Hydraulic lime with low content of soluble salt.

IS IT:

- [X] *Product*
- [ ] *Technology*
- [ ] *Equipment*

APPLICABLE FOR:

- [X] *Restoration*
- [X] *Rehabilitation*
- [X] *New Construction*

APPLICABLE ON:

- [ ] *1. Foundations and underground structures*
- [X] *2. Vertical structures*
- [ ] *3. Horizontal structures and vertical connections*
- [ ] *4. Roof and terraces*
- [X] *5. Façade and building envelope*
- [ ] *6. Finishes and completion elements*
- [ ] *7. Integrated services*
- [X] *8. General strategies for building recovery*

Related companies: *No companies; university research; structural study.*

DESCRIPTION

Hydraulic lime is a binder that has got the ability to set in very humid environments or underwater. This characteristic takes the name of hydraulicity and is conferred by the presence of a reactive mixture of silica and alumina which allows the formation of calcium hydro silicates (CSH) and calcium aluminates hydrates (CAH), capable of reacting with water giving the mixture greater mechanical resistance.

What is commercially referred to as Hydraulic Lime (HL) is obtained by mixing Portland cement and small quantities of aerating additives. These limes are generally similar to low-strength cements, with potential negative effects on the durability of the products due to the possibility of formation of ettringite and thaumasite, with a high content of water-soluble salts.

The hydraulic lime with a low salt content is, on the other hand, the natural one (NHL) produced starting from calcareous-marly rocks (Fig. 1), i.e., limestone that contains a percentage of clay varying between 6-20%. The clay guarantees hydraulic properties as it is rich in silica and alumina. The rocks are extracted and cooked at low temperatures.

Hydraulic lime obtained by mixing (inorganic) hydraulic additives (FL formulated lime), such as pozzolan or fragments of bricks which, during the carbonation phase, react with the lime generating resistant compounds is also low in salts, also in humidity conditions (aerial limes with pozzolanic behavior, UNI-10924).

In the recovery of historic buildings, the mechanical characteristics, porosity, and low content of soluble salts, typical of this hydraulic lime, ensure total compatibility with traditional building materials. High permeability to water vapor and the ability to prevent fungi and molds are other characteristics that give hydraulic lime a hygrometric function in the environments and make it the preferred binder in the field of green building. The low content of water-soluble salts excludes the formation of efflorescence, ensuring the absence of reactions with the salts that may be present in the building materials.

WHY TO USE

Hydraulic lime constitutes a base for the preparation of mortars, stuccos, decorations, marmorins, paints, smoothing on fine mortars, etc. The mortar based on natural hydraulic lime is compatible with new or old masonry: masonry in natural stone, solid bricks, in lightened concrete blocks, in cellular concrete blocks, in tuff, etc.

It is a product suitable for laying masonry, smoothing (Fig. 2) and screeds (Fig. 3); for the realization of inner and external plasters with high breathability (Fig. 4), resistant to sulphates and, therefore, which helps to mitigate the problems of humidity in the walls and capillary rise; it is suitable for the consolidation (fig. 5), by injection, of foundations, pillars, vaults and arches, masonry in general in stone, bricks, tuff and mixed existing buildings, including those of historical and artistic value, where there are cracks, voids and small internal cavities. Its use by injections is possible as the setting does not require carbon dioxide, which – in the contrary – is compulsory in the case of air lime, which would not be guaranteed inside the walls.

Once installed, this mortar has particularly fast setting times and high resistance even to calcareous and sulphatic waters.

HOW TO USE AND APPLY

PRODUCTION OF HYDRAULIC LIME WITH LOW SALT CONTENT (NHL OR FL)

The standard UNI EN 459-1: 2002 defines natural hydraulic limes (NHL) produced by cooking an impure calcareous rock (marl) at a temperature of about 1000 °C, obtaining a quicklime; upon leaving the oven, the material is quenched with water (Fig. 6) and finally ground (Fig. 7).

At the end of the process, natural hydraulic lime is made up of a mixture of Ca(OH)2 (hydrated lime), C2S (dicalcium silicate) and CS (monocalcium silicate) C2A (dicalcium aluminate), as well as non-combined silica and alumina. Their oxides react with lime hydroxide, giving the product its hydraulic quality.

Formulated hydraulic lime (FL) is obtained by mixing aerial lime with hydraulic binders. If the addition of special products that may contain pozzolanic or hydraulic materials is kept up to 20%, hydraulic limes can still be defined as natural.

If the added materials are ground brick powder or pozzolan, the characteristics of the final product are in any case attributable to those of a natural hydraulic lime; if, on the other hand, there are additives during the firing phase

such as hydraulic materials deriving from high-temperature production processes, there would be the formation of tricalcium silicate (C3S), which involves a very rapid setting, typical of cements.

PREPARATION OF A HYDRAULIC MORTAR

The preparation of a low-salt hydraulic lime-based mortar depends on the considered use. In general, a hydraulic mortar is made up of a binder which in this case is hydraulic lime with a low salt content, an aggregate (usually sand) and water.

The preparation of the hydraulic mortar takes place, therefore, without the preparation of slaked lime, as is the case for the aerial lime, but by direct mixing of the three aforementioned components in special concrete mixers. The supply, on site, of the hydraulic lime in clods is much rarer than the air lime, since the extinguishing of the hydraulic lime is much more complicated than that of the air lime: it is necessary to dose the water in a rather precise way to limit its action hydration of calcium oxide without affecting the silicates and aluminates which, in the presence of water, start their setting process. Therefore, generally, a powdery hydraulic lime is used on site by mixing with water (Fig. 8) and with well-washed aggregates with controlled granulometry, according to predefined formulations. Water must be added in order to ensure the desired workability, considering that laying is easier when more plastic.

Due to the hydraulic characteristic, the maturation of the compound is favored by the water, so it is necessary to keep the mortar wet once applied, especially if applied in the warmer months, as dehydration can lead to chalking of the parts that do not, they reacted with water. Setting occurs essentially with hydration processes but also by carbonation of the aerial fraction.

Hydraulic lime constitutes a base for the preparation of mortars suitable for laying masonry, smoothing, screeds, inner and external plasters, consolidation by injection of foundations, pillars, vaults and arches, masonry.

SPECIFICATIONS FOR THE APPLICATION OF HYDRAULIC LIME-BASED MORTAR WITH LOW SALT CONTENT AS BED

The stone fragments must be clean and free of dust; they must not show traces of oils, greases or waxes and must be slightly moistened before laying. The mixture is generally prepared using a cement mixer in a proportion of about 4.5 liters per 25 kg of lime powder and sifted sand in a ratio of 2:1 with the lime. The mortar is applied with the aid of a trowel, exerting strong pressure to ensure its adhesion, and spread across the entire width of the segment.

SPECIFICATIONS FOR THE APPLICATION OF A HYDRAULIC LIME-BASED PLASTER WITH LOW SALT CONTENT

The supports can be cleaned by hydro-washing or hydro-sandblasting until all traces of dirt and weak or insubstantial parts, and any saline efflorescence are completely eliminated. On masonry of poor consistency, it is advisable to apply a plaster holder net, first, (Fig. 9) and subsequently the plaster. The substrate must be wet in excess and the application of the plaster must begin when the water has been completely absorbed. The mixture must be dosed until obtaining a consistent and plastic mortar (about 2.5 liters of water per 10 kg of powder) and sifted sand in a proportion of 2:1 to lime.

SPECIFICATIONS FOR THE CONSOLIDATION OF A MASONRY BY INJECTIONS OF HYDRAULIC LIME-BASED MORTAR WITH LOW SALT CONTENT

To prevent the lime injection from leaking, the inconsistent areas must be restored, sealing any lesions (Fig. 10). Using the same holes created for the injection, it is necessary to saturate the masonry with water and wait at least 24 hours, checking that the excess water is absorbed. The perforations for the injections, carried out by means of a drill (Fig. 11), have a variable diameter between 15-25 mm, a depth of about 2/3 of the facing and in a variable number according to the permeability and compactness of the masonry with a frequency every 20-25 cm (solid brick type) up to a maximum of every 40 cm (mixed masonry type). For thicknesses up to 60 cm it is sufficient to operate on one side of the wall only. The inclination of the perforations must be approximately 45° in order to facilitate the injection process.

The injection mortar can be mixed with a low-speed drill or mixers equipped with a pressure gauge. The mortar is injected into plastic pipes previously fixed in the holes executed in the masonry (Fig. 12). The injections proceeds from the bottom up and from the sides towards the center with an injection pressure between 1-4 atm. The upwards application allows the air to escape, favoring a greater filling of the gaps. For very deteriorated masonry that is not able to withstand overpressure, gravity percolation can be followed (Fig. 13). At the end of the work, both the pipes and the fixings must be removed before proceeding with any plastering.

SPECIFICATIONS FOR THE APPLICATION OF HYDRAULIC LIME-BASED MORTAR WITH LOW SALT CONTENT AS A PRIMER

The substrate must be stable, resistant and clean, brushing brittle and inconsistent surfaces. It is necessary to wet the substrate before application. The mortar is obtained by mixing approximately 7.5 liters of water and 25 kg of lime and screened sand in a ratio 2:1 to the lime with a low-speed mixer.

The application can be done with the aid of a stainless-steel spatula (Fig. 14) or by spray (Fig. 15). The second layer should be applied after 60 mins and finally proceed by moistening the facing with sponge floats, slightly soaked in water (Fig. 16).

SPECIFICATIONS FOR THE APPLICATION OF HYDRAULIC LIME-BASED PLASTER WITH LOW SALT CONTENT, REINFORCED WITH GLASS FIBER NET AND SIMILAR

Especially if the plaster has a cracked pattern, it is advisable to replace it and reinforce the new plaster with a fiberglass mesh or something similar. The mesh gives the system adequate resistance to movements due to thermal expansion or shrinkage phenomena, preventing cracks formation.

Once the wall has been carefully cleaned and the masonry put in sight, a first (rough) layer of plaster is spread within which the fiberglass mesh is drowned by laying the sheets from top to bottom on the still fresh mortar and drowning them with the help of a trowel or spatula. Subsequently, the drafting of the other two layers of plaster are put, taking care to drown, in the second, the support network.

If a plastic mesh is used, instead of a fiberglass one, the same procedure must be carried out in the smoothing layer.

The mortar for a plaster based on hydraulic lime is obtained by mixing in proportion 3:1.5:1 for sand:lime:water.

Where possible, an increase in resistance can be obtained by transversely connecting the reinforcement meshes on the two sides of the wall face, using connectors.

TECHNICAL CHARACTERISTICS

The characteristics of hydraulic lime with low salt content depend on the quantity of clay minerals present in the starting rock or on the quantity and quality of additives present in the artificial mixtures used for its preparation.

The water content is based on the quantity of components (silica, alumina) within the raw material (marly limestone, or limestone plus additives, etc.). The Hydraulics Index is defined as the ratio between the percentages of oxides present in the stone or in the mixture used as raw material.

Lime	Hydraulic index	% Clay	Setting times
Weakly hydraulic	0.10-0.16	5-8	15-30 gg
On average hydraulic	0.16-0.31	8-15	7-11 gg
Properly hydraulic	0.31-0.42	15-19	4-7 gg
Eminently hydraulic	0.42-0.50	19-22	4 gg
Limits (normal cements)	0.50-0.65	22-27	4 gg

RECOMMENDATIONS AND OTHER INFORMATION

Hydraulic lime with low salt content should not be applied on: painted substrates; supports frozen or thawing or with the risk of freezing in the 24 hours following the application; non-homogeneous supports.

During the hottest months it is advisable to protect against rapid drying, possibly by moistening the substrate.

NHL is free of tricalcium silicate and tricalcium aluminate, typical constituents of Portland cement and any other form of clinker.

It can be mixed with any aggregate material as long as it is free of organic content, salts and in the correct particles size.

EXAMPLES

CONSERVATION OF THE SURFACES OF THE "VITTORIO EMANUELE II" GALLERY, MILAN

The surfaces of the "Vittorio Emanuele II" Gallery in Milan are subject to the acid mists of the metropolitan environment, which are harmful for the formation of efflorescence and sulfating (crusts) and the deposition of dust and pollutants. All surfaces are characterized, in general, by a widespread degradation of incoherent surface deposits in greater concentration on the

protruding parts or on the molded ones and degradation due to localized infiltration of water from the roof, which led to the presence of moisture stains, the detachment of the pictorial films, the disaggregation of the surface layers of the plasters, the formation of saline efflorescence and percolations. Furthermore, due to cement-based plasters (therefore rather rigid and not very porous), the surface had branched micro-cracks, cracks, and hollows.

After the preliminary cleaning phases and localized consolidations, superficial or in depth, grouting was carried out to ensure the uniformity of the surfaces. A specially prepared mixture based on weakly hydraulic binders with low salt content, very fine washed sands, polymeric additives, and colored oxides with technical characteristics similar to those of the existing plaster (composition, color and granulometry) for grouting up to level by removing excess using sponges.

For the widest and deepest cracks, after careful cleaning of the edges and the elimination of powdery residues, clogging was carried out by pouring in depth an adhesive product consisting of acrylic polymers in solution or dispersion and fillers (carbonate of calcium, ground stone). Subsequently, the cracks on the surface were sealed with specially formulated putty based on hydraulic binders with low salt content, very fine washed sands, polymeric additives, and coloring oxides.

Fig.1: Degradation of decorative cements, percolations due to previous water infiltrations.

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Fig.2: Micro-cracks present in a widespread way on decorative cements.

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RESTORATION INTERVENTION OF THE MONUMENTAL COMPLEX ROCCHETTA MATTEI

Rocchetta Mattei is located on the northern Apennines, in the town of Grizzana Morandi (Bologna). It was built from 1850 on the ruins of an ancient castle dating back to the XIII century. In 2011 it underwent a general recovery and restoration intervention, which also involved extensive structural consolidation of the walls.

A mortar based on NHL and aggregates with a maximum grain size of 3 mm was used for numerous interventions, particularly concerning stone walls, such as: the revision of the grouting of the joints on existing walls; plastering; the construction of new stone walls.

Another mixture with high resistance to sulphates and a low content of water-soluble salts based on NHL was used in the consolidation of thick-walled masonry, through punctual injections.

Fig.3: Perforations for injections on the internal side of the wall face. *© https://www.kimia.it/it/referenze/restauro-consolidamento-strutturale-rocchetta-mattei*


Fig.4: Perforations for injections on the external side of the wall face. © *https://www.kimia.it/it/referenze/restauro-consolidamento-strutturale-rocchetta-mattei*

Fig.5: Injections of mortar based on natural hydraulic lime with a low content of water-soluble salts.

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Fig.6: Tank and pump for mortar injections.

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Fig.7: Grouting the holes with mortar based on natural hydraulic lime. © *https: //www.kimia.it/it/referenze/restauro-consolidamento-strutturale-rocchetta-mattei*


Fig.8-9: Grouting of the joints on the external side of the wall face using natural hydraulic lime-based mortar.

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IMAGES AND CAPTIONS


Fig.1: Calcareous-marly rocks. © *https: //www.hdsystem.it/it/prodotti/calce-idraulica-naturale-nhl-5/*

Fig.2: Application of hydraulic lime-based mortar with low salt content. © *https: //lancellottirestauro.com/*


Fig.3: Mortar screed based on hydraulic lime with low salt content. © *https: //www.bancadellacalce.it/bdc/prodotti-bdc/massetto-nhl-roman-cement/*

Fig.4: First layer of plaster made of hydraulic lime with low salt content. © *https: //www.bancadellacalce.it/bdc/prodotti-bdc/calce-idraulica-naturale-nhl-5/*


Fig.5: Consolidation of masonry by injection of hydraulic lime-based mortar with low salt content.
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Fig.6: Quick extinguishing of lime. © *https: //tadelakt.it/calce-varieta*

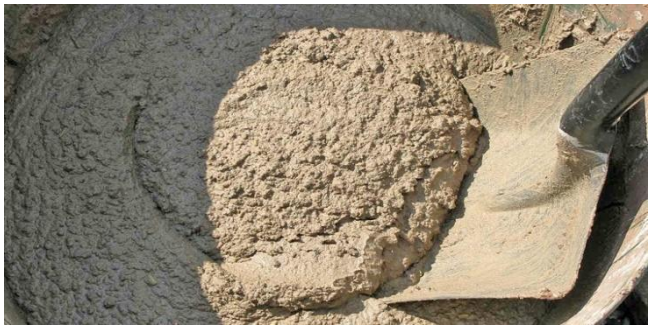

Fig.7: Powder of natural hydraulic lime. © *https: //www.ingenio-web.it/29625-la-calce-idraulica-naturale-il-materiale-deccenza-per-il-restauro-degli-edifici*

Fig.8: Mortar based on natural hydraulic lime. © *https: //www.bancadellacalce.it/bdc/prodotti-bdc/massetto-nhl-roman-cement/*

Fig.9: Plaster, laid on a plaster carrier mesh, based on hydraulic lime with a low salt content.
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Fig.10: Grouting cracks by applying a hydraulic lime-based mortar with a low salt content. © *https: //lancellottirestauro.com/*

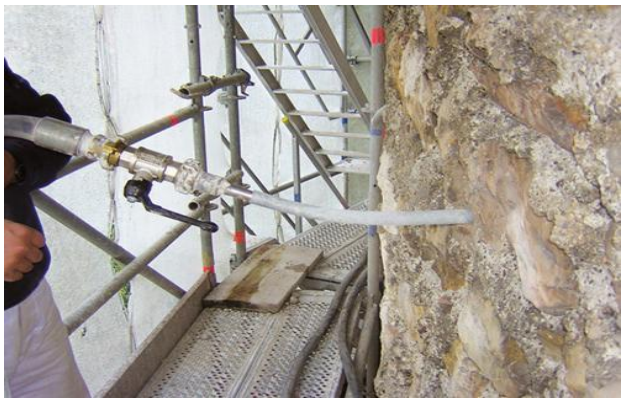

Fig.11: Drilling of the masonry. © *https: //lancellottirestauro.com/*

Fig.12: Consolidation of the masonry by injection of mortar based on hydraulic lime with low salt content.
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Fig.13: Consolidation of the masonry by gravity percolation of mortar based on hydraulic lime with low salt content.
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Fig.14: Application of hydraulic lime-based mortar with low salt content using a stainless steel trowel.
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Fig.15: Spray application of hydraulic lime-based mortar with low salt content.
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Fig.16: Finishing with a sponge trowel lightly soaked in water. *© https: //www.lightstone-srl.it/prodotto/rasastone-07-calcis/*