Plaster made of aerial lime.

IS IT:

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

APPLICABLE FOR:

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

APPLICABLE ON:

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

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

DESCRIPTION

Plaster is a wall covering consisting of a mixture of a binder (lime, cement, gypsum), an aggregate (sand, generally siliceous) and water.

Its function is protecting the masonry surface from the atmospheric agents and condensation, in order to guarantee optimal hygienic conditions into the inner environments; evening the surface, eliminating all the possible flatness and verticality defects; acting as a support for any subsequent finishes.

The traditional classification of binders is based on their characteristic of making the mixture harden in air or in contact with water: hence the general subdivision into air binders (aerial lime and gypsum), hydraulic binders (hydraulic limes, aerial limes with materials with pozzolanic behavior, and cements) as well as less frequently used organic binders and clayey binders.

The mortar based on air lime is the most popular and widespread in history, it shows a series of characteristics such as porosity and breathability, slow hardening, elasticity, low compressive strength, autogenous reconstruction of cracks, absence of soluble alkalis, that make it highly compatible and closer to the historical and traditional building materials. All of that makes it widely used in the restoration and recovery of historic buildings.

WHY TO USE

Air lime-based plaster is a mixture of ancient origins, a traditional material suitable for the reconstruction of deteriorated plasters on a stone support.

Air lime is a binder produced by calcination of a carbonate rock (Fig. 1) which after being mixed with water hardens when exposed to air, giving rise, by carbonation, to calcium carbonate, thus concluding its initial cycle. The firing of a carbonate rock gives rise to a coherent (compact), very porous material (quicklime) (Fig. 2) which, when mixed with water, is extinguished to obtain slaked lime. This porosity causes its performance to be strengthened during the slow carbonation process with a consequent improvement in mechanical resistance since the newly formed calcite gradually fills in the pores of the paste.

HOW TO USE AND APPLY

Plasters can be of the traditional type: mixed on site, or pre-mixed, or a single ready-made mixture. The mixture consists of a binder, an inert and water.

The water must be free, or almost free, of suspended or dissolved impurities as any presence can prevent perfect adhesion between binder and aggregates. The identification of dissolved salts is obtained by means of analysis.

The amount of water must be sufficient to ensure a good workability and cause the setting and hardening process, occurring only in presence of air. In the past, rainwater, collected in tanks and left to settle by the atmospheric dust, was indicated as the best due to the lower dissolved salts content. River or lake water was used as an alternative to rainwater, but only if free from organic substances and derive from areas with continuous water exchange, but it is always necessary its filtering to eliminate suspended particles. A small amount of lime milk can be added on site, which causes the separation of bicarbonates and their transformation into carbonates, purifying the water which must then be filtered.

The setting time of the mixture is influenced by the temperature of the water: hot water makes the setting accelerate and in cold seasons it is suggested to heat it to avoid the formation of ice in the interstices.

The aggregate is, in general, sand (river, quarry, coastal) or crushed rock, with natural or artificial materials with pozzolanic behavior or fragments of mortars. The best sand is the one with the least content of earthy parts; in rivers the most suitable sands are found along the middle course; the marine ones due to the sodium chloride content cannot be used according to the current technical regulations. Nowadays, the sands used on site come, in their almost totality, from mills: produced through mechanical breaking of stone elements opportunely screened.

In the preparation of a plaster with aerial lime mortar, the sand is chosen with a not too thin and well-matched grain size both to absorb the volumetric shrinkage, due to the evaporation of water, and to give good mechanical resistance, to produce a certain porosity, to make it permeable to air.

The air lime binder is produced by calcination of a carbonate rock at a temperature not exceeding 850 - 900 °C in modern or traditional kilns (Fig. 3), thus quicklime is obtained. When limestones containing only calcium

carbonate are cooked, calcium limes are obtained, while magnesian limes are obtained from cooking magnesian, dolomitic or dolomite limestones. Quick lime mixed with water becomes putty lime (slaked lime) (Fig. 4), a very porous and plastic binder. Then in the hardening phase, which proceeds very slowly and gradually from the outside to the inside of the masonry, exposed to the air, by carbonation returns to calcium carbonate, thus concluding its initial cycle (Fig. 5).

Slaked lime is commercially available in paste and on site is mixed with sand and water in the following ratios lime:sand:water: for a rustic plaster 1:1.5:1; for a civil plaster 1:1:1 (the plasters are defined rough or "rustic" and finished or "civil", according to the type of finishing). As an alternative to slaked lime, hydrated lime, less suitable for restoration and recovery interventions, can be used.

Before laying the plaster, the substrate must be prepared by cleaning the surfaces to be plastered in order to eliminate dust, inconsistent parts (Fig. 6), old plaster and anything that may affect good anchoring.

Before the application, it is necessary to wet the masonry until rejection to avoid the absorption of the mixed water by the porous blocks or bricks and the consequent drying of the mortar before it can set. The habit of keeping mortars as moist as possible during a certain period after laying prevents the formation of a superficial carbonate crust less permeable to air and capable of limiting the hardening reaction in the innermost layers.

Depending on the type of wall structure, the lime-based plaster can consist of one or more layers (Fig. 7). On traditional substrates, such as stone, brick or mixed, three layers are preferably applied:

1. anchoring and/or surface regulation layer (rough coat) (Fig. 8): it is a lean mixture with a binder/aggregate ratio of 1/3 and the aggregate has a medium-coarse grain size. Regularizes the substrate in order to ensure good adhesion of the subsequent layers; the lower dosage of binder allows to limit shrinkage. The mortar is spread by spray (Fig. 9) or by trowel and the thickness depends on the cavities and the unevenness of the surface; in those points where the inhomogeneity is high, fragments of bricks can be inserted.
2. leveling layer (medium or final layer): it is a mixture with a binder/aggregate ratio of 1/2 - 1/1.5, never in excess of water, to avoid shrinkage and the onset of cracks. It is applied as soon as the rough coat is perfectly dry, in several coats until the facing is flat and uniform, without undulations, up to a thickness of about 3 mm. The surface must be finished with a trowel (Fig. 10) so that the plaster appears to have a fixed grain and without defects. The application can also be done with the aid of guide strips on the wall, which are nailed at about 90 cm one from each other. This system allows to evenly level the various layers of plaster (this system is used only for the plaster called curl) on the masonry, up to the thickness of the guide strips. The surfaces are leveled with a wooden or metal straightedge, resting on the strips and pushed upwards.
3. finishing layer (plaster or veil): it is a greasy mortar with fine and/or very fine aggregate well screened, spread for a thickness of about 1-2 mm. The application must be carried out with a trowel or roller, possibly on the body of the curl, which is still quite fresh, in order to create a stable connection between the two layers.

Depending on the surface processing technique, can be distinguished plasters with fresh mortar (scratched; rolled, troweled to wood, pressed with iron, sponged, marble stuccoes with glossy surface, etc.), with partially hardened mortar (washed, polished, abraded, ...) or with hardened mortar (hammered, bush-hammered, sandblasted). Whether or not the plasters have an additional coating, they can be distinguished in exposed plasters (colored in the mixture or painted with frescoes) and coating plasters (by painting, painting, varnishing, whitewashing).

TECHNICAL CHARACTERISTICS

The technical characteristics are defined by the UNI EN 459-1:2010. *Construction limes. Definitions, specifications and compliance criteria.*

The slaked lime has a specific weight of 1,300 kg/m³; particle size min. 98% less than 0.1 mm and CaCO3 content max 4%.

The lime-based plaster is:

- durable and resistant over time;
- breathable: the high porosity gives excellent ability to absorb moisture and reduce any condensation and mold phenomena;
- workable: high plasticity and minimum shrinkage;

- ecological: natural and non-toxic product, it is also used at lower temperatures than other binders, releasing less carbon dioxide.

RECOMMENDATIONS AND OTHER INFORMATION

The realization of a lime plaster requires some important attention to avoid the formation of shrinkage cracks and, sometimes, the risk of detachment.

For an optimal result, it is recommended to:

- check that the wall support has well-compacted vertical and horizontal mortar joints, without joints or recesses with respect to the blocks;
- abundantly wet the wall before plastering;
- pay attention to thermo-hygrometric conditions, avoiding operating with too high temperatures, wind, too low ambient humidity (the ideal conditions are those between 5 and 20 °C, with Ur equal to about 50%);
- wait for the rough coat to harden before applying the following layer;
- at the end of the application, spray water on the surfaces for a few days;
- wait at least 10 days before applying the surface finishes;
- In case of spray application, it is recommended to grout the surface from a distance of about 20 cm so that the product is evenly distributed.

The preparation of the mixture can be done by hand on site (Fig. 12).

EXAMPLES

LI VIGNI PLASTERING

In the early 20th century, in Palermo, the plaster was patented by the Li Vigni brothers to imitate the mesh of the limestone and to model decorative forms. The mixture was formulated with 1 part of fatty lime in paste (also obtained from cooking magnesian limestones) and 4 parts of dolomitic sand, with the addition of coloring materials. It is a particular type of aerial mortar historically widespread in the Liberty period in Palermo. Nowadays, it is still perfectly preserved even in areas exposed to the strong action of sea salt. Today, it is generally used as an air lime-based plaster, called "Li Vigni type". That is a mineral mixture, medium-grained with natural sands and specific additives suitably mixed in order to obtain a product with high permeability to vapor, breathability, durable to shocks and abrasion (petrifying capacity).
It is a premixed product that only needs the addition of fresh water and applied using the common tools (trowel, trowel). Below are some examples of facades covered and decorated with Li Vigni plaster, symbols of the Liberty era and observable in the city of Palermo.

Fig.1-2: Li Vigni House, Palermo.

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Fig.3-4: Di Pisa Palace, Palermo.

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Fig.5-6: Jaforte Palace, Palermo.

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CONSERVATIVE INTERVENTION OF THE FAÇADE OF PALAZZO IN SAN POLO, IN THE HISTORICAL CENTER OF VENICE

The intervention involved the reconstruction of the plasters, which were rather deteriorated. The plaster was partly absent, leaving portions of brick wall texture exposed. There were fragments of cocciopesto plaster, plaster of bastard mortar at risk of detachment on the

central floors and cement plaster on the ground floor. The existing plaster fragments in the area under the eaves have been consolidated and a light layer of plaster similar to the existing one has integrated the remaining portions of exposed masonry. Instead, the cement plaster was completely replaced with a new plaster with an air lime binder. The mortar for the layers of the plaster is prepared directly on site and spread in line with the wall face.

Fig.7-10: Photos of the palace before and after the intervention. © *https://www.architettocchi.it/prodotto/palazzo-a-san-polo-venezia/*

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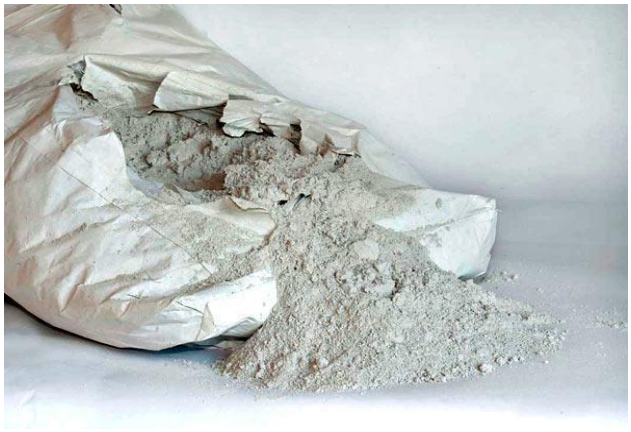

Fig.11-12: Lime rocks before calcination (fig.11). Lots of quicklime (fig.12). © *https://www.bancadellacalce.it/ ; https://www.tecnosida.it*


Fig.13-14: The calchéra (traditional kiln for the preparation of lime) of Lasino in the province of Trento, Italy (fig.13). Extinguishing of quicklime by controlled spraying of water (fig.14).

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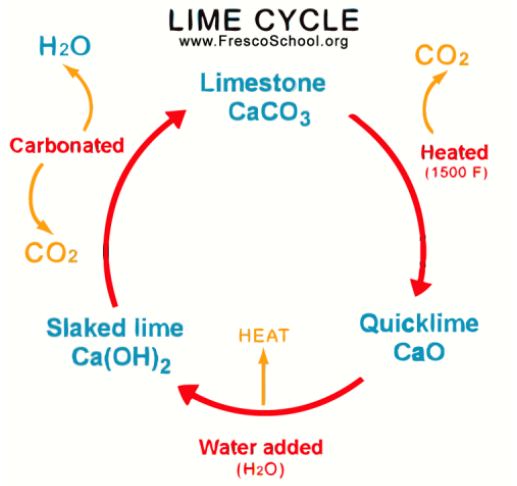

Fig.15-16: Lime cycle (fig.15). Plaster removal (fig.16). © *https://www.frescoschool.org ; https://www.restauroecolore.com/schede-servizi/rimozione-rivestimenti/*

Fig.17-18: Layers of plaster (fig.17). Medium Anchoring layer -rough coat- (fig.18).

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Fig.19-20: Spray application of the plaster (fig.19). Application of the plaster with a trowel (fig.20).

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Fig.21-22: Spreading the plaster with the aid of leveling strips (fig.21). Preparation of aerial lime mortar on site (fig.18).

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