*Mechanic Exercises* The doctrine of handy-works ; applied to the arts of smithing, joinery, carpentry, turning, bricklayery ; to which is added, Mechanick dyalling: shewing how to draw a true sun-dyal on any given plane, however scituated ; only with the help of a straight ruler and a pair of compasses, and without any arithmetical calculation. / by Joseph Moxon.

Moxon, Joseph, 1627-1691.
London : Printed for D. Midwinter and T. Leigh..., 1703. --

Downloaded 2015 from the Hathi Trust.

*Moxon suggests that his work is the first to treat seriously of the hand-crafts and intends that it should disprove the notion that such work is to be despised and the integrity of its practitioners assumed to be weak. He seeks to assert the 'nobility' of skilled labour. It is a summary of later 17th C craft practice.*

*Of Lime*

There are two sorts, one made of stone, which is the strongest, and the other made of chalk, both sorts being burnt in a kiln.
The lime that is made from soft stone or chalk is useful for plastering of seelings, and walls or on the insides of houses, and that made of hard stone is fit for structures or buildings and for plastering without doors, or on the outside of buildings that lies in the weather, and that which is made of greasy, clammy stone is stronger than that made of poor lean stone, and that which is made of spongey stone is lighter than that made of firm, close stone that is again more commodious for plastering, this for building.

*[Moxon is here distinguishing between pure air limes and feebly hydraulic limes, both of which were being used in London at this time, although stone lime did not always indicate feeble hydraulicity - since Vitruvius, it had been felt that the stronger the limestone, the stronger the resultant lime - an idea Smeaton later debunked. The 'chalk' and 'stone' lime distinction was one made by craftsmen at the time, indicating the different properties and typical uses. Elsewhere in the country, such a clear distinction would not have been likely or possible].*

Also, very good lime may be made of *millstone,* not coarse and sandy, but fine and greasy *[ i.e., not millstone grit, a sandstone, but either Derbyshire limestone without inherent hydraulic potential or Belgian blue limestone, which may have been feebly hydraulic]*

Likewise of all kinds of flints (but they are hard to burn except in a reverbratory kiln), except those which are rolled in water, because a great part of its increase goes away by a kind of glass.

But the shells of fish, as of cockles, oysters etc are good to burn for lime.

And the fire in lime burnt, assuages not, but lies hid,so that it appears cold, but water excites it again, whereby it slakes and crumbles into a fine powder.

Lime also is useful in divers things, for tis useful in ils and wines, and good to manure land with; some season new wine with it, mitigating the unpleasantness of the wine therewith.

Moreover, quick lime being cast into an arched vault and water thrown upon it, consumes dead bodies put therein *[or, at least, makes more sterile their decomposition…].*

Also, diers and tanners use it, and likewise physicians use it, but they choose the newest, to wit, that which is newly drawn out of the kiln, and not slacked with water or air.

It will burn so vehemently that it forms crusts and will fire boards or timber against which it lies, but being slacked for sometime, it burns no more, yet warms and dries, and dissolves flesh, and being washed three or four times *[??],* it bites and eats not, but dries quickly.

Lime mixed with sand is much used in building, and Vitruvius says, that you may put **three parts of sand that is digged (or pit sand) and one part of lime to make mortar; but if the sand be taken out of a river, or out of the sea, then two parts thereof and one of lime; as also to river to sea-sand, if you put a third part of powder of tiles or brick, (to wit, tile or brick dust), it works the better.** But Vitruvius, his proportion of sand **seems too much, although he should mean the lime before it is slacked;** for one bushel of lime before it is slacked will be 5 pecks after tis slacked. *[ 4 pecks make a bushel, so expansion here is only 25%, indicating that Moxon is referring to probably moderately hydraulic lime here, not pure lime, which will more than double in volume, making Vitruvius's proportions entirely appropriate and indicating that he is referring to air limes].*

**Here at London,** where for the most part our lime is made of chalk *[but frequently of feebly hydraulic 'grey chalk'],* we put about 36 bushels of pit sand to 25 bushels of quicklime; that is about 1 bushel and a half of sand to one bushel of lime *[leading to a little less than 1:1 mortar on the volumetric expansion referred to above - 6 pecks of sand to 5 pecks of lime. Using a pure airline such a ratio would lead to a mortar of more lime than sand, at least 1 1/2: 2].*

**And lime mixt with sand, and made into mortar, if it lie in a heap for two or three years, before tis used, it will be stronger and better, and the reason of so many insufficient buildings, is the using of the mortar as soon as it is made, as Agricola saith.** *[the insufficiency is unlikely to have been for this reason, it should be said, but recent research indicates that hot mixed mortars laid down improve in strength but at the expense of some of their larger pores (Viega et al 2014)].*

Moreover there is other mortar, used in making of water-courses and cisterns, fishponds etc, which is very hard and durable, as may be seen at Rome, as this day, which is called Maltha, from a kind of bitumen dug there; for as they build most firm walls thereof naturally, so they use it in making of cisterns to hold water, and all manner of water-works, and also in finishing or plastering of fronts to represent stone.

*[a discussion of ancient glues and of 'metalists' which included quicklime…]*

…In latter times, two kinds of cement are in use, in both of which they use the powder of marble, or other stone, to one is added the whites of eggs, to the other is added pitch…

Another material which bricklayers use are laths, which are made of **heart of oak**, **for outside work,** as tiling and plastering, and of **fir for inside plastering and pantile lathing;** their usual lengths being 5 foot and 4 foot, and sometimes longer or shorter; their breadth sometimes 2 inches, and 1 1/2 inches; their thickness about 1/4 inch or thicker. But for pantiling the laths are about 10 foot long, one inch and a half broad and half an inch or more thick.

*[description of nails and of oak tile-pins]*

They also put Ox or cow hair into the mortar which they use for plastering, being called lime and hair, which hair keeps the plaster from cracking or chapping, and makes it hold or bind together.

**And whereas they make use of the sharpest sand they can get 9that being best) for mortar to lay bricks and tiles in, so they choose a fat loamy or greasy sand for inside plastering, by reason it sticks together and is not so subject to fall asunder when they lay it on seelings and walls.**

*[naming and descriptions of bricklaying, tiling and plastering tools, which gives some insight in methods of working also:]*

a Striker, which is only a piece of lath about 10 inches long, with which they strike or cut off the mortar at the britches of the tiles…

A setting trowel, being less than the laying trowel, with which they **finish the plastering when it is almost dry, either by towelling or brushing it over with fair water, or else by laying a thin coat of fine stuff made of clean lime and mixed with hair without any sand, and setting it, that is to say, towelling and brushing it.**

Brushes of three sorts, viz a stock brush, a round brush and a pencil. With these brishes, they wet old walls before they mend them, and also brush over their new plastering when they set or finish it and moreover, white or size their plastering with them.

Floats, made of wood, with handles to them, which they **sometimes use to float seelings or walls with when they are minded to make their plastering very straight and even….Likewise, they use floats, made to fit mouldings, for the finishing of several sorts of mouldings with finishing mortar to represent stone, such as cornices, fascias, architraves etc.**

**The finishing mortar to represent stone should be made of the strongest lime and the sharpest sand you can get, which sand must be washed in a large tub, very well, till no scum or filth arise in the water, which will sometimes require to have water 5 or 6 times, when the sand is somewhat foul, and it requires to have a greater proportion of sand than the ordinary mortar, because it must be extremely beaten, which will break all the knots of lime, and by that means it will require more sand.**

**Sieves…to sift the lime and sand withal before they wet it into mortar or lime and hair** *[this would indicate previous 'dry-slaking' of coarse stuff]….*

A skreen made of boards and wyer, which performs the office of a sieve, and with which one man will skreen as much lime, mixt with sand or rubbish, as two men can with a sieve *[again indicating dry-slaking].*

*[then into building method, stressing the necessity of paper plans at the very least, if not wainscot models, of all floors and lay-outs, so that…]*

there will be no need of alterations or tearing and pulling the building to pieces after it is begun, for besides the hindrance of the procedure of work, it makes the building lame and deficient, **nothing being so well done, when tis put up, and pulled down, and set up again as if it were well done at first. Besides, it makes the workmen uneasy, to see their work, in which they have taken a great deal of pains, and used a great deal of art, to be pulled to pieces.**

The drawing of draughts is most commonly the work of a surveyor, **although there be many master workmen who will contrive a building, and draw the designs thereof, as well, and as curiously, as most surveyors; especially those workmen who understand the theoretic part of building, as well as the practik.** *[contrast Moxon's positive attitude towards craftsmen to that of most 'scientific' writers on the subject in the second half of the 19th C, such as Burrell].*

….Because the well-working and bonding of brick walls conduces very much to their strength, I will here add some necessary rules to be observed in the laying of bricks, to make the walls strong and durable:

First, That the mortar be made of well-burnt good lime, and sharp sand and that it have a due proportion of sand, that is to say, if it be very sharp, a load of sand, being about 36 bushels, is sufficient for an hundred of lime, being 25 bushels or a hundred pecks…to wit, **to one bushel of**

**quicklime, a bushel and a half of sand** *[giving a mortar 1.25: 1.5 or even 1:1 using hydraulic lime].* But if the sand be not very sharp, then you may put a greater quantity of sand, for mortar which hath its due proportion of sand is stronger than that which hath less sand in it, altho' some think otherwise.

Secondly. **When you slack the lime, take care to wet it everywhere a little, but do not over-wet it, and cover with sand every laying, or bed of lime, being about a bushel at a time, as you slack it up, that so the steam, or spirit of the lime may be kept in, and not flee away, but mix itself with the sand, which will make the mortar much stronger than if you slack all your lime first and throw on your sand altogether at last, as some use to do.**

***[Important to note that Moxon is not meaning slake the quicklime to putty, leave and add much later when cold and mature, but is counselling against the method later advocated by Burrell (1857) of slaking to a paste before quickly adding to the sand and mixing, oftentimes, at least, whilst the paste was still hot and possibly still slaking].***

Thirdly. **That you beat all your mortar with a beater three or four times over before you use it, for thereby you break all the knots of lime that go through the sieve** and incorporate the sand and lime well together, and the air which the beater forces into the mortar at every stroke conduces very much to the strength thereof *[Moxon is encouraging the removal of as many 'lime lumps' as possible from the mortar. Beating might, however, be seen rather to reduce the entrained air content and reduce the size of the pores…which would increase compressive strength, as he implies, but not for the reason he imagines. It may reduce its durability in face of severe frost or salt. The heat may mitigate this effect, however].*

If I might advise anyone that is minded to build well, or use strong mortar for repairs, **I would have them beat the mortar well, and let it lie 2 or 3 days, and then beat it well again when tis to be used.**

Fourthly. If you lay bricks in hot, dry weather, and be it some small piece of work that you would have very strong, **dip every brick you lay, all over in a pale of water,** which will make the wall much stronger than if the bricks were laid dry; the reason why I mention a small piece of work is because it is a great deal of trouble to wet them for much work, or a whole building, and besides it makes the workmen's fingers sore; to prevent which they may throw pales of water on the wall after the bricks are laid *[this would only be possible without washing out some of the lime when hot mix was used],* as was done at the building of Physicians College in Warwick Lane, by order of the surveyor, which was the aforesaid Mr Hook, if I mistake not.

Fifthly. Cover all your walls in the summer-time, to keep them from drying too hastily, for the mortar doth not cement so strongly to the bricks when it dries hastily, as when slowly.

Sixthly. Be sure to cover them very well in the winter-time to preserve them from rain, snow and frost, which last is the enemy **to all kinds of mortar, especially to that which hath taken wet just before the frost.**

(other points about construction method and bonding)

…Tenthly. In summer-time use your mortar as soft as you can, but in the winter time pretty stiff or hard.

(descriptive account of the Act of Parliament for building in London).

Twelfthly. When you lay any timber on brickwork, as morsels for mantle-trees to lye on, or lintols over windows or templets under girders, or any other timbers, **lay them in loam, which is a great preserver of timber, for mortar eats and corrodes the timber. Likewise the joyst ends and girders which lye in the walls, must be loaded all over,** to preserve them from the corroding of

the mortar. Some workmen pitch the ends of the timber that lye in the walls to preserve them from the mortar.

….There are two forms of cement which some bricklayers use in cementing of bricks for some kind of mouldings, or in cementing a block of bricks, as they call it, for the carving of scrolls or capitals or such like, etc. One is called cold Cement; the other is called hot Cement…the cold cement being accounted a Secret, is known to but few bricklayers, but the hot cement is common.

*To make the cold cement*

Take half a pound of old Cheshire cheese, pair off the rind and throw it away; cut or grate the cheese very small, and put it into a pot. Put to it about a pint of cow's milk. Let it stand all night; the next morning get the whites of 12 or 14 eggs, then take 1/2 a pound of the best, unslaked quicklime that you can get and beat it to a powder in the morter, then sift it through a fine hair sieve into a tray or bowl of wood, or into an earthen dish, to which put the cheese and milk, and stir them well together with a trowel…breaking the knots of cheese, if there be any. Then add the whites of egg and temper all well together and so use it. This cement will be a white colour, but if you would have it the colour of brick, put into it…some very fine brick dust, or Almegram *[?],* not too much but only just to colour it

*To make the hot cement*

Take one pound of rosin, 1/4 pound of bees-wax, 1/2 an ounce of fine brick dust; 1/2 an ounce of chalk dust…sift both the brick dust and chalk dust through a fine hair sieve…boil altogether in a pipkin or other vessel, about a quarter of an hour, stirring it all the while with an iron or a piece of lath…then take it off and let it stand 4 or 5 minutes, and tis fit for use.

Note. That the bricks that are to be cemented…must be made hot by the fire before you spread the cement on them and then rub them to and fro on one another, as joiners do, when they glue two boards together.