

CONTAINING A COMPLETE EXPLANATION OF THE PRINCIPLES OF SCIENCE, AS APPLIED TO EVERY BRANCH OF BUILDING: Comprising an Entire Course of Instruction for MASONS, SLATERS, BRICKLAYERS, PLUMBERS, CARPENTERS, GLAZIERS, JOINERS, and PLASTERERS, PAINTERS ; INCLUDING THE CUSTOMARY METHODS OF ESTIMATING, MEASURING, AND CHARGING J WITH TABLES. TO WHICH IS ADDED AN APPENDIX, CONTAINING AN EASY AND COMPLETE INTRODUCTION TO THE SCIENTIFIC PRINCIPLES OF GEOMETRY AND MENSURATION, SO FAR AS THOSE SCIENCES ARE APPLICABLE TO THE USEFUL ARTS. BY JOHN NICHOLSON, ESQ. CIVIL ENGINEER. ILLUSTRATED BY FIFTEEN ENGRAVINGS. LONDON : PRINTED FOR SHERWOOD, GILBERT, AND PIPER, PATERNOSTER-ROW. 1830

MORTAR. In making mortar, particular attention must be paid to the quality of the sand, and if it contain any proportion of clay or mud, or is brought from the sea-shore and contains saline particles, it must be washed in a stream of clear water till it be divested of its impurities. The necessity of the first has been clearly proved by Mr. Smeaton, who, in the course of a long and meritorious attention to his profession of an engineer, has found, that when mortar, though otherwise of the best quality, is mixed with a small proportion of unburnt clay, it never acquires that hardness which, without it, it would have attained ; and, with respect to the second, it is evident, that so long as the sand contains saline particles it cannot become hard and dry. The sharper and coarser the sand is the better for the mortar, and the less the quantity of lime to be used; and sand being the cheapest of the ingredients which compose the mortar, it is more profitable to the maker. The exact proportions of lime and sand are still undetermined ; but in general no more lime is required than is just sufficient to surround the particles of the sand, or sufficient to preserve the necessary degree of plasticity.

Mortar, in which sand forms the greater portion requires less water in its preparation, and consequently is sooner set. It is also harder and less liable to shrink in drying, because the lime, while drying, has a greater tendency to shrink than sand, which retains its original magnitude. The general proportions given by the London builders is li cwt., or 37 bushels, of lime to 2E loads of sand ; but if proper measures be taken to procure the best burnt lime and the best sand, and in tempering the materials, a greater portion of sand may be used. There is scarcely any mortar that has the lime well calcined, and the com position well beaten, but that will be found to "require two parts of sand to one part of unslacked lime ; and it is worthy of observation, that the more the mortar is beaten the less proportion of lime suffices. Many experiments have been made with a view to obtain the most useful proportion of the ingredients, and among the rest Dr. Higgins has given the following : — Lime newly stacked one part, Fine sand three parts ; and Coarse sand four parts. He also found that one-fourth of the lime of bone-ashes greatly improved the mortar, by giving it tenacity, and rendering it less liable to crack in the drying. It is best to slack the lime in small quantities as required for use, about a bushel at a time, in order to secure to the mortar such of its qualities as would evaporate were it allowed to remain slacked for a length of time. But if the mortar be slacked for any considerable time previous to being used, it should be kept covered up, and when wanted be re-beaten. If care be taken to secure it from the action of the atmosphere, it may

thus remain covered up for a considerable period without its strength being in the least affected ; and, indeed, some advantages are gained, for it sets sooner, is less liable to crack in the drying, and is harder when dry. Grout, which is a cement containing a larger proportion of water than the common mortar, is used to run into the narrow interstices and irregular courses of rubble-stone walls ; and as it is required to concrete in the course of a day, it is composed of mortar that has been a long time made and thoroughly beaten.

Mortar, composed of pure lime, sand, and water, may be employed in the linings of reservoirs and aque ducts, provided a sufficient time is allowed for it to dry before the water is let in ; but if a sufficient time is not allowed, and the water is admitted while the mortar is wet, it will soon fall to pieces. There are, however, certain ingredients which may be put into the common mortar to make it set immediately under the water ; or, if the quick lime composing the mortar contain in itself a certain portion of burnt clay, it will possess this property. For further information on this head the reader is referred to the sub-head — Plastering.

In walling, in dry weather, when the work is required to be firm, the best mortar must be used ; and the bricks must be wetted, or dipped in water, as they are laid, to cause them to adhere to the mortar, which they would not do if laid dry ; for the dry sandy nature of the brick absorbs the moisture of the mortar and prevents adhesion.

In the winter, it is very essential to keep the unfinished wall from the alternate effects of rain and frost ; for if it is exposed, the rain will penetrate into the bricks and mortar, and, by being converted into ice, expand, and burst or crumble the materials in which it is contained.

The decay of buildings, so commonly attributed to the effects of time, is, in fact, attributable to this source ; but as finished edifices have only a vertical surface, the action and counter-action of the rain and frost extend not so rapidly as in an unfinished wall, where the horizontal surface permits the rain and frost to have easy access into the body of the work. Great care, therefore, must be taken as soon as the frost or stormy weather sets in, to cover the unfinished walls, either with straw, which is the most common, or weather boarding. When weather boarding is employed, it is advisable to have a good layer of straw between the work and the boarding, and to place the boarding in the form of stone-coping, to throw the water off equally on both sides.

In all the operations of plastering, lime extensively abounds ; we shall, therefore, first offer some observations on the properties of this important article. All who have written on the subject of lime, as a cement, have endeavoured to ascertain what is the due proportion of sand for making the most perfect cement ; but with a little attention it is evident, that all prescribed rules must be so very vague and uncertain, as to be of little utility to the workman, for, besides the variation which is occasioned by a more or less degree of calcination, it is a certain fact, that some kinds of lime-stone are much more pure, and contain a much smaller proportion of sand than others ; consequently, it would be absurd to say, that

pure lime requires as small a proportion of sand, when made into mortar, as that which originally contained in itself a large proportion.

The variation thus produced, in regard to the proportion of sand, is found to be extremely great. It is, however, stated, that the best mortar which has come under examination, was formed of eleven parts of sand to one of lime : to which was added, by measure, between twice and thrice its own bulk of sand, which may be allowed to have been at least three times its quantity by weight. Supposing, therefore, that every particle of the lime had been so perfectly calcined as to be in a caustic state, there could not be less than forty-seven parts of sand to one of lime ; but it is hard to suppose, that above one hundredth part of this mass, independent of the water, consisted of pure caustic calcareous earth. From these considerations it is conceived, that it is impossible to prescribe any determinate proportion of sand to lime, as that must vary according to the nature of the lime, and other incidental circumstances, which would form an infinity of exceptions to any general rule. But it would seem, that it might be safely inferred, that the moderns in general rather err in giving too little, than in giving too much sand. It deserves, however, to be noticed, that the sand, when naturally in the lime-stone, is more intimately blended with the lime, than can possibly be ever effected by any mechanical operation ; so that it would be in vain to hope to make equally good mortar artificially from pure lime, with so small a proportion of caustic calcareous matter, as may sometimes be effected when the lime naturally contains a very large proportion of sand. Still, however, there seems to be no doubt, that if a much larger proportion of sand than is common were employed, and that more carefully and expeditiously blended and worked, the mortar would be made much more perfect, as has been proved by actual experiments.

Another circumstance, which greatly tends to vary the quality of cement, and to make a greater or smaller proportion of sand necessary, is, the mode of preparing the lime before it is beaten up into mortar. When for plaster, it is of great importance to have every particle of the lime stone slaked before worked-up, for, as smoothness of surface is the most material point, if any particles of lime be beaten-up before sufficiently slaked, the water still continuing to act on them, will cause them to expand, which will produce those excrescences on the surface of the plaster, termed blisters. Consequently, in order to obtain a perfect kind of plaster, it is absolutely necessary that the lime, before being worked, be allowed to remain a considerable time macerating or soaking in water: the same sort of process, though not absolutely required, would considerably improve the lime intended for mortar. Great care is required in the management ; the principal thing being the procuring of well-burnt lime, and allowing no more lime, before worked, than is just sufficient to macerate or soak it with the water : the best burnt lime will require the maceration of some days.

It has been almost universally admitted, that the hardest lime-stone affords the lime which will consolidate into the firmest cement ; hence, it is generally concluded, that lime made of chalk produces a much weaker cement than that made of marble, or lime-stone. It would seem, however, that, if ever this be the case, it is only incidentally, and not necessarily. In the making of mortar, other

substances are occasionally mixed with lime, which we shall here proceed to notice, and endeavour to point out their excellencies and defects.

Those commonly used, besides sand of various denominations, are powdered sand-stone, brick-dust, and sea-shells : and for forming plaster, where closeness rather than hardness is required, lime which has been slaked and kept in a dry place till it has become nearly effete, and powdered chalk, or whiting, and gypsum, in various proportions, besides hair and other materials of a similar nature. Other ingredients have been more lately recommended, such as earthy balls, slightly burnt and pounded, old mortar rubbish, powdered and sifted, and various things of the like kind, the whole of which are, in some respect or other, objectionable.