

A
TREATISE
ON
INTERNAL NAVIGATION.

EXPLAINING THE PRINCIPLES BY WHICH CANALS AND
THEIR APPENDAGES ARE LAID OUT, CONSTRU-
TED AND KEPT IN REPAIR, TOGETHER
WITH OTHER INTERESTING AND
USEFUL MATTERS CONNec-
TED WITH THE SUB-
JECT;

COMPILED FROM THE LATEST AND MOST AP-
PROVED AUTHORITIES :

TO WHICH IS ANNEXED,
THE
REPORT OF ALBERT GALLATIN
ON
ROADS AND CANALS.

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used for dragging the hoop and bag along the bottom, and for hauling the same up to the surface, when the man at the pole finds that the bag is full, he begins to pull instead of pushing by the pole; this is the employment at Woolwich of a great number of convicts, instead of their being transported. Solid matters or rocks when they happen to need excavating, below the level that the water can be drawn off to, or the ebb of the tide, seem to require all the skill and resources of the engineer.

It may not be uninteresting to the reader, to learn the opinion which was entertained by the great *Brindley*, (who is emphatically stiled the father of British canals) on the subject of the improvement of river navigations. He was the greatest enthusiast, (says *Phillips*) in favor of artificial navigations that ever existed. "Having spoken upon various circumstances of rivers before a committee of the House of Commons, in which he seemed to treat all sorts of rivers with great contempt, a member asked him for what purpose he apprehended rivers were created? Mr. *Brindley*, considering within himself a moment, replied, "To feed navigable canals," see *Inland Navigation* by *J. Phillips*, pages 113-14.

CHAP. XIV.

WATER-CEMENTS. PUZZOLANA. TARRAS. BLACK OXIDE OF IRON. IRON ORES. WOOD-ASHES. COMPACT BASALT. CENDRÉE DE TOURNAY. LORiot MORTAR. NOTE, ON WATER CEMENTS. BLACK OXIDE OF MANGANESE. MATERIALS IN THE UNITED STATES.

AS the construction of locks requires the use of mortar or cement, which will set, indurate or harden under water; a short account of *Water Cements*, may not be improper. Although a well made mortar, con-

posed merely of sand and lime, if allowed to dry, becomes impervious to water, yet if the circumstances of the building are such as to render it impracticable to keep out the water, whether fresh or salt, a sufficient length of time, the use of common mortar must be abandoned; for lime and sand, if mixed together in any proportions, and put, while soft, into water, will, in a short time fall to pieces.

Among the nations of antiquity the Romans appear to have been the only people who practised building in water, and especially in the sea, to any great extent.—The bay of Baïæ, like our fashionable watering places, was the summer resort of all the wealthy of Rome; who, not content with erecting their villas as near the shore as possible, were accustomed to construct moles, and form small islands, in the more sheltered parts of the bay, on which, for the sake of the grateful coolness, they built their summer houses and pavillions. They were enabled to build thus securely in the water by the fortunate discovery, at the neighboring town of Puteoli, of an earthy substance, which, from this circumstance, was called *pulvis puteolanus*, (powder of Puteoli)

Puteolan powder, or as it is now denominated puzzolana, is a light, porous, friable mineral, of a red colour, and is generally supposed to derive its origin from concretioned volcanic ashes, thrown out from Vesuvius, near to which mountain the town of Puteoli is situated. It seems to consist of a ferruginous clay, baked and calcined by the force of volcanic fire, and when mixed with common mortar, not only enables it to acquire a remarkable hardness in the air, but to become as firm as stone, even under water. The only preparation which puzzolana undergoes, to fit it for use, is that of pounding and sifting, by which it is reduced to a coarse powder; in this state being thoroughly beaten up with lime, either with or without sand, it forms a mass of remarkable tenacity, which speedily sets under water, and becomes at least as strong as good free-stone.

It has been before observed, that a composition of pure lime and sand alone will not harden under water,

but limes containing a portion of clay possess this property in a considerable degree, and are therefore generally used in water building. The cement used by Mr. Smeaton, in the construction of the Eddystone lighthouse, was composed of equal parts by measure of slaked Aberthaw lime and puzzolana. The peculiar difficulties of this undertaking, exposed to the utmost violence of the sea, rendered these proportions advisable; but for works that are less exposed, such as locks and basons for canals, &c. the quantity of puzzolana may be considerably diminished. A composition of this kind, which has been found very effectual, is two bushels of slaked Aberthaw lime, one bushel of puzzolana, and three of clear sand; the whole being well beaten together will yield 4.67 cubic feet of cement.

The Dutch have practised building in water to a greater extent than any other nation of modern Europe; and to them is due the discovery of a cement admirably well adapted for this purpose, and called tarras or trass.— This is nothing more than wakke, or cellular basalt, and is procured chiefly from Bockenheim, Frankfort on the Maine, and Andernach, whence it is transported down the Rhine in large quantities to Holland. This substance being, by grinding and sifting, reduced to the consistence of coarse sand, is used in the composition of mortar, with the blue argillaceous lime from the banks of the Scheldt, in the following method. They take of the quick-lime about the quantity which will be wanted during a week, and spread it in a kind of bason in a stratum of a foot thick and sprinkle it with water. It is then covered with a stratum of about the same thickness of tarras, and the whole suffered to remain for two or three days, after which it is very well mixed and beaten, and formed into a mass, which is again left for about two days; it is then taken in small quantities, as it is wanted for daily consumption, which are again beaten previous to using. Thus is composed the celebrated tarras mortar with which the mounds and other constructions for the purpose of protecting the lowlands of Holland against the sea are cemented.

Tarras is frequently used in this country, being imported from Holland for that purpose. The proportions of the materials of the tarras mortar generally used in the construction of the best water works is the same as the Dutch practise. One measure of quicklime, or two measures of slaked lime in dry powder, is mixed with one measure of tarras, and both very well beat together, to the consistence of a paste, using as little water as possible. Another kind, almost equally good, and considerably cheaper, is made of two measures of slaked lime, one of tarras, and three of coarse sand; it requires to be beaten a longer time than the foregoing, and produces three measures and a half of excellent mortar. When the building is constructed of rough irregular stones, where cavities and large joints are to be filled up with cement, the pebble mortar may be most advantageously applied; this was a favorite mode of construction among the Romans, and has been used ever since their time in those works in which a large quantity of mortar is required. Pebble mortar will be found of sufficient compactness if composed of two measures of slaked argillaceous lime, half a measure of tarras, or puzzolana, one measure of coarse sand, one of fine sand, and four of small pebbles, screened and washed.

It is only under water that tarras mortar acquires its proper hardness; for if suffered to dry by exposure to the air, it never sets into a substance so firm as if the same lime had been mixed with good clean common sand, but is very friable and crumbly. Ash mortar is reckoned to be superior for works that are sometimes wet and sometimes dry, but tarras has the advantage when constantly under water. Tarras mortar when kept always wet, and consequently in a state most favorable to its cementing principle throws out a substance something like the concretions in limestone caverns called stalactites, which substance acquires a considerable hardness, and in time becomes so exuberant as to deform the face of the walls.

Although the cellular basalt is the only kind admitted into the preparation of Dutch tarras, yet it appears from some good experiments of Morveau on the subject, that the common compact basalt, if previously calcined, will answer nearly the same purpose.

In some parts of the Low Countries coal ashes are substituted for tarras with very good effect; of which the valuable *Cendrée de Tournay* is a striking instance. The deep blue argillo-ferruginous limestone of the Scheldt is burnt in kilns with a slaty kind of pit-coal that is found in that neighborhood. When the calcination of the lime is completed, the pieces are taken out, and a considerable quantity of dust and small fragments remain at the bottom of the kiln. This refuse consisting of coal ash mixed with about one fourth of lime dust, is called the *cendrée*, and is made into a mortar with lime in the following method. About a bushel of the materials is put in any suitable vessel, and sprinkled with water just sufficient to slake the lime; another bushel is then treated in the same way, and so on till the vessel is filled. In this state it remains some weeks, and may be kept for a much longer time if covered with moist earth. A strong open trough, containing about two cubic feet, is filled about two thirds full with the cement in the above state, and by means of a heavy iron pestle, suspended at the end of an elastic pole, is well beaten for about half an hour: at the end of this time it becomes of the consistence of soft mortar, and is then laid in the shade from three to six days, according to the dryness of the air. When sufficiently dry, it is beaten again for half an hour as before, and the oftener it is beaten the better will be the cement; three or four times, however, are sufficient to reduce the cement to the consistence of an uniform smooth paste; after this period it is apt to become refractory on account of the evaporation of its water, as no more of this fluid is allowed to enter the composition than what was at first employed to slake the lime. The cement thus prepared is found to possess the singular advantage of uniting in a few minutes so firmly to brick or stone, that still

water may be immediately let in upon the work without any inconvenience, and by keeping it dry for 24 hours, it has nothing further to fear from the most rapid current.

A composition very similar to the preceding in materials, which are coal cinders and lime, though seldom prepared with any attention, is the blue mortar, commonly used in London for setting the coping of buildings, and other works much exposed to the weather.

Ash mortar is used in some parts of England. It is prepared by slaking two bushels of fresh burnt meagre lime, and mixing it accurately with three bushels of wood ashes: the mass is to lie till it is cold, and is then to be well beaten: in this state it will keep a considerable time without injury, and even with advantage, provided it is thoroughly beaten twice or thrice before it is used.

The scales, or black oxyd of iron, which are detached by hammering red hot iron, and are therefore to be procured at the forges and blacksmith's shops, have been long known as an excellent material in water cements; but we believe that Mr. Smeaton was the first person who made any accurate experiments on their efficacy, compared with other substances. The scales being pulverised and sifted, and incorporated with lime, are found to produce a cement equally powerful with puzzolana mortar, if employed in the same quantity. Induced by the success of these experiments, Mr. Smeaton substituted roasted iron ore for the scales, and found that this also gave to mortar the property of setting under water; it requires, however, to be used in greater proportions than either tarras or puzzolana; two bushels of argillaceous lime, two of iron ore, and one of sand being carefully mixed, produce 3. 22 cubic feet of cement fully equal to tarras mortar. If the common white lime is made use of, it will be advisable to employ equal quantities of all the three ingredients.

With respect to the water used in the preparation of water cements, that of rivers or ponds where it can be had easily, is to be preferred to spring water; but for

works exposed to the action of the sea, such as piers, light-houses, &c. it is usually more convenient and equally advantageous in other respects to use salt water.

Pumice stone, brick, and tile dust, are also recommended for water cements, but their only advantage seems to be an absorbent quality, which causes the mortar made with them to set sooner, and therefore acquire a greater hardness in the same time, than mortar composed of sand and lime alone, for they have no power of hardening under water.

The Lorient mortar is a composition which has acquired considerable celebrity in France, and has been employed in some large works. It was invented about 40 years ago by M. Lorient, who imagines that he has discovered the process used by the Romans. The principle of this invention consists in adding to any quantity of mortar made in the usual way with lime and sand, but prepared rather thinner than usual, a certain proportion of quick-lime, in powder. The lime powder being well incorporated with the mortar, the mass heats, and in a few minutes acquires a consistence, equal to the best Paris plaster, and is as dry at the end of two days, as an ordinary cement after several months. It also, when the ingredients are well proportioned, sets without any cracks. The quantity of lime powder to be added varies from 1-4 to 1-8 of the other materials, according to the qualities of the lime; too much burns and dries up the mass, and with too little it loses its peculiar advantages; thus the proportions, a point of the utmost importance, can only be determined by experiment. It is its speedy desiccation which rendered the Lorient mortar useful as a water cement, for under water it has only the common properties of a composition of lime and sand of equal solidity; indeed for this purpose various substances, commonly used in cements, are recommended to be added, such as brick and tile powder, and forge scales. The following is an approved receipt. One measure of bricks exactly pounded, two measures of fine river sand, old slaked lime in sufficient

quantity to make a mortar in the usual manner and sufficiently liquid to quench the lime powder which is added in about the same quantity as the pulverised brick.

NOTE.

In addition to the water-cements above mentioned the compiler takes the liberty of extracting the following, on the subject, from *The Chemical Catechism*, by Samuel Parks, F. L. S. page 425.

"Mix four parts of gray clay, six of the black oxide of manganese, and ninety of good limestone reduced to fine powder; then calcine the whole to expel the carbonic acid. When this mixture has been well calcined and cooled, it is to be worked into the consistence of a soft paste with sixty parts of washed sand. If a lump of this cement be thrown into the water it will harden immediately. Such mortar, however, may be procured at a still less expense, by mixing with common quick-lime a certain quantity of what are called the *white* iron ores, especially such as are poor in iron. These ores are chiefly composed of manganese and carbonate of lime or chalk."

That all the materials for making the different kinds of water-cements, except puzzolana, and perhaps except cellular basalt, exist in great abundance, in the United States, there cannot be a doubt; and with respect to cellular basalt, with which the Dutch make the celebrated tarras mortar, it is very probable, considering the extent of our country, and the varieties of our soil, climate and mountains, that this also may be found: but the mineralogy of the United States is yet so imperfectly known, that this, at present, must rest in conjecture. We have, however, it is believed, all the kinds of lime-stone; and the State of New-York can furnish the several varieties, from the pure white lime of the bald mountain in Washington County, to the blue argillaceous and gray ferruginous kind, commonly known in the country by the name of *bastard limestone*. It is hardly worth while to remark, that we have forge scales, or the black oxide of iron in almost any quanti-

ties ; and iron ores exist in such abundance, that it would be superfluous to designate the places where they may be found. Several of the States produce pit coal in considerable varieties ; and wood ashes are in great plenty, and of trifling value, in all parts of the country. The writer of this has, in his possession, a good specimen of the black oxide of manganese, brought from Bennington in the State of Vermont, where it is said to exist, in great quantities, and there is but little doubt, that it may also be found in various other parts of the United States. But perhaps the compact basalt would be the cheapest material for a water-cement that could be procured in the State of New-York : and we have enough of this material, in one place, to supply the United States. The well known rocks, or cliffs, called the *Pallissadoes*, which form a part of the west bank of the Hudson river, below the highlands, are entirely composed of compact basalt. This, when burnt like lime, and pulverised, communicates to the mortar with which it is mixed, the property of hardening under water. It may be pulverised by the rolling of a heavy circular stone with a horse, in the same manner as tanners grind bark ; or by the simple hydraulic machine, with which gypsum or plaster of Paris is broken into small fragments before it is ground.

Basaltes or basalt is of a gray, blue, or purplish black color, destitute of lustre or transparency, commonly presenting a texture composed of granular concretions, and is found in large masses of a regular form, generally columnar. According to *Klaproth*, it is composed of 44.5 silex, 17 alumine, 20 oxide of iron, 9.5 of lime, 2.6 of soda, and 6 manganese and water. See *Chemical Catechism* page 438.