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Limes, mortars, and cements

Curtis Alexander

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CURTIS ALEXANDER.

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Limes

Lime, calcic oxide, or quick-lime contains 40 parts of the metal calcium and 16 of oxygen, by weight, and has a specific gravity, depending on its porosity from 2.3 to 3.8. It is a white alkaline earthy substance, quite infusible and is the only oxide of calcium. It is obtained pure by heating pure calcic carbonate to full redness; which expells the carbonic anhydride.

Lime has a great affinity for water, with which it unites, with violence and evolution of heat, forming calcic hydrate.

Lime is more soluable in cold than in hot water. According to Dalton water dissolves, at 60° F. one seven hundred and seventy eighth, and at 212° F. one twelve hundred and seventeenth of its weight of lime.

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For commercial purposes common limestone, which is an impure calcic carbonate, is burned in kilns. The impurities most generally found in limestones are the following: viz. Silica, alumina, magnesia, oxide of iron and oxide of manganese and sometimes traces of the alkalies, which modify the value of the lime very greatly as a building material.

For building purposes limes are divided into three classes, viz. common, fat or rich lime, hydraulic lime, and hydraulic cement.

There are two classes of kilns used in the manufacture of lime; the intermittent or flare kilns and the perpetual or draw kilns.

The intermittent kilns are usually egg-shaped and made of rough hammered limestone without mortar. They are generally located in the side of a hill, so the kiln can be charged at the top and the fuel supplied and the burnt lime drawn at the bottom.

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The largest pieces of stone to be burnt are selected and formed into an arch, above which, the remaining stone is thrown in loosely from the top, the largest pieces first then the small until the kiln is filled. Care must be taken in forming the arch of stone which will not crack and burst with the application of heat, as they might cause the arch to give way and the charge to fall in. There is an arched entrance in the wall for supplying the kiln with fuel. A small fire is built, at first, towards the back of the furnace which advances towards the entrance as the draught increases. The degree of combustion is regulated by the opening, new fuel is added and the temperature gradually raised until the whole is brought to a state of incandescence. The fire is kept up continuously for three days and nights; the kiln is then allowed to cool and the lime is removed.
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cool each time they are discharged and of raising
the temperature again when the kiln is recharged.
The stone nearest the fire in the intermittent kiln
is liable to be injured by overburning while
that at the top is not fully burnt.
A better form of intermittent kiln has an
outer wall of stone and lined on the interior
with fire brick. The fire-place rests on a
brick arch through which there are openings
to admit air and secure the necessary draught.
Perpetual kilns are intended to secure a reg-
-ular calcination of the stone and to obviate
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and fuel are mixed in alternate layers and
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are mixed in alternate layers has a chamber in the form of an inverted frustum of a cone, from five to five and one half feet in diameter at the bottom and from nine to ten feet at the top, and thirteen to fourteen feet high. The wall of the kiln is generally pierced by three apertures for drawing the burnt lime.

Another form of kiln, belonging to the first class, has the body or upper portion of the chamber cylindrical and the lower portion an inverted conical frustum.

In all kilns of the first class the burning is started by first placing a layer of light wood at the bottom, then a layer of coal on the wood and then a layer of limestone. Layers of coal and limestone follow alternately until the kiln is filled and the stone piled up on top of the kiln. When the lime at the bottom is burnt suffi-ciently it is drawn.

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In perpetual furnace kilns: the stone in
the chamber of the kiln is calcined by the
combustion of the fuel, either wood or
coal, placed in furnaces near the bottom
of the chamber.

A furnace kiln of this class was patented
by Mr. C. D. Page of Rochester, N.Y. The cupola
is of a cylindrical form, being terminated
at top and bottom by conical frusta.

A horizontal section of the interior cupola
is of an oval or elongated form, with grates
and flues ranged along either side.

The conjugate axis of this oval on a level
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the composition of the stone. The pure limestones will stand a high degree of temperature without fusing; loosing only their carbonic acid and water. The impure stones containing much silica fuse under great heat and become more or less vitrified at a little above a red heat. In the impure limestones the heat not only drives off their carbonic acid and water but modifies their other chemical constituents. Great care is required in the calcination of limestones which contain much silica.

Different kinds of limestones should not be burnt together as those which contain silica will be over burnt when the purer varieties are properly calcined.

Moist limestone burns more readily than that which is dry on account of the aqueous vapors aiding the escape of the carbonic acid gas. Steam has been passed in kilns to help drive off the carbonic anhyd-ride but it proved to expensive.

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Limes may be classified with reference
to the amount of impurities which they
contain as follows:
Fat or common limes, the poor or meagre limes,
the hydraulic limes, and the hydraulic cements.
Fat or common limes contain less than 10 per cent
in all of silica, alumina, magnesia, iron and
manganese, and on the addition of water slake
to a paste, the volume of which is from two
to three and one half times that of the original
mass. It is soluable in water with the except-
-ion of a portion of the impurities mentioned
above. It will not harden under water
or in damp places excluded from the air,
but will harden in the air by gradually
absorbing carbonic anhydride from the air
forming carbonate of lime. The paste of fat
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The poor or meagre limes contain silica in the
shape of sand with other impurities mentioned
above, in amounts varying from .10 to .25 of the

whole. They slake sluggishly and seldom pro-
-duce a homogeneous powder. They evolve less hot vapors and increase much less in volume than the rich limes. They do not harden under water and should not be used for mortar when common or hydraulic lime or cement can be procured.

The hydraulic limes are divided into; slightly hydraulic, hydraulic, and eminently hydraulic limes. The amount of silica, alumina, magnesia, oxide of iron, etc., in the slightly hydraulic limes vary from .10 to .20, the hydraulic limes from .17 to .24 and the eminently hydraulic limes from .20 to .35 of the whole. They slake more slowly than the poor limes, with but a slight elevation of temperature and increase very little in volume, rarely exceeding .30 of the original. The slightly hydraulic limes harden under water in 15 to 20 days, but improve very little in strength afterwards. It desolves in pure water very slowly. They are obtained from limestones containing from 8 to 12 percent. of the above in-

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days after immersion in water and continue
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from limestones containing from 20 to 30 per. cent,
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Hydraulic cements are made from limestones
containing from 30 to 50 per. cent. of silica, alum-
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Mortars

Mortar is any mixture of lime paste with sand. There are two principal classes of mortars: Common mortars made of common lime, and hydraulic mortars made of hydraulic lime.

Lime is usually brought to market in lumps, or, in the case of hydraulic limes, which are difficult to reduce to a pulp by slaking, in the state of a powder to which it has been brought by grinding. All limes must be slaked before they can be employed as matrices for mortar.

Three methods have been employed for slaking lime. The first or ordinary method consists in throwing on the lime as it comes from the kiln enough water to reduce it to a paste. It is termed drowning as too much water is generally added which checks the slaking. It is important that all the water required to be thrown on the lime, which varies, with the density, purity and freshness, from two

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and one half to three times its volume, should be added at the beginning before the temperature becomes elevated. If water is added after the process has continued for sometime, it suddenly depresses the temperature and chills the lime, rendering it granular and lumpy.
As soon as a sufficient amount of water has been poured upon the lime, it should be covered with canvas or boards, or if these cannot be used a covering of sand may be substituted, in order to retain the heat and vapors. The lime should not be stirred while slaking.
The second method of slaking lime consists in immersing the lime in water for one or two minutes, withdrawing it before the commencement of ebullition. The opperation is performed with baskets or other suitable contrivances, into which the lime broken into pieces about the size of a walnut, is placed. After the lime has been immersed for a sufficient time, it should be at once heaped together, or emptied into casks

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or bins, and covered up, to confine the heat and vapors. If left to the air the lime becomes chilled and separates into a coarse grit, which is very difficult to slake.
Owing to the many difficulties connected with the practical application of this method, there has been a modification of it, which consists in sprin-kling the broken fragments, of a suitable size, formed into small heaps, with one fourth to one third of their volume of water. When the process is complete the heap is covered over with sand and allowed to remain a day or two before it is used.
In the third method or air slaking the lime is exposed to the air from which it attracts moisture and falls into a powder.
This method is the most objectionable on account of the time required to carry on the opperation. Hydraulic limes are injured by air slaking while fat limes are claimed by some, to be improved.
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The amount of sand to be mixed with lime depends upon the kind of lime and the use of mortar. In the case of fat limes three volumes of sand may be used to one volume of lime. With feebly hydraulic limes two and one half volumes of sand may be mixed with one volume of lime.

Hydraulic limes of good quality admit of a mixture of one and one half to two volumes of sand to one of lime.

For hydraulic works and foundations, equal portions of lime and sand should be used.

The present view generally taken of mortars is the nearer its constituents approach that of a natural sandstone the better will be the results obtained. The best proportions for the ingredients are those in which each grain of sand is enveloped with just sufficient lime

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to cause the whole mass to cohere and set quickly
Too much lime should not be added as it
causes the mass to shrink and crack. If too
much water is added the mass will be porous.
Sands are classed with reference to the locality
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and sea sand. Pit-sand is obtained from
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Hydraulic Cements

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When pulvarized it can be formed into a paste with water without any increase of volume and with little or no elevation of temperature. They are superiar to all other limes for all purposes of hydraulic constructions on account of the useful property which they possess of rapidly setting when immersed in water and continuing to increase in hardness afterwards.

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Hydraulic cements deteriorate by exposure to the air and may in time lose all its hydraulic properties, but it may be again restored to its original energy by recalcination.
Only a small amount of hydraulic cement should be mixed with water at a time and that should be used at once as it soon begins to harden in that state.

Hydraulic cements are divided into two principal classes, natural and artificial.
Natural hydraulic cements are obtained from argillaceous, magnesian, or argillo-magnesian limestones which contain from thirty to sixty per cent. in all of silica, alumina, magnesia, etc.
Natural hydraulic cements are manufactured for the market by burning the limestone, or cement stone as it is generally called, in kilns similar to those used for burning lime. Perpetual kilns are almost exclusively used for this purpose, the rock is usually bro-

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-ken quite small before being charged into the kiln. The calcined rock is drawn twice each twenty four hours from the bottom of the kiln. If any cement stone passes through which is not properly burnt it is returned to the top of the kiln to be burnt again.
The properly prepared cement is passed through a "cracker" which crushes it to about the size of a hazel nut. A "cracker" is made of cast iron and consists of three parts, the "shell" which is an inverted frustum of a right hollow cone and an upper and lower "nut". The "nut" is a frustum of a solid cone, which works con-
-centrically within the "shell". The lower portion is made of chilled iron to resist the rapid wear. Both "shell" and "nuts" are provided with suitable grooves and flanges for breaking the stone as it passes between them.
The "shell" is about 15 inches in diameter at the top and 6 inches at the bottom, and is about 18 inches high. One "cracker" of this size wor-
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per minute will crack from 250 to 300 barrels of cement per day, supplying four sets of mill-stones 3 feet in diameter.
The cement after passing through the "cracker" is ground in a cement mill which is almost identical in design with an ordinary flour mill, the under stone revolves while the upper one remains fixed. One pair of stones grinds daily from 65 to 70 barrels of cement, of 300 pounds each, so from 93 to 95 per cent. of it will pass through a sieve of 2500 meshes to the square inch. One cubic yard of cement stone will pro-duce 2,700 pounds or nine barrels of cement.
The cement is usually packed in barrels lined with paper as soon as ground to prevent it from deteriorating by contact with the atm-osphere. Great care is required in selecting the cement stone to produce a cement of uniform quality, as the different strata of rock in the same quarry vary in composition.
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daily from 65 to 70 barrels of cement, of 300
pounds each, so from 93 to 95 percent of it will
pass through a sieve of 2500 meshes to the square
inch. The cubic yard of cement stone will produce
2,700 pounds or nine barrels of cement.
The cement is usually packed in barrels lined
with paper as soon as ground to prevent it
from deteriorating by contact with the atmosphere.
Great care is required in selecting
the cement stone to produce a cement of uniform
quality as the different strata of rock in the
same quarry vary in composition.
The cement should be thoroughly mixed before
it is packed for the market. Almost all

natural cements are colored by the presence of a small amount of oxide of iron and sometimes of manganese but they do not effect the value of the cement except for ornamental work.

The proper burning of cement stone is a matter of great importance as an insufficient burning will produce an inferior cement and too great a heat produces vitrification

Artificial hydraulic cements are manufactured in localities where there exists no natural cement stone, or where a cement of a given quality is desired. The ingredients can be mixed in such proportions as will form a quick or slow setting cement as desired.

There are several different methods used in the production of artificial cements, among the most common are the following: first where the cement is made from a mixture of thoroughly slaked lime with unburnt clay. Second where pulverized carbonate of lime is mixed with unburnt clay.

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first where the cement is made from a mixture of thoroughly staked lime with unburnt clay. Second where pulverized carbonate of lime is mixed with unburnt clay.

The first method is used when the limestone is hard as it must be calcined and slaked before it can be incorporated with the clay.
The clay is dried and mixed with the lime in such a proportion as will produce an hydraulic cement of a desired quality. The lime and clay should be thoroughly mixed by being passed through a mortar mill, The mixture is moulded into blocks or made up into balls of 2 to 3 inches in diameter before it is burnt. The calcination is effected in kilns similar to those used for burning lime but with a much lower temperature than is required for burning natural stone. The burnt balls or blocks are usually pulverized between millstones.
The second method is used where soft carbonate of lime can be obtained.
The clay and soft limestone are reduced to a very fine powder after which they are thoroughly mixed together either in a dry or wet state, in the proper proportions. The mass is then made

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The clay and soft limestone are reduced to a
very fine powder after which they are thoroughly
mixed together either in a dry or wet state, in
the proper proportions. The mass is then made

into cakes or balls, dried, calcined and ground for use as in the first method.
The first method is more expensive than the second but is claimed by some to make a superior quality of cement. In the first method the mixture must be thoroughly dried before being burned while in the second it need not be. The first is calcined at a moderate or bright red heat and the second at a white heat.

Analyses of Portland Cement.

Number	1.	2.	3.
Silica,	22.04	20.67	20.42
Alumina,	10.11	10.43	13.87
Sesquioxide of iron,	1.61	.87	
Sulphate of iron,	1.78		trace
Lime,	62.93	68.11	65.13
Magnesia,	1.13		.58
	99.60	100.08	100.00

No. 1 Saylors American Portland cement.
No. 2. Artificial Portland cement, analyzed by M. Vicat (See Gilmore Limes Mortars & Cements)
3 Natural Boulogne Portland cement.

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The first method is more expensive than the second but is claimed by some to make a superior quality of cement. In the first method the mixture must be thoroughly dried before being burried while in the second it need not be. The first is calcined at a moderate or bright red heat and the second at a white heat.

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Analyses of Limestones found in Phelps county, Missouri.

Number,	1.	2.	3	4	5
Silica,	6.76	4.20	10.14	11.80	16.22
Lime,	29.53	36.34	28.62	27.58	25.72
Magnesia,	19.78	11.80	18.20	17.05	15.82
Iron & Aluminum oxides,	.67	1.51	.53	1.20	1.22
Carbonic acid,	40.55	42.36	39.64	38.10	35.80
Water & loss by dif.	2.71	3.79	2.87	4.27	5.22
	100.00	100.00	100.00	100.00	100.00

Rolla, Mo. June 5, 1884.

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Rolla, Mo. June 5, 1884