John Smeaton (1791) – a Narrative of the building and a description of the construction of the Edystone Lighthouse with stone; to which is subjoined an appendix, giving some account of the lighthouse on the Spurn Point, built upon a sand. Nicol London *(recounting works and experiments performed 1756 onwards).*

P102 Book III Chapter IV Containing experiments to ascertain a compleat composition of water cements; with their results.

On this subject, I was already apprized that **two measures of quenched or slaked lime, in the dry powder (***either air-slaked or slaked by immersion, therefore),* **mixed with one measure of Dutch Tarras, and both well beat together to the consistence of a paste, using as little water as possible, was the common composition, generally used in the construction of the best water works both in stone and brick,** and which, after being *once set (footnote: this is the term used in the application of calcareous mortar, which denotes a first step, or degree of hardening, but in this state, though it has lost its ductility, it is a very friable substance),* would afterwards become hard, without ever being completely dry, nay, that it would in time grow hard, even under water. This therefore seemed to be the kind of cement adapted to our use, and what (p103) I had yet to learn was the best materials and mode of treating and using them….

I found it commonly asserted by Masons that the harder or stronger the Limestone was, the stronger would be the Lime, but whether this maxim chiefly regarded the usual composition of lime and sand in common buildings…or whether it also held good in Tarras Mortar, did not appear. It was also generally agreed by masons, that mortar, if mixed up with salt water, would never harden in so great a degree, as the same composition would do if made up with fresh water [*Smeaton will later disprove both of these assertions)*….

169. The first object of enquiry, as I had heard much complaint from the workmen of limes not being well burnt, was, whether good or bad burning affected the quality, or the quantity of the lime produced from a given quantity of stone, or both….

I therefore tried a quantity of powder-lime that had fallen from a stone imperfectly burnt, and an equal quantity of lime from one that was thoroughly burnt, and having in other respects treated them in the same manner, **both with sea water and fresh,** I found the former to work **somewhat more harsh,** but that ultimately **there was no material difference in the quality of the mortar,** and from hence I (concluded)…that the complaints of workmen on this head were rather founded upon the *great waste and small produce* from imperfectly burnt lime, than from a real difference in the quality of what is produced.

P104 (Method in these tests:) I took as much of the ingredients as would ultimately form a ball of about two inches diameter – this ball, lying upon a plate till it was set and would not yield to the pressure of the fingers, was then put into a flat pot filled with water, so as to be covered by the water, and what happened to the ball in this state was the *criterion* by which I judged of the validity of the composition for our purposes. (worked the lime to a 'tough but pretty soft paste', afterwards adding the tarras).

(similar balls of just lime and sand would dissolve under water. Some 2:1 lime: tarras also failed under water. Only 1:1 was entirely reliable in its hardening).

Questions:

Question 1st. What difference in the effect results from lime burnt from stones of different qualities, in point of hardness?

(P105) Chalk lime is generally considered by workmen as the weakest of all, and it is accounted for in general, by its being burnt from one of the softest of all limestones. The marble rocks near Plymouth are of so hard a nature that the stone obtained from them to be burnt to lime (**and which is the common lime of that country)** is…blasted off with gunpowder. From observations of the buildings about Plymouth that had been constructed with this lime, at different periods of time, it appeared to me **to be very nearly of the same nature with chalk lime,** not only being of the brightest white, but of the same weak, crumbly nature. I therefore made a couple of balls of tarras mortar of each sort of lime in the above stated proportions of two to one, and also equal parts, and the result of several trials…was that there **was no apparent difference in the strength thereof for the purpose of water building** (footnote – *confirming Higgins' 1780 conclusions)*. Hence it appeared, as the effect of the two limes was the same, that **the strength of the lime** must **depend upon some other quality than the hardness of the stone.**

Question 2nd. What difference results in the strength of the mortar when made up with *fresh* or with *Sea Water,* the compositions being immersed in the same water?

(Balls as before, immersed in fresh water)…the result was that as to what happened immediately, or within the compass of a few days, **there was no apparent difference,** but of the balls which remained entire, when kept under water for two or three months, **those made up with sea water appeared, if there was any difference to have the preference.** Hence I concluded, there was no need to burden ourselves with carrying out fresh water to the Edystone for making the mortar, and in consequence all future trials, except as otherwise mentioned, were carried out with salt water.

Question 3rd. What difference results from different *Qualities* of Limestone, so far as I could procure the specimens?

Having heard of a lime produced from a stone found at Aberthaw…that had the same qualities of setting in water as Terras…(acquired some and burnt it into lime). I found it to require a good deal of fire to make it, by quenching, fall into a fine powder. This stone, before burning, was of a very even, but dead sky blue…but when burnt and sifted, it was of a bright buff colour. Having made up a couple of balls according to each of the former proportions, and also a couple of balls with common lime (Plymouth lime), the difference of hardness after 24 hours was very remarkable, the composition of two measures of Aberthaw to one of Tarras, considerably exceeded in hardness that of common lime and Tarras, in equal parts; the composition of Aberthaw and Tarras in equal parts was still considerably harder, and this difference was more apparent, the longer the compositions were kept.

(because re-tempering would be desirable out on the rock… and because) of a notion entertained by workmen, respecting Tarras mortar, that the longer it was kept and the oftener it was beaten over, the stronger it would set…

Question 4th Whether Tarras mortar, after having been once well beaten, becomes better by being repeatedly beaten over again?

(p106) …I made up a couple of balls of Abethaw lime (in same proportions as above)…and laid them in a damp place upon a water soaken brick, sprinkled them with water, and covered them up with a wet cloth, so that they might be as slow as possible in setting. These I broke down and beat over again, every morning and night for three days and then prepared a couple of balls of the same materials afresh, and beat them very well. These balls were, when set, put altogether in salt water. Between these, where the composition was equal parts, **there was *no discernable* difference,** but of those in which the lime predominated, the **preference seemed due to such as had had the repeated beatings, though the difference was not very remarkable**. The same experiments being tried with **common lime** the preference was evidently **more in favour of repeated beatings** in that composition in which the lime predominated than that of equal quantities.
Hence, **though the practice of workmen is very right, where common lime and the smaller quantity of tarras…are used, yet where the tarras is not spared, and the lime is of superior quality, the repetition of beatings appears not to be material.**

(so for Edystone Smeaton chose to go with 1:1 Aberthaw and Tarras to save labour time in re-tempering. NB Smeaton is in pursuit of maximum hardness. He does not enquire if the mortars need to be this hard).

173. I had heard that *Shell Lime*, that is *Cockle* or other shells burnt, set very hard and made an excellent mortar for under-drawing and inside work. It is mentioned in Wren's Parantalia as having been made use of in St Paul's Cathedral for this purpose, and found excellent. On trying some of the mortar I found it to set hard, and readily, without any admixture of sand, tarras or other matter. In short, for water work tarras scarcely appeared to improve its natural quality. On being put into water, **after it was set,** it did not dissolve, but did not acquire an additional hardness, on the contrary, by degrees it macerated and dissolved, not internally, but gradually from the surface inwards, and hence I concluded it totally unfit for our use. I was afterwards informed, that a part of Ramsgate Pier had been done with this kind of lime, but was afterwards obliged to be taken up, on its dissolving quality in sea water being discovered.

174. Having observed how speedily Plaster of Paris, from a semi-fluid state would set into a hard substance, I conceived it might probably be of some use in our work. On making up a ball as I did with the mortars, but without beating, it readily set, and did not dissolve on putting it into water, but I soon found that, whilst in a moist state, it had little firmness, and did not acquire any additional hardness underwater and by continuance it became less firm…(and) re-disolved, either throughout its substance or by maceration of its surface, like the shell lime (footnote: I am lately told that Plaster of Paris is liable to be perfectly dissolved in a large quantity of water, if suffered to remain in it for a length of

time, and especially if the water is frequently changed or much agitated). …However, the great readiness wherewith I observed plaster to set to a moderate degree of firmness, suggested to me this thought, which afterwards proved to be useful, that when there was not time for our cement to set before it was subjected to the violence of the sea, if it was coated over with plaster, it might thereby be defended till it had time to set, and then, if the plaster should be washed off, it would be of no consequence.

175. The last species of lime I had an opportunity of trying…was a kind that was much commended for water works, (from)…Devon, (p107) at a place called Bridistow…its appearance, both before and after burning, was much like that of Aberthaw, and on a similar trial it answered pretty much in the same manner, but the composition formed with it appeared to be somewhat inferior in hardness.

(Asked, if the hardness of the limestone not the cause of harder limes able to set under water, then what was the reason? Took advice on analysing stones. Burned out lime with aqua fortis)

…if from the solution little or no sediment drops, it may be accounted a *pure* limestone…as containing no uncalcareous matter, but if from the solution a quantity of matter is deposited in the form of mud, this indicates a quantity of uncalcareous matter in its composition.

(Both Chalk and Plymouth limestone left no residue)…. On trying Aberthaw lime in this way, it was dissolved in the aqua forte but the solution appeared very dark and muddy and…I found a small quantity of undissolved sandy particles at the bottom, some of them transparent like crystals, but mostly very minute, and of a dirty appearance…(weighing) nearly one-eighth part of the original mass (12.5%).

P108

179. …I was convinced that the most pure a limestone was not the best for making mortar, *especially* for building in water, and this brought to my mind a maxim I had heard from workmen, that the best lime for the *Land* was seldom the best for *Building* purposes, of which the reason now appeared, which was, that the most pure lime afforded the greatest quantity of Lime Salts, or impregnation, would best answer the purposes of *Agriculture,* whereas, for some reason or other, when a limestone is intimately mixed with a proportion of *Clay,* which by burning is converted into *Brick,* it is made to act more strongly as a cement. (footnote: It is not to be wondered at**, that workmen generally prefer the more pure limes for building in the *Air*, because being unmixed with an uncalcareous matter, they fall into the finest powder, and make the finest paste, which will, of course, receive the greatest quantity of sand (generally the cheapest material) into its composition, without losing its toughness beyond a certain degree, and requires the least labour to bring it to the desired consistence, hence mortar made of such lime, is the least expensive, and in *dry work* the difference of hardness, compared with others, is less apparent).**
This suggested to me…that **an admixture of Clay in the composition of limestone…might be the most certain index of the validity of a limestone for**

Aquatic Buildings, nor has any experience since contradicted it, as all the limestones in repute for waterworks, that I have met with, have afforded this mark, even the Dorking lime much esteemed for these uses in London, and in the country round about, is plainly nothing but a species of chalk, impregnated with clay, of which it makes one full seventeenth (5.8%) part of its original weight.

180. Having thus satisfied myself in repsect to limestone, that, if I had not arrived at the best in the world, I had found one competently good…for the Edystone Lghthouse, I considered that though Tarras was really endowed with those qualities which had justly obtained it a reputation for water building, yet it was generally admitted to have some properties, that for our use were not quite so eligible – in the first place, **though it will cause most kinds of lime to set and become hard *under* water…yet if the Cement grows dry by a gradual exposure to air, it never sets into a substance so hard as if the same lime had been mixed with good clean common sand, but is very friable and crumbly and if, after it has acquired a considerable degree of hardness by immersion in water, it is then exposed to the air, it *loses* a considerable part of its firmness, and also becomes crumbly…**For this reason, though there is **no necessity for using it where the work will *always* be dry, or subjected only to the rain, and though it may be considered as being always wet, where it is in the joints of a massive work immersed every tide, yet in our case, those parts which were above the ordinary swell of the tide and sea, and liable to be wet only in storms, and hard gales of wind…being wet and dry by intervals, tarras is known not to answer well….**In parts so circumstanced, the mortar is the most liable to fail, and to be affected by the frosts, whatever its composition may be, has put artificers upon trying other mixtures, one of the principal of which was communicated to me by Lord Macclesfield:

(Letter in footnote from Lord Macclesfield: …the lime generally made use of in our neighbourhood is made from chalk…The manner of making (ash) mortar is as follows:

Take of lime that is *very fresh* two bushels and take wood ashes three bushels. Lay the ashes in a round trench, and the lime in the middle of the trench, then slake the lime and mix it well with the ashes. Let it lie until it is cold, and then beat it well together and so beat it for three or four times before it is used….Mortar thus made is reckoned, by our bricklayers, to be much more strong than that prepared with Tarras in places that are at sometimes wet and at others dry, though they acknowledge that the terras mortar is better in work that is constantly under water…

(discusses the tendency for stalactites to grow from Trass mortars, which prompted him to look at alternatives) said to be useful in making calcareous mortar to set in water….Terra Puzzolana (being one)…found in Italy. (he got some imported for Westminster Bridge, where they ended up using Trass).

182. On trial of this I found it to be **in every respect equal to terras**, as far as concerned hardening of water mortar, **if not preferable to it….I perceived it in every state of it (**wet, moist or perfectly dry), if made into a mortar with Aberthaw lime, **it exceeded in hardness any of the compositions commonly used in dry work, and in *wet* or *dry,* or wholly wet, was far superior than any I**

had ever seen or experienced….I did not doubt but to make a cement that would equal the best *mechantable Portland Stone* in solidity and durability.

P110 (Turns his thoughts to grout, to fill perpends in the stones of the lighthouse) to consolidate the upright joints by pouring in liquid mortar, commonly called *Grout* in so fluid a state, as to run into every cavity and crevice. **The common way *then in use* of doing this was, by putting as much slaked lime into water, as when stirred would be sufficiently fluid to answer the end, which is called *puttying*. And the best practice was to put the ingredients together according to the due proportion to make the species of mortar intended, and with as much water as would render them fluid, and after *stirring them well together to pour the mixture into the joints*.**

(concerned that this allowed no beating of the mortar, shown to make mortars stronger, so)

184. (experiment entailing making of mortar balls, allowing them the set and then beating again with an excess of water. This apparently set hard, setting slower than 'undissolved' liquid mortar allowed to dry and then dissolved, but that it became ultimately harder.

No mention of hot lime grout, commonly recommended in 19th C texts).

…p111

187. Seeing that both Tarras and puzzolans agreed in two of their obvious properties – **porosity and resistance to the actions of aqua forte, as well as the hardening of calcareous mortar under water,** and also as *volcanic* substances, as having passed the fire, I was induced to try experiments on several porous substances, that appeared to have some similarities to them, such as *Pumice stone, Coal Cinders, Brick and Tile Dust,* and such like. I found them all **possessed of an absorbent property, which caused the mortar made with them to set somewhat more quickly, than when made up with sand alone,** so that where hardness is expected from drying, and time is wanted to produce the effect fully, they may be useful (p112) to this end, as procuring it to be done more speedily. But being, when set, immersed in water, they **did not** appear to possess any powers of resistance to their dissolution, more than the same lime would do with common sand (??), if, by a little more time, the composition was become equally set.

188. Having made up my mind that the proper composition for our mortar was **lime of blue Lyas and Puzzulano, in equal quantities…**

(*Lias lime from Watchet, but length of journey made it prudent to import the limestone and to burn it at Mill Bay, Plymouth, he says. However, building account for Eddystone shows deliveries of 'Lime' from John Winter of Watchet*).

P114. …As nothing could succeed, or be more satisfactory, than the mortar I used…I wished to examine all those limes which discovered any degree of fitness for *Water Building,* and more especially, if possible, to find out a substitute for Tarras and Puzzulano in this kingdom, that we might be in possession of all the best materials for water building within ourselves…

The Limes that I have since examined are as follows:

193. That of *Barrow in Leicestershire*, of which we used considerable quantities in the *Calder Navigation*. I was never at the quarries, but having procured some of the unburnt stone, I found it had the appearance of blue Lyas, only somewhat of a more yellow tinge, and more of the slate kind, it **burns to a buff coloured lime,** like that of Aberthaw and Watchet , and on dissolution affords nearly 1/14th (7.2%) of its original weight of blue clay, with a minute quantity of dirty grey sand, so I have no doubt of its being the true *Lyas*, though perhaps of a less perfect composition than that bordering the Bristol Channel. It contains more clay, can be carried further and remains longer without injury, but in the actual use thereof as mortar, it does not appear to me to acquire quite so firm and stony a hardness as the blue lias of Somersetshire. **It makes, however, excellent water mortar,** if properly treated, and will very well serve in those parts of the kingdom that are more accessible to the Trent navigation, than that of the Bristol Channel.

In fact, in travelling from Glamorganshire through Monmouthshire, Gloucestershire and Warwickshire, into Leicestershire, I found such frequent instances of ordinary walls and cottages, built with stone that appeared to me to be blue Lias, the mortar also being of the same hue, that I have not a doubt, but that the curious naturalist…may be able to trace it from Aberthaw and Watchet quite to Barrow….In Bath they pave the streets with a species of Lias…and joint the paving with a mortar of the same kind of stone.

The Bath freestone is of the pure calcareous kind, and it is remarked that when it is walled with this kind of mortar, which is *frequently,* if not generally, used for the purpose, **the joints are more permanent, and resist the weather better, than the stone itself…**

From Leicestershire it appears to pass by the Vale of Belvoir into Nottinghamshire and Lincolnshire, for a species of this kind of lime is used in some of the buildings of Newark, and the Great North Road is repaired with the blue lias stone for a considerable length in the post stage between Newark and Grantham…I have not yet seen it further north than this.

194. Perhaps nothing will show that the qualities of lime for water mortar do not depend on hardness or colour, than a comparison of the white Lyas of Somerset (which though approaching a flinty hardness, has yet a chalky appearance) with what is called near Lewes, in Sussex, the *Clunch Lime*, a kind of lime in great repute for there for water works, and indeed deservedly so. This is no other than a species of chalk…it is considerably harder than common chalk…(and) heavier, and is not near so white, inclining towards a yellowish colour….(contains a yellowish clay with a small quantity of sand). Hence **the fitness of lime for water building seems neither to depend upon the hardness of the stone, the thickness of the stratum, nor the bed or matrix in which it is found, nor merely on the quantity of clay it contains, but in burning and falling down into a powder of *buff* coloured tinge, and in containing a considerable quantity of clay. I have found all the water limes to agree.** Of this kind I esteem the lime from *Dorking in Surrey* to be; which is brought to London under the idea of its being burnt from a *stone* and in consequence of

that, of its being *stronger* than **the chalk lime in common use there,** though in fact it is a chalk, and **not much harder than common chalk**…

195. There is in *Lancashire* a lime famous for water building, called *Sutton* lime…The stone itself is of a deep brown colour or hue (the lime is buff)…the goodness of the quality as water lime does not therefore consist in the colour before it is burnt…but they all agree in the colour or hue, *after* they are burnt and quenched…(on analysis 6 ¼ % brown or red clay)…so that in reality **I have seen no lime yet, proved to be good for water building, but that…(its stone) contained clay….**

P116
196. Since the above was written, I have had the opportunity of examining others of the *Water Limestones*. I find a species of lime that has been used in some of the works about *Portsmouth,* and recommended as very good for water building, **where the expence of Tarras mortar made with chalk lime could not be *afforded*.** It is called *Grey Lime*, as having been burnt from a…stone called *Grey Chalk*. This…(agreed) so nearly to the *Clunch* lime (of Lewes)…This Grey Lime goes by land carriage from the parish of *Berryton* near *Petersfield in Hampshire* to *Portsmouth*. (Similar in its character to both the Clunch and the Dorking stones and limes; less clay on analysis than the clunch, but more than the Dorking and a good water lime)

(Blue Lias from Lyme (Regis) used in the 'King's Works at Plymouth and at Ramsgate Harbour on Smeaton's recommendation)

p117.

Table (fractions changed to percentages):

Species of Limestone	Proportion of clay	Colour of this
1. Aberthaw	13%	lead colour
2. Watchet	12%	the same
3. Barrow	21%	the same
4. Long Bennington	12%	
5. Sussex Clunch	18.75%	ash colour
6. Darking	5.8%	
7. Berryton Grey Lime	8.3%	
8. Guildford	22%	
9. Sutton	18.75%	

(Tested blacksmith's scales 1:1 with lime to good effect; also iron ore 'after it had passed the fire' …) this being powdered, I found had a very good effect in water mortar, in causing it to set speedily, in preventing cracks, and finally, in hardening it. On this account it was used in the Calder Navigation, for the inside mortars of the best work, and for the face work of the subordinate parts, but its strength in hardening lime was far inferior to that of Puzzulano or of Forge Scales.

198. MINION, or iron stone burnt where it can be had in plenty, is a good succedaneum for puzzulana and tarras, and if it is made up with lias, or other

proper water lime, in equal quantities, **will make a mortar more firm and hard than common lime,** made up with the common quantity of tarras or puzzolana (and so may save cost).

199. I come now to shew the means I have used to make a given quantity of tarras, or puzzulano, produces a greater quantity of good *water mortar*, than either the composition, **where the material is sparingly used,** or that I used at the Edystone, **where nothing was spared,** that had the appearance of being of service….

Limestone …upon quenching, when fully burnt, falls freely, and will produce somewhat better than double the quantity of powder or slaked lime , in point of measure, that the burnt limestone consisted of, and this will be nearly the case, whether it is common lime or water lime. (Will reduce to half this volume when made to a paste with water).

200. The use of sand in mortar…is two-fold, 1st **to render the composition harder**, and 2ndly **to increase it in quantity,** by a material that in most situations is of far less expence, bulk for bulk than lime.
Ration has never been agreed in, yet from common experience
P119
201. The experience of ages has shewn that a considerable quantity of sand and other matter may be introduced with advantage in the making of mortar, but the proportion has never been agreed in, yet from **common experience it appears that there is scarcely any lime, but what, if well burnt, well beaten, a load, or measure of lime, will take two loads, or measures, of sand, that is, the quantity of sand that can be introduced into its composition may be equal to the lime in powder** (and one trass to two also best),,,to make the composition acquire the proposed degree of hardness *under water*.

(Then experiments with increased volumes of sand) …I found that (lime) with good beating, would take in for every two measures of slaked lime, one measure of trass, and three of clean sand (2:1:3)…

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Table of mortars, most of which (Smeaton has) used in different situations and for different circumstances.

(NB Smeaton is using quicklime already slaked to a powder, either by air or by immersion).

Water Lime with Puzzolana	lime powder	puzzolana	common sand
1. Edystone Mortar	2	2	-
2. Stone mortar	2	1	1
3. ditto, 2nd sort	2	1	2
4. Face mortar	2	1	3
5. ditto, 2nd sort	2	½	3
6. Backing mortar	2	¼	3

Water Lime with Minion minion

7. Face mortar	2	2	1
8. ditto, Calder composition	2	1	3
9. Backing mortar	2	½	3
10. ditto, 2nd sort	2	¾	
3			

Common Lime with Tarras		tarras	
11. Tarras mortar	2	1	
12. ditto, increased	2	1	1
13. ditto, increased further	2	1	2
14. ditto, increased still further	2	1	3
15. Tarras backing mortar	2	¾	3
16. 2nd sort	2	½	
3			

Common lime with minion		minion	
17. Ordinary face mortar	2	2	2
18. 2nd sort	2	1	
3			
19. ordinary backing mortar	2	½	
3			
20. 2nd sort	2	¼ or ¾	
3			

Observations on the preceding table

1st…the materials are all supposed to be in a dry state when measured
2nd That the lime is supposed to be thrown into the measure with a shovel, with some degree of force, for to put it in as light as possible, in the way to make the most measure of it, there will be want of the real quantity, and if pressed down, the measure will contain considerably more than what can be expected in purchasing the material, and the same may be said of the puzzolana, the tars and the minion.
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3rd Respecting sand, it is particularly to be noted that if in a moist state, the real quantity is considerably less under the same measure, than if dry…and as moist sand is most frequently brought for use, it is advisable that the operator should take a means of finding the difference of proportion, and allowing accordingly in measure.
4th …If the sand is not naturally a composition of fine and coarse, it should be rendered so by an admixture of different sorts….
5th the due beating of the mortar is, however, of *great* consequence…a degree of beating sufficient to give it all *possible* consistence and toughness before it is used, is in reality *indispensible* and the method I have found to answer the end in the most satisfactory way is, **to mix the due proportion of lime and the puzzolana, the tarras or the minion, together in the dry powder…put as much water to the lime as that with a shovel or beater you can bring it to a paste of moderate consistence, but rather more wet than to be properly used as a mortar in that state, then by degrees, beat in the moist sand and afterwards the dry, bringing it to a consistence by beating after every addition.** The dry sand is intended to take up the superfluous moisture, **so as to render the mortar immediately fit for use,** and if this has not brought it to a sufficient stiffness, you

may let it lie till it inclines to set, and then beat it up to the due consistence, or, if immediately wanted, you may beat in a little dry lime powder to drink up superfluous moisture (but not to neglect the beating)…

6th The customary allowance for tarras mortar beating, first and last, **is a day's work of a man for every bushel of tarras, that is, for two bushels of lime powder with one bushel of tarras….**

(Table of comparative costs of materials:)

water lime per bushel in the dry powder	0s 9d
common lime ditto	0s 4d
puzzolana in powder, prepared	3s 0d
tarras ditto	4s 0d
minion ditto	1s 0d
coarse or fine sand, or mixed	0s 2d
The labour of beating 2 bushels of common lime to terras mortar, is supposed	2s 0d
the labour of beating 2 bushels of water lime	1s 0d

Book IV Chap 1. (account of construction process)

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221. The mortar, which was compounded as shown (above)…was prepared for use by being beat in a very strong wooden bucket made for the purpose, each mortar-beater had his own bucket, which he placed upon any level part of the work, and with a kind of rammer or wooden pestle, **first beat the lime alone, about a quarter of a peck at a time, to which, when formed into a compleat, but rather thin paste with sea-water, he then gradually added the other ingredient, keeping it constantly in a degree of toughness by continuance of beating.** When a stone had been fitted and ready for setting, he whose mortar had been longest in beating came first, and the rest in order; the mason took the mortar out of the bucket, and if any was spared, he still kept on beating; if the whole was exhausted, he began upon a fresh batch…