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Hydraulic Lime Mortars

General Information

Hydraulic limes are a traditional building material that has been used for thousands of years, the Greeks, Egyptians and Romans all used forms of hydraulic lime.

Most pre 1920's buildings were constructed using building limes, either hydraulic lime or hydrated lime.

Small lime kilns were located in many areas throughout the British Isles. However, as much of the available limestone contained impurities that would make it unsuitable for modern industrialised lime manufacture it was particularly suitable as a building material due to the property of hydraulicity present, in varying degrees, depending on the composition of the raw material source.

Hydraulic lime was the principal binder for mortars up to the mid 1800's when Portland cement was developed as a product. Hydraulic lime sets faster and harder than the more pure hydrated limes, which require the addition of cement in order to set, with the strength of the chemical set increasing in proportion to the amount of silicates that are present in the raw material used in manufacture.

Although relatively weak and slow in setting and developing strength, when compared to cement based mortars, mortars produced with hydraulic lime were suitable for the relatively thick walls and lower stresses that generally characterised the more massive masonry construction of former times. In spite of the fact that mortars based on hydraulic lime had for centuries produced a durable product, specifiers, perhaps acting on the premise that 'the hardest and strongest' were the best, began to specify only mortars based on Portland cement. Currently, mortars produced with hydraulic lime are readily used for exterior renders and for the masonry structure itself.

Definitions

The European Standard for Building lime, BS EN 459-1 is entitled: Building lime: Definitions, specifications and conformity criteria. Lime is defined in the standard as calcium oxide and/or hydroxide and calcium magnesium oxide and/or hydroxide produced by thermal decomposition (calcination) of naturally occurring calcium carbonate (e.g. limestone) or calcium magnesium carbonate (e.g. dolomite).

This standard describes two families of building limes:

- Air lime: This is defined as lime which combines and hardens with carbon dioxide present in the air. It is stated that air lime has no hydraulic properties.
- Lime with hydraulic properties: This is defined as consisting mainly of calcium hydroxide, calcium silicates and calcium aluminates. It has the property of setting and hardening when mixed with water and/or under water. Reaction with atmospheric carbon dioxide (carbonation) is also part of the hardening process.

These descriptions help to define the properties of and differences between the two families, Air lime only sets in contact with carbon dioxide in the air and lime with hydraulic properties will start to set when mixed with water and complete setting when in contact with carbon dioxide in the air.

In BS EN 459-1, lime with hydraulic properties can be further classified into three sub families:

- Natural hydraulic lime (NHL): This is produced by burning more or less argillaceous or siliceous limestone and then reducing it to a powder by slaking with or without grinding. The hydraulic properties result from the chemical composition of the raw materials.
- Formulated lime (FL): Formulated lime consists of air lime and/or natural hydraulic lime with added hydraulic or pozzolanic material. Inclusion of any cement or cement clinker must be declared.
- Hydraulic lime (HL); This is a binder consisting of lime and other materials such as cement, blast furnace slag, limestone filler and other suitable materials.

Standard Requirements

BS EN 459-1 lists the chemical and physical requirements for hydraulic limes. For all three categories there are three compressive strength grades (compressive strength is determined in accordance with BS EN 459-2 Building Lime: Test Methods). The strength grades are shown in Table 1.

For each of the three sub families of hydraulic lime, requirements are prescribed for the chemically available calcium hydroxide content (known as the available lime), particle size, free water content, soundness and setting times. There are also tests for mortars made with the lime, (consistence and air content).

Table 1. Compressive strength requirements for hydraulic lime

Type of lime	7 day strength (MPa)	26 day strength (MPa)	Final setting times* (h)
NHL 2, FL2, HL2	-----	≥ 2 to ≤ 7	≤ 40
NHL 3.5, FL 3.5, HL3.5	-----	≥ 3.5 to ≤ 10	≤ 30
NHL 5, FL5, HL5	≥ 2	≥ 5 to ≤ 15	≤ 15

* HL2; HL3,5 and HL5 all ≤ 15h

Strength Development and classification of lime mortars

Natural hydraulic limes were traditionally classified as shown in Table 2.

The strength of a hydraulic lime mortar develops slowly and is defined as that which is reached at 91 days of age as shown in table 3. The Content of lime raw material 'impurities', eg clay as silicates and aluminates, will influence the setting and hardening characteristics.

Additional guidance may be found in DD BS 5628-4: 2008 draft code for use of NHL mortars, which is available – free to download from the NHBC Foundation at www.nhbcfoundation.org.

Table: 2 Traditional descriptions for natural hydraulic lime

Type of lime	Traditional name
NHL 2	Feebly hygraulic lime
NHL 3.5	Moderately hydraulic lime
NHL 5	Eminently hydraulic lime

Table 3. Classification of NHL mortars for use with masonry

Strength Class	Prescribed mortars (vol/vol)			Compressive Strength (MPa @ 91d)	Site Tested Strength (MPa @ 91d)
	NHL 2	NHL 3.5	NHL 5		
HLM 5	-----	1 : 1	1 : 2	5.0	4.0
HLM 3.5	-----	1 : 1½	1 : 2½	3.5	2.5
HLM 2.5	-----	1 : 2	1 : 3	2.5	1.5
HLM 1	1 : 2	1 : 3	-----	1.0	0.5

Applications of Hydraulic Lime Mortars

General guidance on the usage of lime mortars is given below, using the traditional terms for the type of hydraulic lime, but specifiers must also take into account exposure to prevailing climatic conditions.

NHL 2, FL2, HL2 (Feebly Hydraulic)
Natural hydraulic lime NHL 2 is typically used for internal works, external repointing / rendering and building on soft masonry in sheltered areas.

NHL 3.5, FL3.5, HL3.5 (Moderately Hydraulic)
Natural hydraulic lime NHL 3.5 is typically used for most repointing / rendering and building works on most masonry types.

NHL 5, FL3.5, HL5 (Eminently Hydraulic)
Natural hydraulic lime NHL 5 is typically used for external works in exposed areas such as chimneys, copings or river and canal works and provides a faster, harder set.

Properties of hydraulic lime mortars

For all mortar applications good working practices and good workmanship are paramount to achieving a successful outcome in terms of both appearance and the integrity of the finished masonry. The beneficial properties of hydraulic lime mortars are highlighted below:

- Good working and handling properties
- Good bond to bricks and blocks
- Good weather tightness
- Good vapour permeability (ability to "breathe")
- Tolerant of structural movement
- Easier to clean and recycle bricks and blocks
- Autogenous healing of minor cracking
- Reduced CO_2 generated in production.

Health and safety

Appropriate PPE must be worn with particular care taken for eye and skin protection.

Site Practice

Good house keeping at site from storage to use is essential and although site mixing can result in well prepared mortar there is no opportunity to develop a history of consistency or document the quality control required to conform to current standards. The materials for site mixing are generally supplied in bagged form and close site supervision is recommended during the mixing and laying process, as few modern craftsmen have experience with the use of hydraulic lime mortars.

Factory made mortars meet the exacting demands of all current standards and are available, delivered to site, as either ready to use or dry silo, in conformity with all relevant European standards and provide for CE marking, which will be compulsory fom July 2013.

These mortars generally require additional care and protection during the longer curing period.

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The Mortar Industry Association is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries

Mineral Products Association Ltd
Gillingham House
38 - 44 Gillingham Street
London SW1V 1HU
Tel +44 (0)20 7963 8000
Fax +44 (0)20 7963 8001
brian.james@mineralproducts.org
www.mortar.org.uk

There is a real danger of contact dermatitis or serious burns if skin comes into contact with wet mortar. Wear suitable protective clothing and eye protection. Where skin contact occurs either directly or through saturated clothing wash immediately with soap and water. For eye contact immediately wash out eyes thoroughly with clean water. If swallowed wash out mouth and drink plenty of water.

The relevant codes of practice, standards and statutory regulations must always be observed.

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