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Natural Cement

....Natural cement pastes and mortars are about half as strong as corresponding Portland cement pastes and mortars in tension, and only about a third as strong in compression....(After a month) neat natural cement cubes should average 800 psi (5.5 Mpa) or more; and 1:2 sand mortar cubes should average more than 500 psi (3.4 Mpa).

ASTMS standard specification, tensile strength:

1:3 natural cement: sand, 24 hours in moist air, 27 days in water: 125 psi (0.86 Mpa).

Uses of Natural Cement

Natural cement is used sometimes in structural works where mass and weight, rather than strength are required, as in sewers, conduits, massive foundations, pavement foundations, sidewalks, and rarely in large masonry dams, abutments etc. Natural cement when mixed with sand or with lime and sand, makes a suitable mortar for brick and stonemasonry that is not subjected to heavy loads. Natural cement should not be used in exposed places or under water or where it will be exposed to the action of frost before the concrete has set and dried....

Natural Pozzolana Cement

...Good pozzolan cement mortar of a 1:3 mix is about as strong in compression as a like mortar made with Portland cement, but is only about 70% as strong in tension. (Made with hydrated air lime).

LIMES AND LIME MORTARS

...*Quicklime* may be divided into two general grades as follows:

- a) Selected lime – a well-burned lime containing no ashes, clinker, or other foreign material. It contains 90% or more of calcium and magnesian oxides and less than 3% of carbon dioxide. Sometimes called 'white' lime.
- b) Run-of-kiln lime – a well-burned lime containing 85% or more of calcium and magnesium oxides and less than 5% of carbon dioxide.

Hydrated Lime – a quicklime to which just enough water has been added to produce a complete slaking.

Hydraulic Lime – obtained from the calcination of an ordinary limestone containing from 10 to 20% clay....

Manufacture of Hydraulic Lime

...The limestone rock used should be such that, after the silica has combined with the lime during calcination, enough free lime remains to disintegrate the kiln product by its own expansion when it is slaked. Such a limestone usually contains from 40 to 50% of lime; about 1% magnesia; from 7 to 17% of silica and about 1% of alumina and iron oxide....

After the burning, the lumps of lime are...slaked in the same way as quicklime, great care being taken to use just the right amount of water and no more, as an excess of water would cause the lime to harden. The expansion of the quicklime in slaking breaks up the lumps into a fine powder which consists principally of lime silicate with about 25 to 33% of hydrated lime, The lime is then screened through a 50-mesh sieve and placed in bags.

The underburned limestone and overburned materials (known as grappiers), which are left after the hydraulic lime is slaked and screened, , are ground to a fine powder and sold as 'grappier' cement....

Properties of Hydraulic Lime. Hydraulic lime pastes and mortars are about as strong as those of natural cement. ...the strength of hydraulic lime pastes and mortars is about $\frac{1}{3}$ as strong in tension and about $\frac{1}{4}$ as strong in compression (as Portland cement)....The rate of gain in strength is very slow and the maximum strength is not reached in less than a year. Hydraulic limes are about 5 times as strong in compression as they are in tension....

Uses of Limes. About half the lime made is used for various structural purposes...Most of the lime used for structural purposes is mixed with sand to form mortars for laying brick and stone masonry. A large amount of lime is used in plastering the walls and ceilings of buildings....Some lime is used for whitewashing. A little lime is sometimes used in cement mortars to make them more plastic and permeable.

Hydrated lime is used for the same...purposes as quicklime, and it is more easily handled, stored, and shipped as there is no danger of air slaking....

Hydraulic limes and grappier cements are sometimes used for the purposes of interior decoration. At one time they were much used in construction work, but they were replaced some time ago by the natural cements, and later by Portland cement. Hydraulic limes are not suitable for use in underwater work and they are too slow setting for practical construction work.

LIME MORTARS

Lime mortar is a mixture of slaked lime usually in the form of a thick paste, sand or other fine aggregate, and water.

The lime used is usually a quicklime which must be properly slaked or hydrated before the sand or other fine aggregate is added. **In general, a high-calcium lime makes the strongest and best-working mortar for ordinary uses.** Sometimes a hydrated lime (a lime which has been slaked by the manufacturer) in the form of a fine powder is used....

The sand used for lime mortar should be clean and sharp and be composed of rather small grains in preference to large ones...

Slaking the Quicklime. When quicklime is used, it must first be properly slaked before being mixed with the fine aggregate. It is important to secure a complete slaking of the lime and no more, because, if too much water is added, some of the binding power of the lime will be destroyed, and if too little water is used or proper care is not exercised by the workman, some of the lime may not be slaked...If the quicklime is properly slaked, the lime paste formed should have about three times the volume of the original quicklime. There are three general methods of slaking quicklime, namely, drowning, sprinkling and air-slaking.

Slaking by the drowning method is the most common way. The lumps of quicklime are placed in a layer 6 or 8 inches deep in a water-tight box and then water is poured on the lumps. The water should be equal to about two and a half or three times the volume of the quicklime. If the proper amount of water is added, the lime will form a thick paste. With a high calcium (quick-slaking) lime, it is better to add the water all at once, but with a magnesian lime, the water should be added gradually. As lime slakes best when hot, care should be taken not to chill the lime and retard the slaking. 'Burning' occurs when only a little water is present and this water is changed into steam by the heat produced. 'Burning' tends to prevent a complete slaking of the lime.

Another method of slaking by drowning is to fill a water-tight box with about 8 inches of water and then add lumps of lime in sufficient quantity to form a thick paste. The mass must be stirred to assist in breaking up the lumps of lime.

Slaking by sprinkling consists of sprinkling a heap of quicklime with water equal to about $\frac{1}{3}$ or $\frac{1}{4}$ of the volume of the lime and then covering the mass with sand and allowing it to stand for a day or so. If the slaking is properly done, the hydrated lime will be in the form of a powder. This method requires extra care and expert labor and is, consequently, expensive.

Air-slaking consists of spreading the quicklime in a thin layer and allowing it to slake by absorbing moisture from the air. Frequent stirring is required. The method produces a good quality of slaked lime, but is rarely used due to the large storage area, labor and time required.

PROPORTIONING AND MIXING OF LIME MORTAR

Sand should be added to the lime paste for four reasons:

1. to prevent excessive cracking and shrinking of the lime mortar when the water evaporates
2. to give greater strength to the mortar
3. to divide the lime paste into thin films and to make the mortar more porous, thus aiding in the absorption of carbon dioxide...which causes the lime to set or harden
4. to reduce the cost.

The usual proportions vary from 2 to 4 parts of sand to 1 part of lime paste. With most sands and limes, the correct proportion will be from 2 ½ to 3 parts of sand to 1 part of lime paste by volume. ...The volume of the lime paste should be just a little more than enough to coat completely all of the sand grains and fill the voids.

In mixing the mortar, the lime paste is first spread out in a thin layer a few inches thick and the sand spread uniformly over the top. The lime paste and sand are then mixed by hoe or shovel until the mass is of uniform color. A little water should be added, if necessary, to make the mortar of the proper consistency. Thorough mixing is required to make a good mortar....

If too much sand has been used the mortar will be 'short' and 'stiff' and will not work properly; while if too much lime paste is used, the mortar will be too sticky to work properly. A mason can tell very quickly whether the mortar is correctly proportioned or not when he starts to use the mortar in his work. The proportions which give the best working mortar are also the best proportions in regard to strength, hardening and other properties (except when clay or loam is used instead of sand).

Properties of Lime Mortar.

Lime mortar has the important property of 'setting' or 'hardening' when the water evaporates and the lime absorbs carbon dioxide from the air thus forming calcium carbonate. This setting takes place very slowly...

In a lime mortar, an excess of lime paste delays the hardening, increases the shrinkage, decreases the compressive strength, and makes the mortar sticky....

The freezing of lime mortar delays the evaporation of the water and thus delays the absorption of carbon dioxide from the air. The expansion of the water due to the freezing may damage the mortar. Alternate freezing and thawing decrease the adhesive and cohesive strength.

A fine, sharp, clean sand gives the best results in a lime mortar....

Oils, acids, strong alkali, vegetable matter, etc decrease the strength and hardening qualities of a lime mortar.

The tensile strength of a good 1:3 lime mortar, 1 month old, varies from 30 to 60 psi. When it is six months old, the strength will probably be from 10 to 15 psi more.

The compressive strength (of same)...at the age a 1 month will probably be between 150 and 400 psi, while at the age of 6 months the strength may vary from 170 to 750 psi.

Common Lime or Wall Plaster. Is a lime sand mortar in which hair, fiber or some similar material has been thoroughly mixed....to keep the plaster from shrinking and cracking when it sets and hardens on the wall.

Wall plaster is usually applied in two coats, The first...is about half an inch...the finish coat consists of a rich mortar (a 1:1 or 1:2 mix) made of a very white lime paste and a fine, sharp, clean, light-coloured sand.

It is important that the quicklime used in a wall plaster shall be thoroughly slaked before it is placed on the wall. **This is usually made sure of by allowing the plaster to remain in a water-tight box for several days before it is applied to the wall....**

Uses of Lime Mortar. Lime mortar is used as a mortar for stone and brick masonry, where the mortar can be placed in comparatively thin layers and the walls are not very thick, and where great strength is not required. Lime mortar should not be used in massive masonry, under water, or in a wet soil, as the lime will not harden unless it can absorb carbon dioxide from the air....Lime mortar is sometimes mixed with Portland cement mortar to make the Portland cement easier to work and also where a mortar stronger than lime mortar is required.