mortar; if any cleft happen, stop it with **a Cement of clean Hair and Tallow mix'd with unslack'd Lime and Yolks of Eggs well beat, and made into Powder, and mix'd well together.**

Nathan Bailey, John Worlidge (1726) Dictionarium Rusticum, Urbanicum & Botanicum: Or, A Dictionary of Husbandry, Gardening, Trade, Commerce, and All Sorts of Country-affairs: Volume 1. Third (revised) Edition.

But though burning of Bricks be necessary for building of Houses, &c. yet a Wall or House may be made with un-burned Bricks; for which end, 1. Let your Earth be high and well temper'd, smooth and well moulded, as already hinted, and this done in the hottest Season; then dry'd and turn'd after the manner of Brick-making; only it must be longer exposed to the Sun and Elements, till they become hard and tough, and then use them after this manner: **Take Loam or a Brick-earth, and mixing therewith some good Lime, temper them very high till they become tough, smooth and glewy**; let the Wall of your House be one Brick or one and an half thick, and your unburnt Bricks being laid in this well-temper'd Mortar, they will cement and become one hard and solid Body, as if the whole were but one entire Brick or Stone:

When you have raised your Wall 4 or 5 Foot high from the Foundation, let it dry 2 or 3 Days before you proceed further; then build thereon 4 or 5 Foot more, making the like Pause as before, and so proceeding till the Wall is finished: Afterwards temper **some of the same Earth the Wall was made of,** with a little more Lime that was used for the Wall, which you must be sure to temper very well, and with this Mortar plaister all your Wall well on the other side, which will keep off the Weather; and if you would have it more beautiful, it's only putting more Lime to it and less Loam; and when this is dry, you may colour and paint it, with Red, Blue, or any other colour that you like best.

But the usual way to make Pools of Water on Hills and Downs for Cattle, is to lay a good Bed of Clay near half a Foot thick; and after a long and laborious ramming thereof, they lay another course of Clay about the same thickness, and ram that also very well; and pave it very well with Flints or Other Stones, which not only

preserves the Clay from the tread of the Cattle, & c. but from chapping by the Wind or Sun at such time as the Pool is empty. Note also, that if there be the least Hole or Crack in the bottom, it will never hold Water, unless you renew the whole labour.

... Tiling is measured by the ten Foot-square, Workmanship of which is three Shillings and Six pence a Square in the Country, to find all but Tiles, is twelve Shillings, and to find Tiles and other Materials is one Pound six Shillings a Square. **Three Bushels of Lime will do a Square of Tiling, but I prefer Loam and Horse-dung mixed together, and laid about the Middle of the Tile, so as not to touch the Pins or Laths, nor to be so near the point as to wash out, because Lime is too corroding, being apt to make the Tiles scale, and to grow with Moss. _**

'Plasterers. The Plasterer's Work is commonly done by the Yard square, for Lathing, Laying and Setting is Eight-pence a Yard, rendering on a Brick-wall is Three-pence a Yard, stopping and whiting one Penny half-penny a Yard, whiting a Penny a Yard; but Lathing, Laying and Setting with Oak-Laths is ten or twelve Pence a Yard. **To daub a Partition-wall with Clay on both sides is Three-pence a Yard, and to rough cast it without, and render it on the inside, Four-pence a Yard in the Country.** Heart-Laths of Oak are one Shilling and Ten-pence a Bundle or Hundred. Sap-Laths of Oak are one Shilling and Eight- pence a Bundle. Fir-Laths are Twelve-pence a Bundle. A Bundle of Laths they reckon will do a Square . of Tiling, and five hundred of Nails.

... To complete this article let us just take notice of the flooring, which it would be a considerable saving to the occupier to be properly secured: a mixture of lime, cut horse-hair, drift-sand, temper'd-clay, and horse-dung laid pretty thick, will make the floor impenetrable to vermin.

Neve R (1726) The City and Country Purchaser and Builder's Dictionary or The Complete Builder's Guide. Newton Abbot. David and Charles Fascimile edition 1969.

Earthen floors are commonly made of Lome, and sometimes (for floors to make Malt on) of Lime, and Brooksand and Gun-dust, or Anvil dust from the Forge; the particular Method of both which I must at present omit; but I cannot pass by that receipt (given us by the Ingenious Sir Hugh Plat, to make an artificial composition, wherewith to make smooth, glittering and hard floors, and which may also serve to plaister walls with. Take (says he) Ox-blood, and fine Clay, tempering them well together, lay the same in any Floor (or Wall) and it will become a very strong and binding Substance; as I have been told by a Gentleman and Stranger, who affirm'd to me, that the same is of great use in Italy.

Lome: A sort of reddish earth, us'd in Buildings (when temper'd with Mud Gelly, straw and Water) for Plaistering of Walls in ordinary Houses.

White Mortar: this is used in plaistering of Walls and Ceilings, that are first plaister'd with Lome and is made of Ox or Cow-hair, well-mixed and tempered with

Lime and Water (without any Sand). The common Allowance in making this kind of Mortar is one Bushel of Hair to six Bushels of Lime.

…A wise, wealthy and ancient soap boiler, dwelling without Aldgate has…long since erected a fair and stately edifice of brick for his own habitation…the mortar whereof did consist of two load of waste soap-ashes *[wood ashes], one load of lime, one load of lome, and one load of Woolwich sand.*…Another gentleman…has used only lome and soap-ashes, tempered and wrought together for mortar…in Southwark.

Plaistering

Some masons in Sussex tell me, that for lathing and plaistering of walls with Lome on both sides, they have 3d per yard; but if it be done with white Lime and Hair mortar on both sides, they have 4d per yard. …

With rough mortar or rough-cast. In some parts of Kent they commonly rough-cast (as they call it) upon old Lome walls, that is, they give them one coat (upon the Lome) of rough mortar or rough cast, tho' it be commonly struck smooth like Lime and Hair. For this work they have 3 ½ d per yard, only workmanship; but if the wall be new and lathed, and plaistered with Lome on both sides, and a coat of rough mortar on the outside, then they have 4d per yard, only workmanship. But if the rough-cast be wrought in flourishes, then they have 8d per yard…

Of Whitwashing. Whitewashing with Size upon plaister'd walls, is commonly reckoned at 2d per yard.

Walls. Plaistered or Mud Walls.
These kind of walls are common in Timber Buildings, especially of ordinary buildings; for sometimes the walls are made of brick betwixt the Timber: but this is accounted no good way; because the mortar corrodes and decays the Timber.
These mud walls (as they are called in some places) are thus made: The walls being quartered and lathed between the Timber (or sometimes lathed over all) are Plaister'd with Lome…which being almost dry is Plaister'd over again with White Mortar.

Malton Estate Agent's Memorandum Book (1734 – 1808) Fitzwilliam Estate Archive North Yorkshire County Council Records Office NYCCRO ZPB III 5-2-1

July ye 7th 1736. Agreed with Will. Ellis, James Luccock and Parlour to wall all the stone walling thorough which shall be wanting at Wm Foxe's House, to make the front wall of Pye Pits wall stone & as good as Mr Carr's house, the whole walling to be done at seven shillings and sixpence per Rood and one shilling per arch for every arch in the front turned & that they shall find all materials whatsoever & the best mortar that can be got & to have six pounds for carrying up Eight Chimneys in the said house & twelve shillings per thousand for laying on Tyles & finding lime & sand & to give them one shilling & sixpence per yard for flagging what there will be occasion for & to give four pence per yard for all plaistering against the walls, finding lime etc & to give them eight pence per yard for every Cubical yard for digging the seller & carrying off the rubbish from the first to the last. We promise to begin forthwith and to finish with al spede as possibly we can, as witness our hand,

John Freer, James Luccock, Richard Smith, Robert Owram, John Seller, Wm Ellis.

January ye 5th 1737. Agreed with James Luccock & John Frear to build a house for Widow Rowntree 31 foot long from end to end and 18 foot broad and sixteen foot high and to carry up a kitchin chimney, a little parlour and chamber chimney, the workmen to find all materials whatsoever & to fetch the best mortar and to point the outside walls with lime & to have all the old stone & to receive six shillings per rood & forty shillings for carrying up the 3 chimneys. No money for the chimneys if they smoke. As witness our hands, James Luccock, John Freer.
January 5th 1737. Agreed with **Robt Owram & Richard Smith** to do all the **Daubing & Plaistering** work that is necessary to be done at Widow Rowntree's House & to have three pence a yard, they finding, **mortar, lime & hair,** and twelve shillings per thousand for laying on the tiles & pointing. As witness our own hands, Richard Smith, Robert Owram.

July 6 1738. Agreed with James Luccock, John Freer, Richard Smith & Francis Stephens to wall a stable round as was set out & to receive seven shillings per rood & to carry up four little chimneys & to receive Two Guineas & to dig the foundation & clear off all the rubbage & receive two pounds ten shillings & to have twelve shillings per thousand for tiling & pointing. The walls to be pointed with lime and to receive one Guinea now at John Willoughby's House & to be finished ten days after Michaelmas or half the sum to be forfeited. Witness our hands, John Freer, Richard Smith, Francis Stephens, James Luccock

June ye 28th 1739. Agreed with John Freer to make a wall by Castle Dyke Side & to be equally as good as the wall below and to make it twenty two inches broad & to put throughs which shall reach into the bank & the said Freer to find all stone and mortar & to cope it with Beilby's Quarry stone the same as the other wall & to lay it on with lime & to receive when it is finished four shillings & 6 for every rood and to begin on it the next week, John Freer.

1st July 1748. Agreed with Percival Luccock for himself and (sic) behalf of James Luccock, his partner to build a wall to Fenton and Robinson's yard adjoining Water Lane 7 foot high with the coping at 5s per rood and to do it with old stone in the yard. They are to have two chaldern of lime allowed to mix with the mortar which is to be taken fresh out of the kiln, and Mr Turner to see it measured. Witness my hand, Percival Luccock.

Campbell Robert (1747) The London Tradesman, Being a Compendious View of All the Trades, Professions, Arts, both Liberal and Mechanic, now practised in the Cities of London and Westminster. London. T Gardner.

(The Plaisterer) is employed in plaistering and white-washing the Ceiling, and such Part of the Walls as require it, or are not to be wainscoted.

He first nails on the Laths upon the Ceilings, **upon which he lays a Coat of Clay, mixed with Hair, or hay; over which, when dry, he lays a Coat of fine Plaister.** He is attended when plaistering by a Labourer, who holds the Plaister up to him in a hod; he takes it off the Hod with a Trowel, like that used by the bricklayer, and lays

it up on a Trowel peculiar to his Business; which is a flat plate of iron, with a Handle fixed upon the Back of it instead of the End.

For Walls and Mouldings he uses another kind of Plaister, especially for Walls that are to be done, **commonly called Stucco**: **This is prepared only of Stone-Lime and two or three parts sand,** according as the Lime is of Strength, or as the Work is to be finished. If the Work is designed to explain, there is a coat of Mortar laid on rough; that is permitted to dry.

Batty L (1750) London Prices of Bricklayers' Materials and Works Both of New Buildings and Repairs, Justly Ascertained. London Richard Adams 2nd Edition.

Of Pargetting Mortar.

This Kind of Mortar is chiefly used for to plaister the Insides of the Funnels of Chimneys and is also very good for to point common Pan-Tiling, &c. and is thus made:
To 1 heaped Bushel of fine skreened *clear Lime* add about a 4th Part of fresh Horse-dung clear from Dirt and Straw; which incorporate with the Lime by well beating it, as is said of Terrace Mortar.

1 Bushel of *fine lime*, taken out of 2 bushels of unscreened Lime	0	0	4 ½
Horse-Dung and Labour to get it	0	0	1 ½
Labour to ***slack, sift, turn up*** **and** ***beat***	0	0	4

Of Furnace or Fire Mortar.

This Mortar is made either of Woolwich Loam, or of Windsor Loam, viz. Loam brought from Woolwich in Kent or from the Brick Kiln at Gerrard's Cross by way of Windsor.
Both these Kinds of Loam endure very great Heats before they will vitrify.
The Manner of making them into Mortar is to well chaff and beat them, as outside common Mortar is done, and of such a Consistency as to work easy.

Of White Plaister Mortar.

Plaister prepared (vulgarly called Plaister of Paris) when mixt with Water, becomes a Mortar or Cement that sets very soon and hard; and **by Bricklayers is used for setting of Galley Tiles in the Covings of Chimneys, Cold Baths, Pastrys, etc.**

And as common Lime is made of Chalk calcined so Plaister is made of Alabaster-stone, or Talk, calcined and pulverized or first pulverized in the Raw stone and calcined afterwards in a Boiler.

To Calcine Alabaster-Stone, and to make Plaister commonly called Plaister of Paris, Beat the Stones to Pieces, about the Size of a Hen's Egg; then burn it or bake it, until the Shining Quality within each Piece (which is easily known by breaking some of them) be entirely gone, and they appear entirely white within like Chalk, then beat it

on a flat Purbeck Stone, enclosed with a Frame, about 3 Feet square, and sift it through a fine Wire or Lawn Sieve into a Tub for Use.

Dossie R (1771) Memoirs of Agriculture and Other Oeconomical Arts Vol 2

The manner of preparing this mortar is as follows: **Take of unslacked lime, and of fine sand, in the proportion of one part of the lime to three parts of the sand,** as much as a labourer can well manage at once: and then, **adding water gradually**, mix the whole well-together by means of a trowel, till it be reduced to the consistence of mortar. Apply it immediately, **while it is yet hot,** to the purpose, either of mortar, as a cement to brick or stone; or of plaster for the surface of any building.

It will then Ferment for some days, in drier places; and afterwards gradually concrete or set; and become hard. But in a moist place it will continue soft for three weeks or more; though it will, at length, attain a firm consistence, even if water have such access to it so as to keep the surface wet the whole time, After this, it will acquire a stone-like hardness; and resist all moisture *[this is very likely a feebly hydraulic lime].*

P23 Chalk-lime, which is the kind most commonly used in London, is not fit for this purpose, on account of its containing flints; which makes it required to be skreened before it can be tempered with the water and sand. This skreening renders the slacking the lime previously necessary: and the slacking it before it be mixt with the sand prevents its acting on the sand, so as to produce their incorporation; which power it loses, in a great degree, after its combination with the quantity of water that saturates it. Lime made of limestone, shells, or marble, must be therefore had for this purpose: and the stronger it is, the better the mortar will be….

The superiority of this to the common mortar is **owing to the intimate commixture of the lime with the sand, at the same time it is combined with the water**, before its attractive power, be diminished by its combination with water: and **this shews the defect in the common method of making mortar: where the lime is slacked before it is (p25) commixed with the sand; and where, in part, old mortar, <u>common earth, or other substances, with which lime has no peculiar specific attraction, are generally added, or used wholly in the place of sand.</u>**

(the 'common method' to which Dossie refers is the slaking of the quicklime in a ring of sand, with which it will be mixed as soon as slaking is complete and whilst the just slaked lime remains very hot. He goes on to indicate that the principles of this method should be more generally adopted)….

West Yorkshire Archives, Leeds. WYL/678 acc 3810

Building a dwelling house and schoolhouse at Headingley 1783-1805

(no lime in this account, Earth and sand.)

Stonework or walling at 1s per rood
Slating and pointing at 3 ½ d per yard
Chimney pieces at 3s each
Stone steps for the chamber stairs at 4d per foot.

Dwelling house – 18 feet long by 20 broad with a chamber above.

Schoolhouse to be 27 feet long by 20 broad.

The said Harrison and Walker to find all materials in wood and iron doors, window shutters, boults, bars, hinges, nails, crook locks, laches and catches, boards and all other materials in wood and ironwork and sufficient honest workmanship for 16-0-0.

Dimensions of the timber:

3 baulks, two in the schoolhouse, one in the dwelling house, each 10 by 6; 2ribs each side 4 ½ by 6 1/2 ; principals 10 by 3 ½ ; spars 3 ½ by 3; joice 4 by 3. All to be good, sound red deal. The pitch to be 5 feet; the floor to be laid with good red deal of an inch thick.

Mr Kirk, leading:

1782 To leading stones 1 day
to leading 3 load of wood
to 3 days one day, one horse cart leading earth

March
To leading stones
To leading sand and stone
To fetching timber from Leeds and paying turnpike
Stones – more leading; more sand.
One day leading brick, sand and stones
One day leading slate
Leading flags, slate and rigging

Joseph Kirk account 1784

To leading stones
To leading 3 load of wood
To 3 days, one horse cart leading earth
Stones, sand
To paying Wilson for removing clay

1783 stones, timber, sand.

January 1st 1784

Paid Benjamin Harrison for meat and drink at the raising 0-9-0
Paid Hartley for him and son one day carrying or filling earth
1 horse and cart for laths, nails and brads

paid for a wattering pan
slate, rigging, flags.

May 25th Paid Robinson for lime 1-1-0
For lead and paint
For 4 quarts of oil and a bladder.

Paid for wheeling earth and carrying out stones and rubbish and levelling the floors for flagging.

Marshall W (1796) The Rural Economy of Yorkshire Vol 1

CEMENT. **Formerly, ordinary stone buildings were carried up, entirely, with 'mortar'; that is, common earth beaten up with water, without the smallest admixture of lime** *[but see below for contradiction of this - earth mortar with lime lumps present]*. The stones themselves were depended upon as the bond of union; the use of the 'mortar' being merely that of giving warmth to the building, and a degree of stiffness to the wall *[we would disagree with this assumption]*.

The event, however, proves that walls built without lime have, in many instances, stood for ages. Even part of the walls of Pickering Castle, formerly esteemed a fortress of considerable strength, have been carried up with a cement which, *to appearance,* seems little superior to common mortar: nevertheless, such is the effect of time, upon walls which are exposed on every side to the atmosphere, that they now hold together with considerable tenacity…

EXP 1 CEMENT OF PICKERING CASTLE: - the coarser specimen, taken from the ruins of the central tower.
In *general appearance* it resembles dirty chalk, thickly interspersed with small gravel; some of the granules as large as peas. Its *tenacity* that of common writing chalk; the asperities easily broken off with the fingers. One hundred grains, pounded, dried, immersed in water, and balanced together with the menstruum lost in solution 25 1/2 grains of air, and yielded by filtration 40 grains of residuum; which afforded…35 grains of gravel and rough sand, and 5 grains of suspendible mudlike matter; the solution yielding, by precipitation, 64 grains of calcareous earth…

From this analysis it appears,

1. that the proportion in this case (supposing crude limestone in lumps fit for burning to be of equal weight with sand and gravel) was three measures of unslaked lime in lumps to two of sand and gravel. *[probably the opposite by volume, since lump lime 40% lighter than unburned limestone]*.
2. That the sand and gravel, in this case, has been washed; either by the brook, which runs at the foot of the Castle mound, or more probably, by hand; the proportion of dirt being smaller than that which is generally found among *drift sand.*
3. That the lime had not regained the whole of its fixed air.

EXP 2 - finer specimen of the central tower.

General appearance that of stale lime, run together with water, and baked to a crust; almost a pure white; surface rough; shewing the cells and the unbroken granules of the original lime. *Contexture*, more brittle than common chalk; full of pores; the materials do not seem to have been well incorporated, at the time of preparation. One hundred grains yield, in decomposition, 21 grains of air; 42 grains of whitish grit, 5 grains of suspendible dust like particles; 56 grains of pure chalk.
OBS. The residuum…is evidently *the powder of free stone.* The particles are small, and of irregular figures, very different in appearance (when magnified) from common sand. I was at a loss to ascertain their nature, until pounding some freestone, and washing it in the manner I had done the residuum, I found it to resemble exactly the 42 grains of washed grit of the experiment. It appears to have been pounded or ground very small, and to have been put through a fine sieve…no fragment so large as a pin's head.

It is observable that the cement of this experiment is *weaker* than that of the last (different aggregate; less lime content)….It is also observable that, in the decomposition of the specimen, a urinous smell rose, during the solution…**It is at present a practice, among some plasterers to make use of urine in the preparation of plaster.**

EXP 3 - taken from the ruins of the old outer wall facing the northwest. Collected in three or four different places; a few feet above the foundation; and mostly from the inner parts of the wall, not from the outer surface.

In appearance that of sandy loam, interspersed with specks of chalk *[quicklime, surely]*, some of them larger than peas *[we see this pattern locally where quicklime has been added to earth mortar]*. Its fragility similar to that of dried brick earth.

100 grains…yield 13 1/2 grains of air; 30 grains of rough sand, and a few large fragments; 37 grains of silt and fine sand; 36 grains of calcareous earth.

OBS. There are two causes of the *weakness* of this cement: the small proportion of lime, and the impurity of the base…chiefly of mere mud, or of sand so fine as to be impalpable between the fingers. *[all consistent with the simple use of locally sourced sub-soil and modest addition of quicklime - the sand and silts being naturally part of the subsoil. Fairly typical of modern disaggregation in this area]*.

EXP 4 - taken from a fragment in the northwest corner of the fosse.

The general appearance somewhat resembling the last-noticed specimen; but in *contexture* very different. The crust of the outer surface, which has been exposed to the influence of the atmosphere, probably during many centuries, has acquired almost the hardness of limestone; nor is any part of it to be broken with the fingers; nevertheless, this specimen also, is **full of lumps of unmixed lime;** some of them the size of small hazel nuts, and, at the time I took the specimen (the season wet), as soft almost as butter; when dry, they are of the consistency of very soft chalk.

One hundred grains of this specimen yield 15 grains of air; 8 grains of fragments; 12 of coarse sand; 36 of fine sand; 3 of size-like matter; 45 of chalk. *[linseed oil?]*.

…GENERAL OBS:

1. All these cements, whether weak or strong, have laid hold of the stones with a degree of firmness proportioned to their respective strengths. **Every crevice of the wall is filled with cement; whole form one united mass.**

Hence, it is more than probable that these cements have been poured into the walls, in a liquid state, in the state of *puddle…*

2. The subjects of EXP 3 and 4 are strong evidence that, in the preparation of these puddles, the ancient builders were very deficient *[we would probably disagree]*. Not more than half of the lime they contain appears to operate *[as binder, but will seed carbonation as porous aggregates]*. The lumps, whether large or small, are *more* than wasted; weakening, rather than strengthening, the cement *[Marshall is going somewhere with this argument - see below]*.

3. From the whole of these experiments, it is evident , that the several cements had acquired the principal part of their fixed air; chiefly, perhaps, after they were deposited in the buildings *[by carbonation]*. Hence it is entirely probable that the stonelike tenacity of old cements is chiefly owing to the transmutation of lime and sand to calcareous earth and sand; a substance resembling the original limestone *[the lime cycle]*.

On examining a wall, which has been built with loam alone, without any admixture of lime, and which has stood about a century, I find that the loam has laid not hold whatever of the stones, and that time has made no alteration on its contexture. It is still the same friable substance it probably was the day it first became dry in the building; without having the smallest appearance of **acquired tenacity** obtained during the century of time it has been exposed to the influence of the atmosphere.

It is therefore probable that the atmosphere imparts nothing *voluntarily* of a cohesive nature to the mortar of walls which are exposed to it.

But it is more probable that cement, **containing a portion of lime, imbibes from the atmosphere something, which gives it a degree of tenacity, superior to that which it had on its first becoming dry in the wall;** and it is a fact well established, that lime begins to imbibe, the moment it grows cool from the kiln, that which the fire has deprived it of, namely, fixed air; which fixed air being imbibed, after the cement is deposited in the walls, is *probably* a principal cause of tenacity.

Thomas Luccock proposals for building a stone tenement in Old Malton 1799. Fitzwilliam Estate Archive NYCCRO.

3rd Augt 1799. I agree to build a tenement in the cow pasture in Malton Fields according to the plan hereunto annexed or with such alterations as may be made therein before the building is begun at the prices within mentioned, and to compleat and finish the same in a good and sufficient substantial workmanlike manner and to the satisfaction of Mr Hastings, so as to be fit for a tenant to go

into it on or before Michaelmas next or forfeit five guineas, Witness my hand the day and year above, Tho Luccock.

s	d	
6	-	per rood for walling stone
1	9	per rood for the stones, for loading nothing
2	6	per rood for leading stones
1	6	per rood for mortar without lime
11	9	without pointing [11s over-written]
12	6	if pointed [12s written in by Hastings]
1	9	per rood for brick of bredth walls
4	6	per squair for tiling
1	0	per yard for squaring and for laying common flags
1	0	per yard for each flew (flue)
0	3	per yard for two coat plastering
0	3	per yard for brick flooring
0	5	per yard for cellar digging and filling the stuff.

Marshall W. The Rural Economy of Yorkshire Vol 1 1788

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time, upon walls which are exposed on every side to the atmosphere, that they now hold together with considerable tenacity…

The citadel, or central stronghold, of the fortress under notice, has been built with better cements; which, however, vary much in outward appearance. One specimen…is a smooth childlike substance; another, a coarse rough mass, composed of sand and gravel, with a smaller proportion of chalk-like matter [….lime].

In the fosse, which surrounds the outer wall, lies a fragment…whose cement has acquired a stone like hardness, especially the part which is exposed on the outer surface.

I have bestowed some attention on the decomposition of these four specimens…

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Marshall W (1796) The Rural Economy of Gloucestershire; Including Its Dairy: Together with the Dairy Management of North Wiltshire; and the Management of Orchards and Fruit Liquor, in Herefordshire, Vol II Cotswold Hills. Raikes. Gloucester.

CEMENT. Lime is excessively dear; and **sand not to be had**, I believe, at any price; nevertheless, an excellent mortar is here prepared, at a moderate expense. **Invention is seldom more successful, than when necessity prompts it.**

The scrapings of the public roads; namely, levitated lime stone, impregnated more or less with the dung and urine of the animals travelling upon them, are found to be an **excellent basis for cement**. For ordinary walls, the scrapings alone are frequently used. And, from what I can learn, the proportion, for the best building, is **not more than one part lime to three of scrapings.** Nevertheless, I found mortar, which had not lain in the walls more than ten years, of a stone-like tenacity: much firmer than the ordinary stone of this country: probably much harder, than either of the stones, from which the basis of the lime was made. Similar scrapings might be collected, in any district where limestone is used as a material of roads.

The method of PREPARING this CEMENT is, simply, that of **collecting the road-scrapings, slaking the lime, mixing them intimately together, and, as the mass is worked over, carefully picking out the stones** or other foulness, which may have been collected. **This, for stonework, is found sufficient: for brickwork, however, it might be necessary, that the materials should pass through a**

skreen or sieve; previously to their being made up. The price of lime, here, is 8d. a bushel of eight gallons, level. The price of coals about 30s. a ton. The kilns small, with funnel tops; to carry off the smoke, and, by breaking off the wind, to give a more regular draught.

BARN floors are of a good size: 12 to 14, by 18 to 20 feet. The best of oak: some of stone: but a species of earthen floor, which is made here, is thought to be superior to floors of stone, or any other material, except (p20) sound oak plank. The superior excellency of these floors is owing, in part, to the materials of which they are made; and, in part, to the method of making.

The materials are the calcareous earth of the subsoil, a kind of ordinary gravel, which is found in different parts of these hills, and the chippings of freestone (calcareous granite) from the freestone quarries, in equal quantities. The method of making is founded on a principle which is peculiar, perhaps, to these hills. Earthen barn-floors are made, in other places, with **wet materials**;—a kind of mortar which, as it dries, is liable to crack; and requires some months, after it is made, to dry it hard enough for use.

On the contrary, the materials, in the practice under notice, **are worked dry: they of course do not crack; and are ready for use as soon as they are finished.**

The materials, mixed together, are sifted twice over. The first time, through a wide sieve, to catch the stones and larger gravel, which are thrown to the bottom of the floor. The next, through a finer sieve, to separate the more earthy parts from the finer gravel, which is spread upon the stones, (p21) and, upon this, the more earthy parts; making the whole about a foot thick; and trimming down the different layers, closely, and firmly, upon each other. The surface being levelled , it is beaten with a flat wooden beetle, made as the gardeners turf beater ; until the surface becomes hard as stone, and rings at every stroke, as metal. If properly made, they are said to last a length of years; being equally proof against the flail and the broom.

Rondelet (1803) Theoretical and Practical Treatise on the Art of Building.

(Rondelet was the architect of the French Pantheon and member of the Civil Construction Council within the French Ministry of the Interior).

p218 Adobe blocks with he calls in French briques crues (uncooked bricks)., he focuses on older constructions like Babylon, the Tower of Babel, the pyramids, Greeks constructions. He puts what Vitruvius said about abobe blocks. Then :

Anywhere that adobe is used, the adobe block is made with clay soil. [...]. *In Persia, and in the Orient*, the masons, to make abobe blocks, knead the earth with their feet, adding short cut straw. They shape them in very thin wooden moulds. The dimensions of these are about 22 centimetres in length, 16 centimetres in width and 7 centimeters thick. When moulding them to make them more uniform, they pass their hands over them, after having wet them in a bucket of water, in which chopped straw is mixed (a finer straw than the one used to make the blocks). After 2 or 3 hours, these bricks acquire sufficient firmness to be stacked in an open space, in the shade, to finish drying.

House walls built of adobe blocks are covered with a clay and chopped straw render, which is enough to protect them from the rain. The top is covered with a course of burnt bricks, and sometimes abobe, angled to shed water.

The walls of more important houses are rendered with a mortar of lime mixed with *(gypsum)* plaster, crushed and mixed with water. This type of render is very solid and endures well in the air. This plaster is not as beautiful nor as white as ours, its grain being coarser.

In several regions of France, such as in la Somme, l'Oise, l'Aisne and la Marne, we build timber frames and we pack the infill panels with a mixture of crushed earth and straw or hay, which we call *'torchis'*, wattle-and-daub, which is no better than the use of adobe blocks.

Article II Rammed earth

Rammed earth is a method of building in earth which is even more simple than building with adobe blocks. It is very much used in the regions of l'Ain, Rhône and Isère. This cheap method, which make solid dwellings, safe from fire, would be worthy of spreading to other regions, where we build in wood, particularly for barns and other rural buildings.

When the walls in earth pise are well made, they form a monolithic structure and when they have a good exterior render, they can last several centuries.
In 1764, I was in charge of the restoration of an old castle in the region of the l'Ain; it was built in earth pise more than a 150 years ago. The walls had acquired a hardness and consistency equal to the soft stones of medium quality such as Saint-Leu stone. We had – to enlarge windows and make new openings - to use a pointing hammer and a cutting tool such as would be used on stone ashlar. This type of construction, which seems to have been the practice in this country since time immemorial, was known by the Romans, Pliny talks about it as an extraordinary thing which must inspire admiration.

<u>Method of making Rammed Earth</u>

Any soil which is not too fat nor too lean are good to be used for rammed earth. The best is the 'terre franche' *(agronomical soil stable in all its elements, assuring regular growth for vegetation, its theoretical composition would be: 65% sand, 15% of clay, 10% of humus and 10% limestone, souce Wikipedia)*, which is a bit gritty. Any time a pickaxe, a spade, or a plow removes heaps of soil that need to be broken up, this earth is good for adobe rammed earth). Cultivated soils, garden soils, natural soils can be also used.
To prepare the soil, it needs to be beaten with a medium rake to extract any stones bigger than the size of a walnut. It the soil is too dry, we wet it by aspersion and stir it with a shovel. The soil needs to be humid enough that a handful, when thrown back into the mix retains the shape given to it in the hand.
When the soil is prepared, we throw it into a mould, or mobile box, where it is beaten by workers with a pestle.*)*

This box is formed with two boards of fir wood that the earth builders around Lyon call *banches*, composed of tongue and grooved boards, strengthened with other boards laid across-ways and nailed. To facilitate the positioning of these *formworks*,

we put two handles on each.
These formworks are laid on transoms, and placed in grooves in the already existing wall. These four transoms are called *lassoniers* or *clefs*.
[…] We leave inside the formwork a space equal to the widest walls to be built - about 54 cm - and we decrease the width as the wall and the formwork are raised…
[…] such a wall will be 795 millimetres at the bottom and 108 mm narrower at the top…The *formwork* is usually 3,248 mm by 893 mm.

P233 Once the formworks are in place, we put mortar flashing, which we could do in plaster or even in earth, as it serves only to avoid the flowing out of the first soil thrown (*between the formwork as it meets the already constructed wall*). We then cover the top of the transoms with a small plank, placing also along its length firmed earth mixed up with water, that is to say, a bit wetter that the rammed earth mortar.
Then we put as many rammed earth-makers as there are divisions in the formworks. After the bottom has been cleaned and wetted, the labourers carry the ready-made soil to the rammed earth builders in wicker baskets. They spread the soil with their feet to form a layer of uniform thickness, which should be no more than 10 cm.

Then, each of them a pestle, they ram this layer of earth, reducing it slowly to half its original thickness. This first layer compressed, the labourers bring more soil to form a second layer of the same thickness and do the exact same thing.

To talk about the pestle in detail: the flat part of the pestle with which the worker hits the soil is the most essential part. It needs to be very uniform and smooth. Good rammed earth builders are proud to have a good pestle that can hit the soil in any part in the box. We choose for this tool a hard wood, such as the roots of elm, ash or walnut trees.

We use the pestle by turning it after every hit, in such a way as to cross the imprints left on the layer, beating it everywhere equally.

When we begin a wall, we put at one end of the formwork, a closure of two boards joined with bars *(to prevent spillage and allow for full compaction)*. The other extremityis finished to a 60° slope. This is done to link the first section to the one that follows.

The first section finished, we dismantle the box to place it right next to it in such way that the formwork entirely surrounds the sloped area that ends the first one. We follow the same methods back and forth along the wall…

[…] When the rammed earth walls are finished, they need to dry for a time, the period dependent on the temperatures of the country and of the season, before being coated with a render, whether of plaster *(of Paris)* or mortar.

Even though rammed earth is made with just barely moist soil, whilst adobe blocks are kneaded with straw and water, it is important to be careful and remember the observation of Vitruvius about not applying a coating to a wall built this way before being certain it is dry. Rammed earth made during high temperatures is soon dry on the exterior but humidity will remain present to the interior, from whence it will escape slowly to the surface. If this surface has a coating, this will detach, the water being trapped between the surface and the coating. One should not be scared to let the rammed earth dry when it is done well, because the drier it is, the better the

coating will stick to it. I saw, in the region of l'Isère, very old houses, built of rammed earth, that had never been coated/rendered/limewashed but had nevertheless been resistant to all types of weather.
My advice to those who wish to use this cheap building method would be to consult the books of Cointeraux, Professor of rural architecture, who studied this type of construction with great zeal and success. He has published several books with infinite interesting detail essential to success. However, as I had the opportunity to run *(projects with rammed earth)*, I will conclude indication of the method which has suitsed me perfectly and which tends to give the rammed earth more tenacity.

The alterations I was in charge of to the castle before-mentioned, were to the main building, raised two stories and an attic. The soil I had to use was, to my knowledge. a bit dry and of mediocre quality. To compensate for these inadequacies, after beating it in the normal way and stirring it with a rake, I **moistened it with milk of lime instead of pure water**. This simple method produced a rammed earth with more firmness and consistency than the one made with good soil. Its surfaces were so hard and smooth that we did without any coatings on this and several other buildings. We only whitewashed the surfaces with lime. As to the main building, the walls were covered with a mortar layer made of lime and sand *(plaster)* because it was next to the castle's apartments and seeing it, we would have never guessed that it was a construction in earth.
It is clear that with this method, we could use adobe blocks as the ancients did it, which would have more consistency and solidity.
[…].

Martin M E (1829) The Art of the Mason L'encyclopédie populaire ou les sciences, les arts et les métiers, Paris, Audot éditeur.

<u>Batifodage</u>
We often substitute for the plaster, for economy, or for obtaining a lighter and warmer plaster *(enduit)*, **heavy soil, kneaded with care, mixed with a certain quantity of hair *(bourre)* and if we want, a fifth of old slaked lime.**

P 104 This mix we call batifodage can be used as a plaster for walls and ceilings, we give a white colour with white of Spain (fine crushed chalk) wetted with strong size. (eau de colle forte).

P113 **Rammed earth construction**

The construction of rammed earth being of the greatest importance in some regions, we believe it useful to understand the method, particularly today, with woods becoming rare and stone and brick often being materials too expensive in certain areas and particularly for rural construction.

If the art of rammed earth construction was practiced with the same care as in Lyon and in the Dauphiné, we would not doubt the number of healthy and suitable dwellings would multiply more quickly and the working classes would find it a great benefit.
This method of building was introduced into areas lacking in stone where previously we were using wood instead, and this circumstance hopefully would permit that such a useful way to build be introduced in other regions, where, due to the scarcity and

the high price of materials, the poor citizen has to live in unhealthy and poorly roofed cottages.

We give the name of rammed earth to a construction in which masses of natural soil, made compact and hard through particular handling, are placed one along the other and one on top of the other to form the entire thickness of the walls as stones do. These masses are worked where they are placed in a type of movable mould that we remove only when the layer we have just finished has acquired all its necessary hardness.

Here how it is done: when the mould, which is a type of deep frame made of timbers, distanced by transoms, is placed where the wall has to be continued, we throw loose earth, about a foot square each time and then beat this soil very well before anymore is added.

P 115 In order that no soil will escape from the boards of the mould at the bottom, **we apply a bead of good mortar made of sand and lime, mixed**. These beads, also called *moraine* by the workers, can thus be used to see, once the wall is done, the given height of each course, or *banchée*. When raising the work, we will make sure to give the exterior side of the mould a batter, in such ways it results in a diminution of an inch for about every *toise* (old unit of measure for length = 2 m). We are certain to build rammed earth constructions on good foundations, 2 or 3 feet high to protect the rammed earth from the moisture of the ground and from the splashing of rainwater. The roof also has to be very well cared for because water would cause great damage in little time. As for the walls, we protect them with a good coating of lime and sand that we renew when necessary. With these precautions, buildings of this type have a lifespan as long as the ones in wood or rubble.

P116 In the Lyonnais and the Dauphiné, where this method of construction is very common, we see an infinity of these houses built 150 years ago that have not needed more significant nor more frequent repairs than if they would have been built in stone.
The height we can build the rammed earth without compromising its solidity is 20 feet above the foundation, and this height of two stories is enough for every need. Even though it is not usual in this construction to build the quoins in brick or ashlar, we suggest it only offers advantages and we advise this practice in every region where we would look to introduce the use of rammed earth, where it would not have been known from experience
Of the rest, the doors' openings and apertures should always be built in bricks, ashlar or wood. Bricks or ashlars are preferable as they bind perfectly with the rammed earth.

P117 The wood however, always detaches slightly and even though we paint it with oil, we obtain window frames of poor taste. The best is, when plaster is not too scarce, to lath the wood and to cover the jambs and lintels with plaster.
When we build in rammed earth, we usually do not tend to leave voids for every aperture of the building. Sometimes even, we do not put any and we simply carve them out, once the building is done, to accommodate the frames. When we have opened the space this way and we have placed masonry or wooden jambs, we wait until the building has dried well before putting a coat of plaster (enduit). Indeed, we should be careful not to trap humidity inside the walls because then, they could be susceptible to be damage by frost. Moreover the wall shrinking in its dimensions,

the dried plaster would be lifted in plaques and would fall.

P118 **Thus, the construction of rammed earth should always be done early *(in the year)* in order for it to have time to dry before the cold weather, and we should never plaster them before the moisture has come out. The plaster (crépi) with which we coat the rammed earth wall is done with a mortar of lime and sand that we prepare with care and where we only use good angular sand in the proportion of 3 parts of sand for 1 part of lime. This mortar should not be spread in water but it requires to be kneaded for a long time and be softened.**
When [...] we reach the level of a floor, we need to stop the building if this floor is only made of joists, whereas it can continue if these floor joists are carried by beams. In the latter case, after the building is done, we open the rammed earth for the spans of each beam and we install in these openings timbers 2 feet long and 1 foot wide, laid in mortar of lime and sand if it is fir tree and of plaster or earth mortar if it is oak.

P 119 The beams are then placed on pads (coussinets). We fill with bricks the part of the wall that corresponds to the extremity of the beams and the exterior part of the pad and we continue the rammed earth after that.

[...] p 120 The soil we can use for the construction of the walls is a mix of clay and sand in which the sand seems to be in greater quantity at first glance but which is, however, capable of being kneaded and moulded. Even if it is not usual to work it as the earth brick/adobe *(la terre à brique*, it needs, however, to be mixed well, because it only gets its good qualities from this method. It also needs to be rather moist to bind when it is beaten in the mould. We can make sure if a soil is good for rammed earth by packing a flared bucket with it. If it is good *(quality)*, the heap once removed from the bucket will stand the weather without crumbling *(loosing its shape)*.

1841 FARMER'S GUIDE COMPILED FOR THE USE OF SMALL FARMERS AND COTTER TENANTRY IRELAND.

The cottage walls should be built of stone, either dry or with mortar, the crevices in the former case being well filled with moss, or dry peat mould, and both outside and inside carefully pointed with mortar. The inside should never be without whitewashing, at least once a-year. This is of consequence on the score of health, and also makes your rooms lighter, giving a cheerful appearance even in the gloomiest weather; and there is a decency and propriety in a nicely whitewashed apartment, however homely the furniture, that is always pleasing. The floors may be of earth or, clay, well mixed with sand and lime, and beaten hard and smooth, and raised from eight inches to a foot above the level of the ground outside; the roofing ought to consist of beams and rafters laid properly on the walls, and the thatch may be of heath, bent, fern, or straw, and should be well laid on, at least one foot in thickness. Fern and heath make a durable thatch, either singly or mingled with straw; but the best of all roofing is slate, whether for the palace or the cottage.

Doyle M (1844) Cyclopedia of Practical Husbandry, Rural Affairs in General. London

Stones and bricks are often too scarce and expensive for the poorer classes of farmers and labourers; but happily for them, **clay walls, if properly constructed, and well plastered and dashed on the outside with lime-mortar, are cheap, durable, and warm**. The mode of preparing mud wails is as follows:

A sufficient quantity of cohesive clay, free from any stones, being collected, the labourer digs it thoroughly, and renders it as fine as possible; when well saturated with water, he works it with his shovel until it acquires the consistence and toughness of dough.

After lying eight or ten days, it should be again wetted sufficiently for use, and a small quantity of sound chopped straw (for if this be long and stringy, the surface of the wall will not be easily dressed and polished afterwards) is to be intermixed through the mass. The foundations of the walls are best laid with stone, or brick, two feet or more in depth, and two feet in thickness. On these, the mortar, being sufficiently turned and worked, should be placed in courses of two or two and a half feet in height. At this level it has been recommended by a recent writer, who himself attached great importance to the invention, to bed into the mortar at the angles, single or double ties or braces, of any timber, provided its scantling be not less than two inches and a half, and to pin them into the walls with pegs about nine inches long.

…Before the winter rains set in, the roof should be put on with double collars, and thatched with a considerably projecting eave, for the protection of the walls: walls left unthatched, soon become materially injured. Common farm-labourers are in many places very expert in building these walls, and smoothing them at both sides perfectly with spades. If the plastering and dashing, or either, be carefully preserved on the outside, such walls will last for a long series of years. The floor should be laid on a stone foundation, as well as the partition walls, and covered with tiles, bricks, or clay and lime mortar, well tempered and evenly laid.

In many parts of England walls of mud and straw are used about the farmer's house and yard, with a thatched eve; they last some time, if not exposed to severe frost, which soon crumbles them away; at best they are not very durable, and are much less permanent than wooden walls or paling, where timber is abundant and cheap.

Loudon J C (1846) edited by Loudon J W. An Encyclopaedia of Cottage, Farm and Villa Architecture and Furniture London Longman, Brown, Green and Longmans

Design IV. — A Dwelling for a Man and his Wife, without Children.

57. Construction, The walls of this cottage are here shown eighteen inches thick, with a view to their being built of rubble stone (stones rough from the quarry) ; of pise (to be described hereafter) ; of mud blocks (which is nearly the same thing as build ing in pise) ; or of compressed blocks of common earth (also described hereafter).

Design V. — A Dwelling for a Man and his Wife with Two or more Children, with a Cow-house and Pigsty. 61. Accommodation. This is a simple, economical, and comfortable dwelling, without pretensions either to ornament or style. It contains an entrance lobby, a ; kitchen, b ; back kitchen, c ; children's bed-room, d ; bed-room for the father and mother, and the infant children, e; tool house,/; pantry, g; place for fuel, h ; privy, i; cow-house, k ; and dairy, I. There is a yard behind the house containing a pigsty and the manure well. This yard is entered from the back kitchen, c ; and also by doors in its boundary fence, m. 62. Construction. The walls may be of stone, brick, or earth ; the two former materials will not only be found more suitable in reality, but more satisfactory to the eye ; for walls of earth, when not whitewashed, have always a mean appearance, from the inferiority of the material ; and when whitewashed, this meanness, though concealed, is still known to exist; for no building was ever whitewashed, but for the purpose of concealing something, and every one must feel, with Wood, that the grandeur or the beauty of any building is never heightened by this operation. " The world in general," says this philosophical artist, " is exceedingly unwilling to acknowledge beauty of form when the material is bad ; and, on the other hand, where the materials are good, it is ready to praise the form also ; the one is a much more obvious and indisputable merit than the other." {Letters, SfC. Vol. II. p. 96.) Where white washing or lime-washing a building, with any colour, contributes to the preservation of the wall, it is justifiable ; but no genuine lover of truth will ever admit that this operation can add to the beauty or character of a building. The idea which it conveys of the neatness and cleanliness of the inhabitant is its principal recommendation ; and yet it is a fact, that where lime-washing is most employed, as in Wales and Scotland, the interiors of the cottages are less orderly and clean, than in the unwhitened mud and rough stone cottages of England.

158. Construction. The great art in building an economical cottage, is to employ the kind of materials and labour which are cheapest in the given locality. In almost every part of the world the cheapest article of which the walls can be made, will be found to be the earth on which the cottage stands, and to make good walls from this earth is the principal art of the rustic or primitive builder. Soils, with reference to building, may be divided into two classes : clays, loams, and all such soils as can neither be called gravels nor sands ; and sands and gravels. The former, whether they are stiff or free, rich or poor, mixed with stones, or free from stones, may be formed into walls in one of the three modes already mentioned, viz., in the pise manner, by lumps moulded in boxes, and by compressed blocks. Sandy and gravelly soils may always be made into excellent walls, by forming a frame of boards, leaving a space between the boards of the intended thickness of the wall, and filling this with gravel mixed with lime mortar ; or, if this cannot be got, with mortar made of clay and straw.

In all cases when walls, either of this class or of the former, are built, the foundations should be of stone or brick, and they should be carried up at least a foot above the upper surface of the platform. In the course of this work, we shall describe all the various methods of building earthern walls, and we shall here commence by giving one of the simplest modes of con struction, from the work of a very excellent and highly estimable individual, Mr. Denson, of Waterbeach, Cambridgeshire, the author of The Peasant's Voice, who built his own cottage in the manner described below.

159. Mode of building the Mud Walls of Cottages in Cambridgeshire. After a labourer has dug a sufficient quantity of clay for his purpose, he works it up with

straw; he is then provided with a frame eighteen inches in length, six deep, and from nine to twelve inches in diameter. In this frame he forms his lumps, in the same manner that a brickmaker forms his bricks; they are then packed up to dry by the weather; that done, they are fit for use, as a substitute for bricks. On laying the foundation of a cottage, a few layers of bricks are necessary, to prevent the lumps from contracting a damp from the earth. The fire-place is lined, and the oven is built with bricks. I have known cottagers, where they could get the grant of a piece of ground to build on for themselves, erect a cottage of this description at a cost of from £15 to £30. I examined one that was nearly completed, of a superior order; it contained two good lower rooms and a chamber, and was neatly thatched with straw. It is a warm, firm, and comfortable building; far superior to the one I live in; and my opinion is, that it will last for centuries. The lumps are laid with mortar, they are then plastered, and on the outside once rough cast, which is done by throwing a mixture of water, lime, and small stones against the walls before the plaster is dry, which gives them a very handsome appearance. The cottage I examined, cost £33, and took nearly one thousand lumps to complete it. I believe a labourer will make that number in two days: the roofs of cottages of this description are precisely the same as when built with bricks, or with a wooden frame. Cow house sheds, garden walls, and partition fences, are formed with the same materials; but in all cases the tops are covered with straw, which the thatchers perform in a very neat manner. — Denson's Peasant's Voice, p. 31.

Design XXIX. — A Cottage Dwelling of Three Rooms, with various Conveniences.

219. Construction. This building is well designed for having the walls executed in compressed earth, because these walls are thick, have few openings, and the dwelling is only one story high. The roof is of a low pitch, and should therefore be covered with some description of slate, tile, or metal, and not by any kind of thatch. Beneath the floors may be flues heated from a fire under the boiler in the back kitchen. The windows are shown in the French style, shutting by an air-tight joint, as exhibited in § 19G, fig. 177. The panelled pilasters on each side of the door, and at the angles, a cross section of which is given in fig. 195, to a scale of half an inch to a foot, may be finished in plaster or cement.

Design XXXIII. — Two Cottage Dwellings, under the same Roof; each having Two Rooms and other Conveniences.

258. Construction. This building having only one story, the walls may be made of earth, smoothed, and lime-whited externally ; and lathed and plastered inside. The columns of the porch may be portions of the trunks of fir or pine trees, with the bark re. moved, and the knots and other irregularities reduced. The roof may be of slate ; and, as it is of considerable span, it may be constructed as in fig. 248, with principal and, secondary rafters,

(p416) **Walls of mud**, or of compressed earth, are still more economical than those of timber; and if they were raised on brick or stone foundations, the height of a foot or eighteen inches above the ground, or above the highest point at which dung or moist straw was ever likely to be placed against them, their durability would be equal to that of marble, if properly constructed, and kept perfectly dry. The cob walls of Devonshire, which are **formed of clay and straw trodden together by oxen,** have been known to last above a century without requiring the slightest repair; and we think that there are many farmers, especially in America and

Australia (p417) who, if they knew how easily walls of this description could be built, would often avail themselves of them for various agricultural purposes. We shall therefore here describe the **Devonshire practice,** as furnished us by the Rev. W. T. Elicombe, who has himself built several houses of two stories with cob walls, in the manner which he details in the follow ing paragrap ; and who, moreover, informs us that he was born in a cob-wall parsonage, built in the reign of Elizabeth, if not a few years earlier, which was only taken down last year (1831) to be rebuilt.

839* Cob Walls, as they are called, are composed of **earth and straw mixed up with water like mortar, and well beaten and trodden together.** Chappie, in his Survey of Devon, 1785, derives cob from the British word chwup (ictus), or from the Greek kotttos (contusus), because the earth and straw ought to be well beaten or pounded together." **The earth nearest at hand is generally used, and the more loamy the more suitable it is considered for the purpose.** These walls are made two feet thick, and are raised upon a foundation of stonework. The higher the stonework is carried the better, as it elevates the cobwork from the moisture of the ground. **After a wall is raised to a certain height, it is allowed some weeks to settle, before more is laid on. The first rise, as it is called, is about four feet ; the next not so high ; and so every succeeding rise is diminished in height as the work advances. The solidity of cob walls depends much upon their not being hurried in the process of making them**; for, if hurried, the walls will surely be crippled; that is, they will swag, or swerve from the perpendicular. **It is usual to pare down the sides of each successive rise before another is added to it. The instrument used for this purpose is like a baker's peel (a kind of wooden shovel for taking the bread out of the oven), but the cob-parer is made of iron.** The lintels of the doors and windows, and of the cupboards or other recesses, arc put in as the work advances, (allowance being made for their settling), bedding them on cross pieces, and the walls being carried up solid. **The respective openings are cut out after the work is well settled. In Devonshire, the builders of cob-wall houses like to begin their work when the birds begin to build their nests, in order that there may be time to cover in the shell of the building before winter. The outer walls are plastered the following spring. Should the work be overtaken by winter before the roof is on, it is usual to put a temporary covering of thatch upon the walls, to protect them from the frost.**

840. **In forming cob walls, one man stands on the work to receive the cob, which is pitched up to him by a man below; the man on the work arranging it and treading it down.** Each workman generally uses a common pitchfork, though sometimes a three- pronged fork is employed. **Cob houses are considered remarkably warm and healthy; and they are generally covered with thatch.** The durability of cob is said to depend upon its having " a good hat and a good pair of shoes;" that is, a good roof and a good foundation. The Devonshire thatching is very superior to that in most other parts of England. It is done with combed wheat straw, called reed, consisting of the stiffs unbruised, and broken stalks, which have been carefully separated from the fodder straw by the thresher, and bound up in large sheaves called nitches. In this way the thatchcr is enabled to finish his work much more neatly than in other counties where no reed is made. Instead of brick nogging for partitions, cob is used for filling in the frame work, which is previously lathed with stout slit oak or hazel. This sort of work is called rab and dab.

841. Cob walls thatched are very common for garden boundaries. The trees are

trained against them by being pinned with maple hooks; but such walls in the course of time become full of holes, and afford a hiding-place for insects; they, therefore, frequently require a fresh coating of plaster.

842. In estimating the merits of cob walls, it must not be forgotten, that, when pulled down, the materials are good for nothing but as manure; whereas the materials of brick, stone, and sometimes even of timber walls may be used in rebuilding. It also deserves to be remarked, that earth or mud walls are not in use in any district of Britain which is in an advanced state of improvement; they appear to be chiefly suitable to a rude state of society, where every man is his own builder, and where mechanical skill, and good tools for working in timber and stone, are scarce. However, though they cannot be recommended for general adoption where brick and stone walls are common, yet the very circumstance of their being neglected, or not known, in such places, renders it probable that a great economy would be produced by their occasional use; on the same principle that, in a country where the common labourers live on bread and butcher's meat, one of them who should determine to subsist merely on oatmeal or potatoes would save money.

2443. Building Cottage Walls of Clay Lumps. John Curtis, Esq., of Rougham, informed us that he had built cottages, barns, and farm-yard walls, with what are called clay lumps. They are, he says, more durable than any thing except stone, very dry, and from 600 to 700 per cent cheaper than bricks. " I have built the walls of a farm-yard one foot thick with clay lumps; and, when at the desired height, made a coping for it of a frame-work of boards one inch and a half thick, and six inches wide. These, nailed together with cross pieces at every four or five feet's distance, are laid on the top of the wall, which thus forms the eaves, by projecting two inches on each side of the wall; the outer edges of the boards being beveled or sloped off to facilitate the drip of the water from the wall, similarly to a drip brick. The coping is then finished by covering it with worked clay, in the state that it is when ready for making lumps. This, with a little occasional repairs, will last for many years."

2444. To make Clay Lumps. Three loads of soft tender clay, which should be yellow, not blue, the latter being too strong, will make one hundred lumps; which, when dry, will weigh six stones, of fourteen pounds each. The three loads should be put into a heap, all large stones being carefully picked out, and soaked with as much water as the mass will absorb; then tread it with one or two horses, and, as it is trodden, mix as much short old straw as can properly be mixed with it, by adding more water as may be required. The edges of the mass should be turned into the middle of the heap from time to time; and the horses should be kept treading it till all the clay is thoroughly broken, and mixed so as to become like stiff mortar. All the secret depends on well mixing the clay with plenty of straw. It should not be made too thin. As soon as this quantity is properly prepared, men should be making it into lumps, which is done by putting sufficient clay into a mould of wood, of the following dimensions: eighteen inches long, twelve inches wide, and six inches deep, no bottom. The mould, when well filled, by the men putting in the clay with a spade, and pressing it with the foot, the top being smoothed with the back of the spade, should be lifted up, and the lump will then be left perfect. Wet the mould with a wisp of oat straw, to prevent the clay hanging to it, and place the mould about two inches from the first lump, and fill as before; then wet the mould and place it about two inches off, and proceed as before. This filling of the mould is best done on level grass ground. As soon as the lumps get a little stiff, that is, just enough to admit of handling them, they should be set on one edge, and as they dry be turned; and in

doing this, place the wet side to the sun. The rough edges must be trimmed with a spade, or any edged tool, as they become dry enough to be haled (that is, built up in rows about three feet high, one brick wide, and the lumps one or two inches apart at the ends, as new-made bricks are before they are burned), so as that the wind can pass between each lump. Winter is the best time to get the clay into heaps, that the frost may pulverise and mellow it. In March, as soon as the severe frosts are over, begin to work the clay and make the lumps, and, if the weather is favourable, they will be fit to build with in three weeks or a month.

2445. To build a Cottage, Barn, or any Building, with Clay Lumps, the foundation must be good; that is, built with brick or stone at least eighteen inches above the surface of the ground. The larger the building, the higher the foundation should be; say three feet ; and it should be two inches wider than the lumps, so that one inch of plaster may be put on each side of the wall ; the width of the walls being according to the size of the building. Of course lumps can be made to any size, according to the building in tended. The expense of building the walls (which are eighteen inches thick) is 6d. per yard; and Id. per yard, covering each side of the wall with cement, which is only common clay mixed well with very short straw, being very particular in picking out every stone, and treading it more than usual. Let it lie in the heap till the autumn, and then (in October) apply it to the walls as a coat of plaster is applied to any common wall. — J.C. Feb. ^. 1842. vol. xxxvi. p. 85).

2457. Cement Floors for Cottage Bedrooms have been strongly recommended for their durability, and as, in some degree, rendering cottages fireproof. They are common in Italy, and to be found in some parts of France and Germany, but they are comparatively rare in England. The best that we know of are at Houghton, in Norfolk, which we examined upwards of thirty years ago, and through the kindness of John Curtis, Esq., who sent us the information respecting building walls with clay lumps (§ 2443.), we are enabled to give the following account of them : —

2458. The Cement Floors at Houghton Inn, and in some of the farmhouses on the Houghton estate, are thus formed. The floor joists are laid in the same manner as if for boarding, but well stiffened by what is locally called bridging, which consists of pieces mortised into each joist…But as this mode weakens the joists by cutting into them, a better one would be, to use cross strutts in the usual manner. Some floors are first laid with reeds, so as to bear the cement on a floor of reeds; and others (which is the better way) are covered with double laths, but the ends of these laths should only just meet in the middle of the joists. The cement is then laid on, half an inch or two inches thick, and the floor must not be left by the workmen till it is quite finished, that is, they must keep beating and smoothing it over, night and day, till it is completely set, in order to prevent its cracking. This can only be done by having a swinging scaffold from the ceiling for the men to work from. The cement must be laid on directly it is made; therefore, while some persons are making it up, others must be laying it on. The cement is commonly called red plaster, which is red gypsum. It is burnt for this purpose, by making a fire with small billets of wood, and mixing small lumps of gypsum with the wood, and then covering the whole with turves to prevent the fire escaping, in the same manner as billets are covered when they are made into charcoal ; or a better way is, to grind the gypsum in the flour stones of a mill, and then bake it in an oven, before mixing it into a cement, which should be done with the iron dust which falls from a blacksmith's anvil, and not with the smithy ashes ; the scales of iron being so much harder and better for the purpose. Chalk and lime are both unfit for the purpose, though ground floors for cottages and

barns are frequently made of these materials, well beaten together. — J. C.

2461. Clay Floors, that is, floors formed of a mixture of clay and marl, were formerly a good deal used in Norfolk for barns, malt-houses, hay-lofts, cottages, &c. They are composed of clay and marl mixed with chopped straw, well trodden by horses, and mixed together in the manner clay lumps are to be made (§ 2444.) ; and, when the mixture is to be used for malt-floors, bullock's blood is added. Much of the excellence of these floors depends on the thoroughly mixing and working of the material. — W, T.

Scott Burn R (1860) Handbook of the Mechanical Arts, concerned in the construction and arrangement of dwelling houses and other buildings. Edinburgh and London William Blackwood and Sons.

(Originally prepared for the exclusive use of COLONISTS and EMIGRANTS…This second edition of broader scope)

P124 Pise, or HARD-RAMMED EARTH.

TAKING into consideration the ease with which the material is obtained, worked into its requisite form, and the durability which undoubtedly characterises it, we are certainly surprised that it should have been so sparingly adopted. **No valid objections have yet been raised against it.** It is admitted by all to be cheap, and no less efficient than cheap. Numerous examples have been carried into sheet with marked success, and abundant evidence is easily obtained to prove that it is lasting. The term " pisé " is derived from the name of the instrument with which the earth is rammed down, pisoir. The kind of earth or soil best adapted for pisé is that known as gravelly. By this term is meant a soil in which the pebbles or stones are round, not flat or angular. It is evident that in ramming the soil the packing will lie equally round the circular pebbles, while the flat or angular ones may resist the stroke of the rammer, and ward off in a measure the force of the stroke from some portion of the soil beneath them.
[most rammed earth structures in Spain have angular stone inclusions, however].

Brick earths are well adapted for pisé; but, owing to the capacity for retaining moisture, they are apt to crack, unless carefully shielded from the wet, during the process of drying the walls. All kinds of earth, however, may be used, with the exception of light poor lands, and strong clays: these, however, will do if judiciously mixed with other better-fitted soil. To show how this mixing may be most successfully carried out, a few sentences may be useful: the principle of mixing is simply to blend a light earth with a strong, a clayey with a sandy or gravelly kind. Where the best kind of soil that is gravelly cannot be obtained, small round pebbles, &c., may be mixed with it. All animal or vegetable substances that are apt (p125) soon to decay must be carefully kept out of the soil to be used. The following indications, which may be observed in order to judge of the fitness of the soil for pisé in any district, may be useful:

In digging, if the spade brings up large lumps at a time, the soil is well adapted for the work; this holds also where the soil lies on arable land in large clods, and binds

after a heavy shower and a hot sun. Where vermin holes are smooth in the inside and firm, or where the small lumps generally found in plenty in all fields are difficult to be crumbled between the fingers, the soil is good. Soil of good quality is generally found at the bottom of slopes that are in cultivation, and on the banks of rivers. In preparing the earth for building, the first operation is breaking the clods or lumps, and thereafter placing the soil in a conical heap: this form facilitates the removal of large, flat, and circular stones, which, falling to the bottom, are easily removed from the mass by means of a rake. The teeth of the rake should be placed at intervals of 1 inch or thereabouts, so that only stones exceeding this in size may be withdrawn; or what would be better and quicker, a bricklayer's sieve or "screen " might be used, having the meshes about an inch square. Where two varieties of soil are to be mixed, the operation should be done at this stage. **Enough of soil should only be prepared to last a day's working.** Care must be taken to prevent rain saturating the earth with water, as in this state it will form mere mud in the mould. It is necessary to note that the soil is in best condition for working when neither too dry nor too wet. It is very evident that less time will be lost in slightly wetting the soil, when too dry, than in waiting for it to dry should it get saturated with rain by a careless exposure. The next point we have to explain is the construction of the " mould." This should be made of clean thin planks of pine, or other light wood, well seasoned, to lessen the chances of their warping. Their thickness should be about 1 inch, well planed on both sides. The length should be from 12 to 14 feet for ordinary work; but shorter moulds, as 7 feet, will be at times useful. The depth of the mould should be 14 inches—some recommend 2 feet 9 inches; but a practical experiment, where the former depth was adopted, showed that it was more convenient than the latter…

P131

UNBURNT BRICKS.

MUCH as many may dispute the fact, it is nevertheless true, that unburnt bricks form a much drier wall than ordinary burnt bricks, inasmuch as they are not so absorbent of wet or damp. To make these, any ordinary clay will answer. If dry when obtained, it must first be moistened, and thoroughly worked by the feet of cattle, or pounded by hand. Cut some straw into pieces about 6 inches in length. After being duly mixed with the straw, the clayis ready to be made into bricks. A mould of any size must be made; a convenient size is 12 inches long, 6 inches wide, and 5 inches deep : this mould should have a bottom, but not air-tight, in order to prevent the brick from sticking in the mould. The clay is put into this mould, and the brick formed much in the same way as ordinary bricks. . Should the clay be very tenacious, a little sand sprinkled in the mould will enable the brick to leave it freely. The bricks are placed upon level ground to dry, turning them on their edges on the second day; thereafter left in piles, protected from the rain, for ten or twelve days. The foundation must be formed of stone or burnt brick; and, to prevent damp rising, a course of slates should be laid above the footings in hydraulic cement. The walls formed of these bricks will be exactly 12 inches in thickness—that is, the length of the mould; the partitions are formed by laying the bricks length- wise, thus giving a thickness of 6 inches, the breadth of the mould. To obtain the necessary bond in the walls, the work is carried up in alternate courses of headers and stretchers— —one course having the bricks laid across the wall, the next course having them side by side. A good ordinary brick mortar is to be preferred, although a weak mortar of lime and sand will do for laying the bricks. The doors and window (p132) frames

should be previously made, to be ready to insert when required. These frames should be of stout plank, the exact width of the thickness of walls—they will thus help to cover the joints and strengthen the walls. Lintels and sills of stone, when easily had, will much improve the appearance of the structure: pieces of timber 3 inches thick, width equal to thickness of walls, may be used in place of stone ; these should have a clear bearing of at least 12 inches on each side of the opening. Of whatever kind the roof is, it is essential, in this form of material for external walls, that it should be an overhanging one, in order to guard the walls from vertical rains. The outside of the walls is plastered with good lime mortar mixed with hair, and then with a second coat pebble dashed as in roughcast. The inside walls are finished in the usual way. A cottage may be built in this way for an in credibly small sum—warm, dry, and of course comfortable. As to its durability, it is only necessary to state, that it is by no means a difficult matter to adduce instances where such structures have existed in thorough efficiency for a great length of time; in some, for upwards of two hundred years. The method of forming the unburnt bricks will be described under the head of BRICKMAKING.

Jacques D H (1860) RuraI Architecture: Or, How to Build Country Houses and Out-BuildingsOR, HOW TO BUILD COUNTRY HOUSES AND OUT-BUILDINGS.

UNBURNT BRICK FOB BUILDING. The following particulars are compiled from the Report made by Mr. Ellsworth while Commissioner of Patents: Almost every kind of clay will answer; it is tempered **by treading it with cattle**, and cut straw is added, at the rate of two bundles of straw to clay enough for one hundred bricks. It is then ready for molding. It is found that the most economical size for the bricks for building such cottages is the following, viz., one foot long, six inches wide, and four inches thick. The cellar or foundation must be formed of stone or burnt brick. In damp soils, the dampness should be prevented from rising from the soil into the unburnt wall by laying one course of slate, or of brick, laid in cement or hydraulic mortar, at the top of the foundation. The walls of the cottage are laid up one foot in thickness of the unburnt brick. This thickness is exactly the length of the brick, or the width of two bricks, and the strongest wall is made by laying the work with alternate courses of leaders and stretchers (ie one course with the bricks laid across the wall, the next course side by side). A weak mortar of lime and sand is generally used for laying the bricks, but a good brick mortar is preferable. Where lime is scarce, a mortar composed **of three parts clay, one part sand, and two parts wood-ashes,** answers very well as a substitute for lime mortar. The division walls may be six inches thick, just the width of the brick; but when the cottage has rooms wider than twelve feet, it is better to make the first-story partitions two bricks thick. The doors and window-frames being ready to insert, the cottage is very rapidly built. These frames are made of stout plank, of the exact thickness of the walls, so that the casing inside and outside helps to strengthen the wall and covers the Joints. If lintels and sills of stone are not to be had, pieces of timber three inches thick, of the same width as the wall, and a foot longer on each side than the opening, may be used instead.

The roof may be of shingles or thatch, and it is indispensable in a cottage of unburnt clay that it should project two feet all around, so as completely to guard the walls from vertical rains. The outside of the wall is plastered with good lime mortar mixed

with hair, and then with a second coat, pebble-dashed, as in rough-cast walls. The inside of the wall is plastered and white washed in the common way. Built in the simple way of the prairies, these cottages are erected for an incredibly small sum, costing no more than log houses, while they are far more durable and agreeable in appearance. But we have also seen highly ornamental cottages built of this material, the bricks made entirely by the hands of the owner or occupant, and the whole erected at a cost of not more than one half of that paid for the same cottage built in an equally comfortable manner of wood or brick. When plastered or rough-cast on the exterior, this mode of construction presents to the eye the same effect as an ordinary stuccoed house, while it is warmer and far less costly in repairs than any other cheap material is.

Wiltshire Archives 1461/928-940. Goddards of Swindon.

Mainly comprises work books of mason/bricklayer carrying out repairs across properties in the ownership of the Goddard family, including the Goddard's Arms, which still remains.

A L Goddard Account Book with R Horsell.

April.
Repairing and whiting the house stables etc at the Mews Farm:
3 men and boy 4-11-0
14 bushels of lime 0-7-0
76lb of plaster 0-9-6
2 (?) of whiting 0-9-4
2 firkins of size and coulours 0-6-6
laths, nails and hair 0-3-6

May 4
Repairing and whitening 2 cottages, Lower Town:
Man 4 days 0-14-6
3 pails of white and size 0-4-6
2 pails of coulour 0-4-0
12 lb of plaster 0-1-6

April 2nd
Work done at Beerhouse:
2 masons 1-18-0
150 bricks
2 loads of dirt 0-4-0
2 quarters of lime 0-8-0
Man 11 ½ hours (mixing) the same 0-4-7 ½

Wall at Quarry Cottages

2 masons 10 days 2-3-2
2 labourers 6 ¾ days 0-13-6
2 loads dirt 0-4-0
2 labourers 1 day each digging foundations.

May
Laying paving in garden by greenhouse:
2 masons 5 days 8 hours 1-3-2
Labourer 3 days 0-6-0
206 feet super of banked facing 5-11-7
mortar for same 0-6-0

Building closet at cottage:
2 loads dirt
1 ½ quarters lime

June
Repairing Hall
2 masons 11 days 9 hours 2-7-7 ½
labourers 10 days 8 hours 1-1-7
8 ½ quarters lime 1-14-0
6 loads dirt 0-12-0
3 loads ashes 0-6-0

1865

Feb 10
Repairing Mr Vincent's at Hiscocks, Newport Street and lime whiting:
Man and boy 1 ¼ days 0-6-6
Cement and mortar 0-2-0
Lime white and bricks 0-2-6
200 laths 0-3-6

March 3
Man and boy 2 days 0-9-0
2 pecks cement 0-4-6
2 bushels lime 0-1-0
hair and slates 0-3-0

Bruce Allen C (1886) Cottage Building, or Hints for Improving the Dwellings of Working Men and Labourers. London Crosby, Lockwood and Co.

Gravel is the best sort of earth for this kind of walling, and it should be of a loamy nature, with a large proportion of stones. It should be used as dry as possible, no cement being required, as it is held together by the force of cohesion alone.

The foundation upon which Pise walling is to be erected is formed of stone or brickwork, rising not less than six inches or a foot above the surface of the ground, and about six inches wider than the thickness of the intended wall. It should be covered with a layer of Roman cement, stone, or tile, to prevent the rising of damp.

The foundation being completed, frames (p32) formed of planks of any convenient length are fixed by resting them on the edges of the stone or brickwork, on either side they are held together at the top and bottom by iron bolts, and kept apart at the top by pieces of wood called 'guides,' placed about three feet asunder. The Pise gravel is then thrown in, about half a bushel at a time, spread evenly, and rammed down till the surface becomes perfectly hard. The work proceeds in this way till the frame is filled to within an inch or two of the upper bolts. A portion of the wall being thus completed, the lower bolts are drawn out and the upper ones slightly loosened: the frame is then raised bodily, till the lower holes rise above.
One course may be raised upon another, as thus described, immediately it is finished; but it is found more convenient, and makes better work, to carry on the courses horizontally, and keep them of an equal height. As the work proceeds, the tops of the walls are kept dry by copings or other means; and when completed to the necessary height, the roof (which should be already framed and ready for fixing) is immediately put on and covered in.

The spaces for the doorways and windows are formed by placing partition boards, fastened to the frame-work by bolts, of the breadth of the wall and height of the frame, on either side of the space to be left vacant; and pieces of timber, two or three inches thick, shaped like truncated wedges, are then inserted, with their bases in the wall itself, and with their smaller sides touching the partition boards: to these timbers the door-posts and window-frames are afterwards fastened. If the building rises above a ground story, sleepers or plates are laid on the inner side of the walls, as in the ordinary manner, for the floor-joists to rest on, the bolts are then replaced, and, together the top of the wall with those at the top, screwed up, and the work is proceeded with as before.

*A great improvement in the Pise walling, and which would make it as durable as stone or brickwork, would be effected by forming the angles and door and window jambs of brick or stone. The solid Pise itself is found to be, when well and carefully constructed, so hard, that when struck with a hammer, the flints break rather than start from the work. Pis4 walls, if thus constructed with stone quoins, doorways, and windows, would be well adapted for churches and schools in poor localities. See Wild's 'Cottages for the Peasantiy and for Emigrants,' 8vo.

(p33) The above method of forming Pise walling is different from the mode of building common in Devonshire and the West of England, and known by the name of cob-building, as will be seen, and is greatly superior to it, and far more durable. The substance of which cob walls are made is loam or clay mixed with straw and moistened with water it is formed in; frames, in the same way as that above mentioned, but in courses of not more than one foot or one foot and a half in height it is then left some time to dry and become consolidated before a second course is imposed. The window and door frames are inserted as the work proceeds, and their respective openings cut out after the work is finished. The strength and solidity of cob walling depends much upon its not being hurried in the process of forming, and, when finished, it must be left some months to dry and settle.

Mud walls, or walls of clay lumps, are thus formed: The clay to be used is first freed from all large stones, and soaked with as much water as it will absorb; it is then well beaten, and a quantity of short old straw added, and the whole well and thoroughly

mixed up together, continued by the treading of horses, or otherwise, till the clay becomes thoroughly broken, and of about the consistence of mortar: it is then put into moulds, 18 inches long, 12 inches (p34) wide, and 6 inches deep, without a bottom, and moulded in the same manner as bricks. These lumps are then dried in the sun, and laid in the usual manner with mortar.

Transcribed by **Nigel Copsey** 2016