RALEIGH REGISTER.

AND

NORTH-CAROLINA GAZETTE.

"Ours are the plans of fair, delightful Peace,
"Unwarp'd by party rage, to live like Brothers."

VOL. XXIII. FRIDAY, MARCH 15, 1822. NO. 1173.

REMARKS ON THE

PREPARATION OF MORTAR.

BY D. OLMSTED,

Professor of Chemistry and Mineralogy in the University of N. Carolina.

[Published by order of the Agricultural Society of this State.]

PRESUMING that the objects of this Society are sufficiently comprehensive to embrace all subjects appertaining to Rural Economy, I take the liberty to offer a few remarks on the preparation of Lime-Mortar, for building. I have been led to make choice of this subject, from the belief that the defective and perishable modes of building, common in many parts of our country, are owing, in no small degree, to the imperfections of the mortar employed. The correctness of most of the remarks that will be offered on the composition of mortar, I have had opportunity to verify by actual experiment. To some members of the Society, particularly those who have been much conversant with building, I must apologize for reciting facts, and giving reasons, already familiar to them. The explanations are made as plain as possible, for the sake of those who have not had opportunity to acquire the same information. If any improvements can be suggested in the ordinary modes of making mortar, it is doubtless important that they should be *generally known;* for it is only in the most expensive undertakings, and consequently in such as are of rare occurrence, that we can avail ourselves of the skill and experience of the professed architect.

The ancient Romans, who displayed their political wisdom in so many ways, regarded the preparation of mortar of such vast importance to the strength of their architectural works, and the durability of those structures which they designed for conveying to distant posterity an impression of their opulence and power, that they enacted laws to prohibit the use of bad, and to enforce the use of good mortar. Nor, as we shall see by and by, were their artisans less attentive to the subject than their legislators. And what has been the consequence? Such parts of their buildings, and other public works, as the despoiling hand of barbarians has spared, have only grown firmer and more imperishable by the lapse of two thousand years. The mortar with which their structures of stone or marble were cemented, has acquired a hardness which, in many cases, surpasses that of the materials themselves, so that the whole fabric has gained the firmness of a solid rock. Happily, Roman Authors have given us the exact details of the process by which this cement was prepared; but neither their statement, nor the examination of the article as it is found in the remnants of their works, indicates that any thing was used in its composition but lime and sand: its excellence must therefore have arisen from the quality of these materials, and the perfect manner in which they were united.

I propose to speak of the chemical principles involved in the manufacture of quicklime, and the hardening of mortar; of the qualities of good mortar; of its composition or formation; and, finally, of the preparation of hydraulic mortar, or water cement.

I. For the sake of some who may not have had opportunity to understand the nature of the changes that occur in the manufacture of quicklime, and the hardening of mortar, I may be permitted to explain the PRINCIPLES on which these changes are produced.

Limestone, before it is burnt, is a compound of quicklime and fixed air, or what is called by chemists *carbonic acid*. Some, who have never turned their attention to subjects of this kind, may find it difficult to conceive, how a species of air can make a constituent part of a body so solid as limestone. This difficulty will vanish when they reflect, that air consists of solid particles in a very minute state of division; that when it goes into union with a solid substance, as quicklime, those particles that were before separated in the form of air, are brought, by the force of attraction, so near to each other, as to be reduced into a comparatively small space. On the application of heat, these particles are expanded again to their former dimensions, and fly off from the solid in the state of air. These principles enable us to explain what takes place in the conversion of limestone into quicklime. By calcination, the fixed air, which made up forty parts in a hundred of the whole mass, is expelled. The imperfections of lime not sufficiently burnt, arise from its still retaining a portion of fixed air, the substance being partly in the state of limestone, and partly in the state of quicklime. On the other hand, when the heat is carried too high, the lime becomes partially vitrified, by which means its qualities are very much impaired. Pure limestones are not so much inclined to vitrify as those which contain foreign ingredients, such as sand, clay or iron. Limestone containing either of these substances, requires to be burnt with a lower heat, and continued longer than usual. When properly burnt, they often constitute some of the best kinds of lime, especially for water cement.

I may be pardoned for digressing here a little from the main subject, to give some rules which will enable any one to decide, whether a given mineral is limestone or not. The different kinds are exceedingly various in appearance, but may all be known by one or more simple trials. Limestone is generally of such a degree of hardness as to be readily scratched with a knife; but it is too hard to be cut like soapstone and gypsum. If a drop of any strong acid fall on limestone, it will boil or effervesce. This is the most convenient test, and is not apt to lead into error. For the acid, oil of vitriol, or aqua fortis, or muriatic acid, may be employed, one or all of which may generally be obtained of apothecaries or physicians. It may be diluted with an equal bulk of water, and kept in a small phial with a stopper of glass or beeswax. When used, the stopper may be wet by turning down the acid upon it, and then applied to the mineral. If this effervesces, we may conclude it to be limestone. A mass, say a quarter of a pound, may be put into a blacksmith's forge, and kept at a high heat for an hour. If this mass, when cold, slacks on the application of water, we may be sure that it is lime.

Every one knows that the properties of lime are greatly altered by calcination. The only point upon which it may be necessary to remark, is the strong attraction quicklime has for the fixed air that was separated from it by burning. If left entirely open to the atmosphere, it will speedily acquire nearly the whole of what it had lost, and become as unfit for mortar as powdered limestone would be; and its strength is weakened, and its properties are impaired, in proportion to the quantity of this principle absorbed. Hence, in keeping lime, and in the several operations attending the manufacture of mortar, we ought to use all possible means to prevent its combining with fixed air. Some of these means will be noticed as we proceed. In Great-Britain, it is deemed a point of so much importance to have the lime, when it is used, perfectly free from carbonic acid, or fixed air, that in the structure of the public works, at Woolwich, it is taken hot from the kiln, and used immediately afterwards. But after the mortar is made up, and applied to the purposes for which it was intended, then we no longer wish to prevent the lime from absorbing fixed air; for by this means, and by consolidating a portion of water, it returns from the state of quicklime to that of limestone, and resumes the hardness it originally possessed while in the state of massive rock. The hardening of mortar, therefore, depends chiefly on two properties—the power of absorbing fixed air from the atmosphere, and of rendering solid a portion of water. *Slow drying* also contributes very much to its ultimate hardness, and time is necessary to enable it to acquire its greatest solidity. The unrivalled hardness of the Roman cement is owing in part, no doubt, to the length of time that has been occupied in its consolidation.

II. THE QUALITIES OF GOOD MORTAR are, "to adhere readily to the substances to which it is applied; to cement them together; and to acquire by time a strong hardness." Consequently, mortar will not be good if it crack in drying, or if it be soft and brittle when dry. When a chimney, for instance, is laid with good cement, the detached parts, after some time, become united into one mass; so that the whole structure has the same firmness as it would have, were it composed of a single mass of brick or stone; and a wall plastered skilfully, will present a surface almost as firm and impenetrable as marble. On the contrary, it is obvious that a cement which does not bind the detached parts of a structure together, operates merely by filling up the crevices, while the fabric has little more stability, than what results from piling brick or stone one upon another. A wall likewise made of soft or rotten mortar, will be liable to cleave off on every agitation, or even by its own weight; or if it cracks, the aggregate strength of the wall will be feeble, compared with that which would result from the firm cohesion of all its parts. Let us enquire, then, by what means we may compose a cement, which shall possess all the good properties enumerated, without the bad.

III. What relates to the COMPOSITION OF MORTAR, comprehends, the selection of the materials—the proportions in which they are united—and the mode of incorporating them.

1. *Materials.* The essential ingredients of good mortar, it is well known, are lime and sand. But it is plain, that articles very diverse in kind and quality may be signified by these terms; and it may be useful to enquire what kind of lime, and what kind of sand, are to be selected. It is asserted by high authority, that the coloured varieties of *lime*, the blue, for instance, compose a stronger cement than the white. The latter, indeed, consists more exclusively of lime, the former being mixed with more or less iron, sand, or clay. These foreign ingredients, however, improve the quality of the mortar; but since the white lime will take a larger quantity of sand, it is generally preferred in our market. An opinion may be formed of the comparative excellence of a given specimen of white lime, by observing the force with which it slacks. Dip a small mass into water, holding it with a pair of tongs, and after it has remained a short time, lay it upon a board. If it swells, cracks, and falls into powder, with great heat, we may pronounce it to be of good quality. If it does not slack readily, with the foregoing appearances, we may infer that it has much fixed air, which it has either absorbed since its calcination, or which was never entirely separated from it during that process. We may be sure the latter is the case, when hard lumps remain after slacking. This preliminary experiment is a useful one, to enable us to judge of the strength of our lime, and to regulate the proportion of sand accordingly. The best way, where it is practicable, is to use lime recently from the kiln, or to burn it over just before it is used. In the selection of the *sand*, there is room for much care and discrimination. In all cases it should be sharp and clean, perfectly free from clay or dirt. For brick work, coarse sand is preferable, because it makes the hardest cement; for plastering, finer sand is better, because it makes the compound more plastic. Such sand as is found on the banks of rivers, or in the street, or at the bottom of hills washed by rains, is the kind intended. Sea sand contains a mixture of certain salts, which prevent mortar that is made with it from hardening, and therefore, when used, ought to be repeatedly washed with fresh water. In places, also, where sand cannot be found free from clay or dirt, it may be separated from these ingredients by washing. An appropriate apparatus has been contrived for this purpose, and various expedients may be devised to suit different circumstances. In common operations, it will be sufficient to stir up the impure sand in a tub of water: the sand will first settle to the bottom, while the other ingredients remain suspended, and may be turned off along with the water. If this be turned into a separate vessel, the impurities will, in time, fall to the bottom, and the same water may be used repeatedly.

It is the practice of many of the masons in this country to add a certain portion of clay to their mortar, or at least to select such sand as naturally contains it. This is done with a view to render the compound more plastic; or, in other words, to prevent its being *too short*. But any portion of clay does great injury to the cement by imparting to it the following properties.

1. *Such mortar contracts in drying.* This is a distinguishing property of clay, as every one knows who has ever observed the fissures that appear on the surface of clay ground which has been wet and dried. When mortar of this description is applied to brick work, a chimney for example, it shrinks as it dries, into a smaller compass, and consequently the chimney settles down, often so unequally as to distort it, to disjoin it from the house, or to produce rents in the body of it; or, when used in plastering, such mortar cracks and falls off from the laths.

2. A cement that contains much clay *will never acquire great hardness.* With this ingredient, it will indeed be more plastic, and easier to work, and will make a smoother wall than mere lime and sand; but for all the purposes of a wall, of which *strength* must be admitted to be most important, it will be far inferior to one composed of those ingredients simply. In addition to our own observations, we have the authority of *Smeaton*, the famous Engineer, who built the Edystone Light-house, for asserting, that "mortar of the best quality when mixed with only a small portion of *unburnt* clay, never acquires that hardness and dryness which, without this addition, it would speedily have attained." Clay, however, that has been *baked*, becomes a useful constituent of mortar; and it might be well worth the attention of those who live where it is very difficult to procure good sand, to make trial of brick dust. Refuse bricks would be very suitable for this purpose; and probably methods may be devised of reducing them to powder, which would render the task neither arduous nor expensive.

Next to the *materials* for mortar, we were to consider,

2. *The proportion of the ingredients.* For brick work, the proportion generally recommended is 1-5 lime, or 4 bushels of sand to 1 of lime. But in a country like this, in many parts of which lime is very dear on account of the distance to which it is transported, the fact ought to be more generally known, that *a good mortar may be made with a much smaller proportion of lime.* With clean sharp sand, one-tenth of good stone lime will answer very well; and indeed, with proper management, will compose a cement extremely hard. Masons complain, however, of its being *too short;* but this difficulty may be obviated, first, by dexterity in the use of the trowel, a dexterity which may be speedily acquired; secondly, by suffering the mortar to remain some time before it is used; and, thirdly, by incorporating the materials very thoroughly together, especially just before using. On this subject, I tried the following experiment. A cask of good stone lime, which slacked with great heat, and crumbled into a fine powder, without lumps or other impurities, was mixed, immediately after slacking, with coarse sand that was sharp and clear, in the proportion of one to nine, the lime forming one-tenth of the whole. Small beds were made up at a time, in order that the ingredients might be more effectually incorporated. As little water as possible was added, but the mass was rendered plastic by continued working with a hoe. As fast as the beds were made up, they were successively thrown into a pit dug in the ground three feet deep, and sufficiently capacious to contain the whole. Finally, the mortar was covered over with boards, and suffered to remain for three months. At the end of this time it was taken up, worked over anew, and used for laying bricks. After an interval of 15 months since it was applied, I have an opportunity of comparing it with such as contained one-fifth and one-seventh lime, made up in the ordinary way, and used soon after; and I find it harder than either of those. I have detailed this experiment with some minuteness, hoping that it may be useful to those who are engaged in building, but live in a place where lime is dear, to know how small a proportion of it may be made to answer the purpose; and hence that they may be induced to employ pure lime and sand, instead of clay or dirt. It is probable, indeed, that a cement might be made with these proportions, that would answer tolerably well for brick or stone work, without taking so much pains in the composition of it. But as it was my object to make the best cement possible with the least lime, it may not be amiss to review the several steps, in order to see how each part of the process conduced to my purpose.

1. The mortar was made up three months before it was wanted for use, for two reasons: one was, that the lime was on hand; if suffered to remain in the cask, its stength would be impaired by combining with more or less of fixed air. The other reason was, that the quality of mortar is essentially improved by keeping before it is applied. We are assured by one of the best authorities,* on this subject, that such mortar "not only sets sooner, but acquires a greater degree of hardness, and is less apt to crack;" and that the ancient Romans, whose mortar was so famous, "were prohibited by law from using that which was less than three years old."

2. My object being, throughout, to prevent the absorption of fixed air, the reason for slacking small parcels at a time, and stowing away the mortar as fast as it could be made up, is sufficiently obvious.

3. That as little water as possible should be used, and that the mass should be rendered plastic by *working*, is strongly recommended by experienced masons. The Greeks, we are told, deemed this point so important, that in the structure of their large buildings, they separated a mass of mortar into small parcels, contained in separate basons, and kept ten men at each; and the precept of ancient masons to their labourers was, *that they should wet their mortar with the sweat of their brow.*† The Romans also are known to have beaten their mortar with heavy machinery. Perhaps the principal reason for using but little water, is the greater probability in this case of the compound being worked more effectually.

4. The mixture was kept in a pit under ground, partly because this furnished a convenient receptacle for it, and partly because, in this situation, it was screened from the action of the air, which would affect it very little, except on the upper surface.

(Continued on fourth page.)

* Aikin's Dict. 1, 278.

† Rees' Cyclop. Art. "Mortar."