Listed Buildings and Lime mortar

(An overview)

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What is Lime?

Lime can be the term used for (i) calcium carbonate ($CaCO3$) or Limestone (ii) calcium oxide (CaO) or Quicklime (iii) calcium hydroxide (Ca{OH}2) or Slaked Lime / Lime putty / Powdered hydrated lime / Hydraulic Lime

Brief History of Lime

Lime has been used for thousands of years. In ancient Egypt inside the pyramids (circa 4000bc), Roman times for Aqueducts , the binder in the mortar for the Great Wall of China, right up to WW2.
After the rapid uptake of cement based mortars post WW2, Lime mortars were a relative rarity in the construction industry. Through the later part of the 20th century, it was becoming increasingly clear how cement based products used on lime built structures were not protecting the structures as originally intended , but quite the reverse, Hence the current renewed interest.

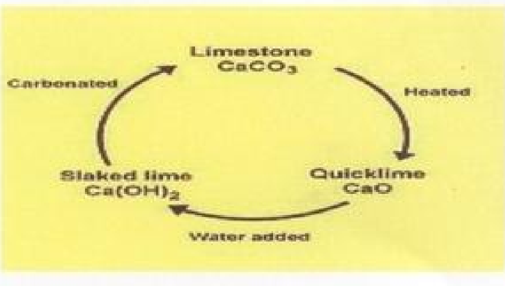
Brief History of Cement

Although various forms of cement were being experimented with in the mid 18th century (including roman cement) OPC or ordinary Portland cement was patented in the 1820's. The use of cement and cement based products really took off after WW2. Cement is able to withstand much higher compressive forces than lime and is therefore ideal for higher rise structures. It is much easier to build with cement as the quicker setting times radically reduce building times and the need to have several sites running at a time.
There is plenty of evidence that cement renders and plasters applied to Cob (earth) buildings could cause spontaneous collapse. The originally dry mud walls had no damp proof course to speak of and relied on evaporation to control dampness. Sealing such a building with cement based render externally and fitment of uPVC windows prevented moisture from escaping the walls, which in tern caused internal damp issues. Many of these buildings were "damp-proofed" using hard cement plasters internally. The result was that as there was no means of escape for the dampness the cob walls became saturated and turned from stable rammed earth into slippery mud, leaving only the internal plaster and external render supporting the structure. Partial collapse often followed.
Similar dampness problems and some damage can also be caused by applying cement products to lime built structures.

Lime vs Cement

Lime	Cement
Breathable	Not breathable
Flexible	Not flexible
Soft	Hard
Durable	Strong
Slow set (weeks / months/ years)	Fast setting (Hours / days)
Long history – 6000 years	History of approx 150 years. Intensive use for 7 decades.

The Lime cycle



Different types of Limes

A Pascal is 1 Newton per Msq. Mpa is mega pascals one million newtons per square metre

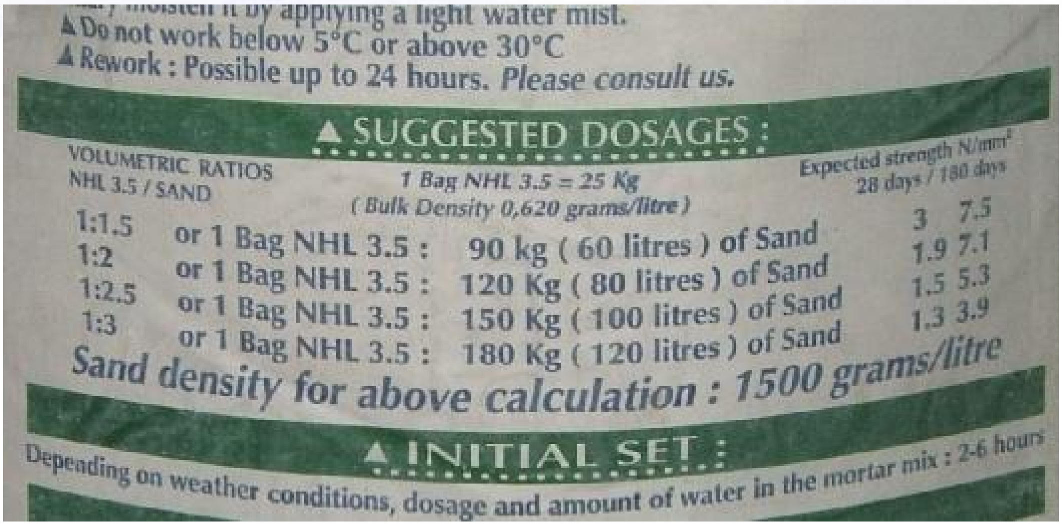
Material	Appearance / Common Use	Compressive strength @91days Mpa
Lime putty	Like soft Philadelphia cheese used for Plasters , Pointing mortar for stone and ancient brick	
Hydrated Lime	Light coloured Powder used as an additive for composite sand/ cement/ lime mortars as a plasticiser	
Feebly Hydraulic Lime NHL 1.0 – 2.0	Light coloured powder used as binding agent in mortars for some plastering and rendering applications and pointing soft brick and stone.	1.0-2.0
Moderately hydraulic lime NHL3.5	As above but used as external render and pointing mix for more durable bricks.	3.5
Eminently Hydraulic lime NHL 5.0	Light coloured powder used as a binding agent in mortars used for chimneys, cellar plasters and external renders in exposed areas.	5.0
		N .B. Mpa is Mega Pascals . A Pascal is 1 Newton per Msq

Lime and Dampness within Structures

Whilst lime will not cure every damp problem in every building. Correct specification and use of lime can encourage evaporation and therefore has the possibility to reduce dampness in any given structure as well as enhancing the look, life and authenticity of a building. In Listed buildings use may be mandatory. Your local authority conservation department would vet specifications.

Environmental benefits

The reduced firing temperatures used in manufacture means that less CO_2 is produced than a similar quantity of cement. Lime mortar will also tend to reabsorb CO_2 during carbonation (setting) and has been considered CO_2 neutral, although in practice this is not strictly 100% true due to losses in manufacture and transportation.
Buildings that "breath" tend to be drier and warmer and therefore take less energy to maintain an acceptable level of heat.
A good lime repair on a lime built building will often outlast a cement repair, as the cement repair will often fail as it is unsuitable in the first instance.



chaux & enduits St Astier
StA
St. Astier pure and natural hydraulic
Working with NHL 3.5 : general recommend
▲SANDS
▲For building, pointing, base coats and coarse finishes on renders
well graded sharp sand free of silt/clay 3mm or 2.36mm down to 0.075.
▲For finer work use softer sands, 1.18 or even 600 microns down
binder quantity must be diminished.
▲ALWAYS USE A WELL GRADED SHARP SAND
▲In a conventional mixer, dry mix lime with sand until uniform
Add water slowly until the required consistency is reached.
increase the setting time and can cause shrinkage.
increase the mixing time : 20 minutes approx.
▲Always wet or dampen the bricks or the application background to control suction
▲The amount of water used in this operation depends upon the water absorption of
the background or the materials used.
▲Protect from heavy rain and frost for approximately 72 hours or longer in protracted
adverse conditions.
▲Allow the mortar to dry gently by protecting it from strong wind or direct sun action.
If necessary moisten it by applying a light water mist.
▲Do not work below 5°C or above 30°C
▲Rework : Possible up to 24 hours. Please consult us.
▲SUGGESTED DOSAGES :
VOLUMETRIC RATIOS NHL 3.5 / SAND
1 Bag NHL 3.5 = 25 Kg
(Bulk Density 0,620 grams/litre)
Expected strength N/mm² 28 days / 180 days
1:1.5 or 1 Bag NHL 3.5 : 90 kg (60 litres) of Sand 3 7.5
1:2 or 1 Bag NHL 3.5 : 120 Kg (80 litres) of Sand 1.9 7.1
1:2.5 or 1 Bag NHL 3.5 : 150 Kg (100 litres) of Sand 1.5 5.3
1:3 or 1 Bag NHL 3.5 : 180 Kg (120 litres) of Sand 1.3 3.9
Sand density for above calculation : 1500 grams/litre
▲INITIAL SET :
Depending on weather conditions, dosage and amount of water in the mortar mix : 2-6 hours
▲INJECTION :
1 Bag NHL 3.5 : 30 litres of clean water. Mix with non cavitating whisk.
If caseine is added reduce amount of water.
Pump capacity 1.1m3 per hour.
Pressure : max 3 bars.
SAFETY
LIME
▲GRAVITY FEED :
1 Bag NHL 3.5, 45 kg fine sand
(1mm - 0.075)
Add water to obtain required fluidity.
STORE IN DRY PLACES
RESEAL PARTLY USED BAGS
CE

From Wikipedia entry (https://en.wikipedia.org/wiki/Hydraulic_lime):

Hydraulic lime (HL) is a general term for varieties of lime (calcium oxide), or slaked lime (calcium hydroxide), used to make lime mortar which set through hydration: thus they are called hydraulic. The other common types of lime mortar set through carbonation (re-absorbing carbon dioxide (CO2) from the air) and are sometimes called air lime. Hydraulic lime provides a faster initial set and higher compressive strength than air lime and eminently hydraulic lime will set in more extreme conditions including under water. Calcium reacts in the lime kiln with the clay minerals to produce silicates that enable some of the lime to set through hydration; any unreacted calcium is slaked to calcium hydroxide which sets through carbonation: These are sometimes called semi-hydraulic lime and include feebly and moderately hydraulic lime, NHL 2 and NHL 3.5. The terms hydraulic lime and hydrated lime are quite similar and may be confused but are not necessarily the same material: hydrated lime is any lime which has been slaked whether it sets through hydration, carbonation, or both.

The two basic types of hydraulic limes are natural hydraulic lime (NHL) and artificial hydraulic lime (AHL):
Natural hydraulic lime (NHL) is produced by heating (calcining) limestone that naturally contains clay and other impurities: no materials may be added to create the hydraulicity. In the United States NHL may be called hydrated hydraulic lime (HHL) per ASTM C-141 Standard Specification for Hydrated Hydraulic Lime for Structural Purposes.[1]
Artificial hydraulic lime (AHL) or artificial lime (AL) becomes hydraulic when hydraulic and/or pozzolan materials are added either before or after burning in a lime kiln. Artificial limes are more specifically identified as hydraulic lime (HL), as defined European Norm 459 (EN-459), "Consists of lime AND other materials such as [Portland] cement, blast furnace slag, fly ash, limestone filler and other suitable materials.";[1] formulated lime (FL) (EN-459) consists of "...mainly of hydrated lime and or NHL with added hydraulic and/or pozzolanic material. It is identical to HL but its composition must be declared on the CE marking.";[1] pozzolanic hydraulic lime (PHL) (ASTM C-1707) is "[v]ery similar to HL or FL. Consists mainly of hydrated lime with one or more pozzolans with possible inclusion of inert filler. When [Portland] cement, even traces, is present (can be up to 20% of binder weight), it has to be labeled as 'PHLc'."[1]

John Lynn - Smeaton's Eddystone Lighthouse. John Smeaton is credited with pioneering hydraulic lime in the 18th century which lead to the development of Portland cement and thus modern concrete.

Hydraulic lime is a useful building material for the following reasons:
It has a low elastic modulus.
There is no need for expansion (movement) joints.
It allows buildings to "breathe", and does not trap moisture in the walls.
It has a lower firing temperature than Portland cement, and is thus less polluting.
Stone and brickwork bonded with lime is easier to re-use.
Lime acts sacrificially in that it is weaker and breaks down more readily than the masonry, thus saving weaker stone such as sandstone and limestone from the harmful effects of temperature expansion and mortar freeze.
It is less dense than cement, thus less cold bridging.
Lime re-absorbs the carbon dioxide (CO2) emitted by its calcination (firing), thus partially offsetting the large amount emitted during its manufacture. The more hydraulic a lime, the less CO2 is reabsorbed during set, for example, 50% of CO2 is reabsorbed by NHL 3.5 during the set, compared to 100% of CO2 being reabsorbed by pure calcium hydroxide (fat lime putty).