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Introduction

The common term **lime** can be real confusing as there are several kinds of "limes" within the building industry. To avoid misunderstandings and costly mistakes, including health, it is important to use correct terminology.

The basic product is limestone such as calcium carbonate (CaCO_3) which is extracted from quarries or mines. Selected to its mineral composition the limestone is then heated to a temperature of about 1 000°C in kilns fired by fuels as coal, gas, oil, etc. to get calcium oxide (CaO). Where best results are obtained in wood or electric kilns.

Due to the mineral composition of limestone it can be divided into two groups:

A. High purity calcium carbonate with its chemical symbol CaCO_3 consists mainly of:

CaCO_3 >95%

B. Calcium-magnesium carbonate with its chemical symbol $\text{CaMg}(\text{CO}_3)_2$ consists mainly of:

CO_2 48%
 CaO 30%
 MgO 22%

The high temperature releases the carbon dioxide (CO_2) from the limestone converting it into calcium oxide (CaO).

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The result is **burnt lime**, also called **quicklime**. A white very highly alkaline product.

When slaked with an excess of water the reaction is highly exothermic and also dangerous as water starts to boil within one minute. And can even explode.

The white slurry must then mature necessary time and the surplus water disappears. In the former days maturing time was minimum one year.

The result is **hydrated lime** (builders lime) as the calcium oxide (CaO) has been converted to calcium hydroxide - Ca(OH)₂.

Normal hydrated lime must be soaked in water for at least 16 hours. **Special hydrated lime Type S** develops its plasticity within 30 minutes when mixed with water. (See **Material Specification 1-420**.) A typical water addition can be 15 litres per 100 kilos of lime (ratio 13 : 87). Must then be stored in air-tight containers before use.

Hydrated lime, non-hydraulic lime or **slaked lime** of high purity improves paste and workability.

Of importance is to understand, that in simple terms, limes can be divided into two **main** groups:

Non-hydraulic lime

Hydraulic lime

1. **Non-hydraulic lime** sets only by carbonation. I.e. a chemical reaction starts first when the mixing water has evaporated so the coating will be in contact with CO₂ in the atmosphere. That means it can remain soft for months or even years.

Calcium hydroxide - Ca(OH)₂ - is a **non-hydraulic** lime. Mixed with water it is called **lime water**. When exposed with carbon dioxide (CO₂) the lime water turns into a milky solution. First when the water evaporates the chemical reaction starts.

Should it be blended with OPC (Ordinary Portland cement) the chemical reaction will start immediately once water is added and a typical pot life is 1-2 hours.

Instead of blending with OPC in most cases it is better to add a suitable pozzolan that exhibits cementitious properties and allows a longer pot life.

2. **Hydraulic lime** has an initial set when water is added, and a second set by absorption of carbon dioxide (CO₂) to harden further.

Hydraulic lime is also produced by heating limestone, where the difference is that the limestone contains clay. The result is that calcium reacts with the clay minerals in the kiln to produce silicates that enables the hydraulic lime to set without exposure to air. In Europe it is quarried mainly in England, France, and Italy.

Moderately hydraulic lime (NHL 3.5) can be used for external works in most areas. Contains clay in the range of 11-20%. (See **Material Specification 1-620**.)

Eminently hydraulic lime (NHL 5) is used for exterior works and contains clay in the range of 21 to 30%. Sets within one day after the addition of water.

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It is possible to make a **hybrid lime** by blending non-hydraulic lime and hydraulic lime (NHL 3.5) ratio 75/25, 50/50 or 25/75. Such mixtures are suitable for severe exposure or other demanding situations where lime plaster may be subject to repeated cycles of wetting and drying. Also the advantages that the product is more workable, working time prolonged, and material cost decreased. Finished product is still incredibly beautiful.

Lime Colour Wash

Subject is a coloured Lime Wash. I.e. pigments have been added but no fillers. For further details see Lime Wash.

Lime Mortar

Normally a combination of one part lime and three parts of fillers as sharp quartz sand. The fillers must be correct graded so the lime can fill the voids between the aggregate particles. (See Void Test.) The lime can be non-hydraulic or hydraulic lime.

Lime Paint

Note: A **paint** consists of; **1. Binder** (vehicle) to make the adhesion and bind fillers and pigments together. **2. Filler** (extender) and **Pigment**, where fillers reduce the costs of pigments and also thicken the paint film, and Pigments make the colour. (A paint with fillers will be more opaque, and without fillers more translucent - lasur.) **3. Solvent** (for lime products water). **4.** Small amount of **additives**, where a thickener prevents the sedimentation of fillers and pigments as these have nearly three to four times higher density in comparison with water.

Normally 50/50 (by weight) of hydraulic lime and fillers. For interior application (dry areas) a non-hydraulic lime can be used as the binder. For exterior application use a hydraulic lime, or a combination of hydraulic and non-hydraulic lime.

Fillers (extenders) must be clean, dry and correct graded. Best is to use calcium carbonate or dolomite. Fillers of quartz sand colours will be darker, and in case of spraying the quartz sand with its higher hardness will wear orifices of spraying nozzles.

To get a pearly lustre include 10% of a mica mineral as light is reflected on their flat surfaces. The sparkling can be increased by also adding talc (50/50 mica and talc).

To get a Lime Paint with solids of roughly 30% (by weight) add 70% of water. Can be applied with brush, roller or spray. If spraying solids should be reduced to roughly 20%.

Start to add 80% of the water to the powder. Mix for 10 minutes. Then add remaining 20% of water and mix for 3 minutes.

To avoid sedimentation of fillers include 0.5% of a compatible thickening agent.

To enhance the adhesion a compatible acrylic dispersion can be added (5%) diluted with some of the mixing water. (See **Material Specification 1-551.**)

A Lime Paint can be integral coloured with titanium dioxide, iron oxide or chrome oxide pigments to get deep and vibrant colours. Normally two coats are sufficient (12 hours between coats).

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Lime Plaster

For a high quality at least 25% of lime (by weight) and 75% of correct graded fillers. Same fillers as for Lime Paint, where also crushed glass (size # 00) can be included.

The lime can be non-hydraulic or hydraulic lime. As well as a combination (hybrid).

Water is added to get a viscosity like a thick pancake batter. Estimate there is an extra need of nearly 0.1 litre of water per each kilo of added fillers.

Should be applied with a trowel. (See separate pages Lime Products – Installation.)

To enhance the adhesion a compatible acrylic dispersion can be added (5%) diluted with some of the mixing water. Do not use linseed oil as it will not resist the high alkali, and therefore can saponify.

Can be integral coloured with titanium dioxide, iron oxide or chrome oxide pigments. Or after an uncoloured Lime Plaster, painted with a coloured Lime Paint. Or treated with Pro Reactive Sealer that has been coloured with pigments.

Lime Putty

Quick (burnt) lime that has been slaked with water. Sieved and left to mature for several months, and thickens as a gel to the consistency of white toothpaste.

Essential is to know the water content. If not stated, check the water content with the producer. Because lime putties can have a water content of 60-70%. I.e. solids 30-40%. Where solids are of importance to know as the lime is the vehicle that binds added fillers and pigments. The density should be minimum 1.35 g/cm³. CAS-No. 1305-62-0. HS Code 2522 30 00. See **Material Specification 1-650**.

Lime putty can also be prepared from type S hydrated (non-hydraulic) lime by mixing with water having a hardness of <5 °dH. I.e. the water must be very soft. Because hard water has high concentrations of calcium (Ca) and magnesium (Mg) ions why there can be a reaction. If soft water is not available, distilled water must be used.

Lime Skim Coat

A very thin layer equal to a Lime Paint to get a smooth finish, or rubbed up to create a more porous finish. Can be coloured with pigments. Or when dry treated with Pro Reactive Sealer coloured with pigments.

Lime Wash

Subject product produces a unique surface with superb depth which ages over time due to the refraction of calcite crystals. When applied it first has a very low opacity, but after drying the opacity will increase.

It is a mixture with solids by volume of about 15%. As example, 20 kg of Lime Putty and 100 litres of water. That means a ratio of 1:5. The more water, the more transparent.

Can also be made of 15% (by weight) of hydraulic lime (NHL 3.5) and 85% of soft water.

Slowly stir the hydraulic lime powder until completely wetted. Allow to separate. Once it has separated, stir and allow the mixture to separate again.

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The clear water from the top is the Lime Wash to be used. Siphon off to get a clear saturated solution. (At this stage do not remix the lime from the bottom.) Then further water can be added to the sediment of lime (up to five times) to get more Lime Wash.

To enhance the adhesion a compatible acrylic dispersion can be added (5%) diluted with some of the mixing water. Do not use linseed oil as there is a risk of saponification due to the high alkali of the lime.

Can be integral coloured with pigments. To avoid sedimentation of pigments include 0.5% of a compatible thickening agent. The result will be a so called **lime-water-glazing** as the colour will be slightly transparent. Then apply a coating of Pro Reactive Sealers for final protection.

Lime Water

Subject is a saturated solution of calcium hydroxide and water, but can create misunderstandings as it is used for many various purposes. As example, when used within the medicine field it is the question of **0.3%** only. But when used within the building field it is the question of up to 15%, why a more correct word should be **Lime Wash**.

Milk of Lime

See Lime Wash.

White Wash

Subject is more or less a Lime Wash but where fillers for the whitening as calcium carbonate or dolomite have been included. Also white pigments as titanium dioxide can be added (TiO₂). Consequently it is a Lime Paint.

To prevent sedimentation of the heavy fillers and pigments a compatible thickener (0.5% based on the weight of water) should be included. See **Material Specification 1-403**. For better adhesion, and wear resistance, add 5% of a compatible acrylic dispersion. Without the addition of an acrylic dispersion White Washes will rub off on clothing.

To eliminate rub off, another alternative is to apply Pro Reactive Sealers that also can be coloured with pigments.

Fresco

Must be applied when the plaster is still **damp** and has begun to set. Normally from 4-5 hours after plaster application. The Lime Wash can be coloured with pigments.

Note that the pigments sink into the wet plaster. When dry the coating can be protected with Pro Reactive Sealers to get an excellent durability.

Secco

There are two types of Secco; **Patina Coat** and **Lime Wash**. Both types can be applied on **dry plaster**.

Patina Coat consists of 5% of lime and 95% of water that are pigmented with 2% of oxide pigments.

The composition of the **Lime Wash** as mentioned on pages 4-5, i.e. solids of about 15%.

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Stucco - Traditional

Same as Lime Plaster, that has been for thousands of years. I.e. **no** OPC involved.

Stucco - Modern

Besides Lime also OPC (Ordinary Portland cement) is included and other additives.

Venetian Plaster

Thin layers of lime plaster with fillers of calcium carbonate applied with a trowel and then burnished to create a smooth surface with depth and texture. Similar technique includes marmorino, scagliola and sgraffito.

Void Test

Of importance is that the lime fills the voids between the aggregate particles. For the reason that the lime is the **binder** to get the adhesion with the aggregates. Ask the supplier of the grading and fineness, including the value for Oil Absorption. If not available:

1. Carefully measure a quantity of actual aggregate into a clear container. (The aggregates must be completely dry.)
2. Fill same quantity of water into a measuring container.
3. Slowly pour the water into the aggregate until the water level is exactly the same as the aggregate.
4. Measure remaining water and subtract the figure from the original volume of water.

A figure that shows the volume of lime required to fill the voids in the aggregate.

Pozzolans

Pozzolans in combination with hydrated lime has been used for thousands of years.

Pozzolans must have very fine particle sizes with a high content of silicon dioxide (SiO₂) and low in alkalis (Na₂O and K₂O). Typical types of pozzolans today are:

Pulverised Fuel Ash (PFA) is a very fine grey powder. Typical fineness <10 µm. CAS-No. 68131-74-8. HS Code 2621 90 00 00. See **Material Specification 1-636**.

Ground Granulated Blast Slag (GGBS or GGBFS) is a very fine white powder. Typical fineness 30 µm. CAS-No. 65996-69-2. HS Code 2523 90 10 00. See **Material Specification 1-693**.

Metakaolin (MK) is a micro-sized white powder. Typical fineness 2 µm. CAS-No. 92704-41-1. HS Code 2507 00. See **Material Specification 1-536**.

Silica Fume (SF) is an ultra micro-sized powder. Typical fineness 12 nm. CAS-No. 7631-86-9. HS Code 2505 10 00 00. See **Material Specification 1-440**.

Metakaolin and silica fume have very high water demands and a typical figure for Oil Absorption is in the range of 70 g/100 g. Therefore mixed pastes tend to be very sticky and are difficult to work with.

Very fine Ground Glass Powder (PGP) is a white powder fineness <35 µm and should be from flat glass waste. The finer the glass powder, the higher its pozzolanic reactivity.

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Pulverised ground glass with fineness <0.3 mm and graded can even be used as 60% replacement for fine aggregates. The result is that the plaster appears to be brighter to the human eye. Also the working consistence of mixed paste is improved.

Colouring Lime

One of the advantages with true lime products (no OPC involved) is the unique quality of reflecting multi-nuances and warm colours.

However, pigments must be well dispersed where the problem is that pigments are as clusters hold together by electrical charges between the individual particles.

When dispersing pigments normally is used disperser blades with rectangular teeth and the speed can be up to 20 linear metres per second (72 km/h). A typical dispersion time can be one hour. Otherwise most of the pigments could not be efficiently, or have the correct colour.

The dispersing consists of three stages: **1.** Wetting of the Pigments. **2.** Mechanical Milling to break-up particle aggregates and agglomerates. **3.** Long-Term Stabilization to prevent coagulation (flocculation).

It goes without saying that it is not possible simply to just stir the pigment into the lime. It is much more efficient to use concentrates of pre-dispersed pigments.

Percentages of pigment should be calculated on involved lime weight. A too high percentage of pigment will result in failure of the lime plaster or lime paint.

Light colour 1-2%, medium colour 3-5% and dark colour 6-8%. An addition of 8-10% will not give an increase in colour strength.

Black	-	Saturation point 6%.	A normal dosage is 1-2%.
Brown	-	Saturation point 7%.	A normal dosage is 1-2%.
Red	-	Saturation point 8%.	A normal dosage is 3-5%.
Yellow	-	Saturation point 9%.	A normal dosage is 6-8%.

Colouring Tips

Following comparisons are based on a pigment addition of 3%.

For the colouring of **Lime Plaster** there is a need of 30 g of pigments per kilo. Should 5 kilo of Lime Plaster be integral coloured Lime it means **150 g** of pigments.

As alternative, instead an uncoloured Lime Plaster can first be applied. Then painted with integral coloured **Lime Paint**. Based on two coats per m² of Lime Paint there is a consumption of roughly 400 g per m² which means **12 g** of pigments (instead of 150 g.)

Another alternative is to use a coloured Reactive Sealer (instead of a coloured Lime Paint). Based on two coats (wet-in-wet) there is a consumption of roughly 200 g per m² which means **6 g** of pigments.

Environment

Lime is the ultimate eco-friendly green construction material. A real Green Product.

One ton of OPC mortar produces **172 kg** of CO₂. One ton of lime mortar produces **19 kg** of CO₂. During the hardening (carbonisation) process lime mortar absorbs much more CO₂ making the lime mortar **90% cleaner**. Nearly **97% less CO₂ emissions**.

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Limes will not promote organic growth as it has natural anti-mould and anti-bacteria properties due to its very high pH. Also it has anti-allergic properties, and is non-combustible. It is odourless, solvent-free and no harmful emissions. Living conditions are highly improved due to the breathability of lime.



All our products for the treatment of lime are waterborne and safe to use, as well as **zero-VOC**.

Anti-Graffiti

Apply several thick coats of lime paint, but without the sealer. Unwanted graffiti is easily removed by just sanding without the need of any dangerous solvents.

Health & Hazard

All lime products are caustic and care should be taken and correct safety equipment worn when handling these materials.

Hazard:			Irritant	Irritant to skin and respiratory system. Risk phrase R 37/38. Risk of serious eye damage. Risk phrase R 41. Tolerance 5 mg per m ³ of air.
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Prolonged or repeated contact with skin may cause severe irritation or dermatitis. Always wear splash proof safety goggles, rubber gloves and rubber boots as lime is caustic when wet. When spraying Lime products wear an approved facemask as Lime is irritating to the respiratory tract. Also when sanding old dry lime.

Used packages should be disposed according to municipal regulations. EWC Code No. 10 13 99.