BS EN 459 - The new Standard for Building Lime

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History of Building Lime Testing

Lime has been used for many hundreds of years and until recent times the quality of Building Lime was measured using the expertise of the craftsman, rather than by analytical instruments.

Building Lime was produced locally, from whatever source of calcium was available and so the properties of the lime produced varied considerably. Chalk and limestone of varying purity and even sea shells were used. Product quality testing was basic and relied heavily on the experience of the lime burner. Experienced men were (and some still are) able to tell the quality of the lime they made from its' colour, weight and smell. Good quality, well burned quicklime has a distinctive smell and sounds like china when two pieces are knocked together, it is also considerably lighter in weight than the raw stone. The degree of burn can be seen by breaking open the quicklime lumps to reveal the unburnt core, which is darker in colour. Another indication of the degree of burn is the ferocity of the reaction between quicklime and water.

Over time, Building Lime production has moved from a local cottage industry, to an industrialised automated process which is carried out in large scale by a small number of companies.

This means that Building Lime as we know it is very different to the Building Lime used by our ancestors, even as recent as our parents in some cases. Product quality is now measured in numbers by the results of testing, rather than by appearance, smell and sound.

Modern day test methods and equipment are designed to produce results which are repeatable by staff in the same laboratory and reproducible by laboratories throughout the world. Test methods are well documented and standard equipment is used.

In the new Millennium, Lime is used for a myriad of applications and millions of tonnes of Building Lime are sold throughout Europe. The majority of this volume is sold as quicklime (calcium oxide) for the production of Autoclaved Aerated Concrete Blocks or Soil Stabilisation[(1)] or as hydrated lime (calcium hydroxide) for calcium silicate bricks, cement / lime / sand mortars or asphalt. It is important that Building Lime products are consistent in order to give predictable performance in these relatively high tech applications.

The British Lime Association website[2] contains information on the uses of Building Lime and lime for other applications.

Standards - a measurable improvement

In 1940, the British Standards Institute introduced British Standard BS890 for Building Lime[3], which gave limits for chemical and physical requirements for quicklime, hydrated lime and lime putty. Hydraulic lime was not included in the standard. BS890 was revised in 1966[4], 1972[5] and 1995[6].

In 1998, the European Committee for Standardisation (CEN) decided to amalgamate the Building Lime and Masonry Cement standards which existed in its member countries to create a harmonised standard. In May 1989 CEN began the process of drafting the new standard, with the goal of publishing completed national standards in mid 1992. Inevitably, there was some difficulty in reaching a European compromise and the process took much longer than predicted.

A number of important changes were made during the period, perhaps the most important of these was to separate the Building Lime and Masonry Cement standards work and to include hydraulic lime within the Building Lime standard.

The 1995 revision of BS890[6] made reference to the work of CEN and the forthcoming EN 459 standard for Building Lime, although the British Standard still made no reference to hydraulic limes.

EN 459 Building Lime[7] was finally published in 2001. The standard was split into three parts.
Part 1: Definitions, specifications and conformity criteria
Part 2: Test methods
Part 3: Conformity evaluation

Part 2 and 3 deal with testing for factory production control and factory inspection for CE marking. Part 1 is the most important part for the user as it contains the description of types of Building Lime and classes (different qualities) within the types.

Within EN459-1:2001 there are four types of lime which are classified as follows:

Type of Building Lime	Type Classifications
Calcium Lime	CL90, CL80, CL70
Dolomitic Lime	DL85, DL80
Natural Hydraulic Lime	NHL2, NHL3.5, NHL5
Hydraulic Lime	HL2, HL3.5, HL5

Calcium Lime and Dolomitic Lime are both known as Air Lime because they slowly harden in air by reacting with atmospheric carbon dioxide.

Natural Hydraulic Lime and Hydraulic Lime have the property of setting and hardening under water. Atmospheric carbon dioxide contributes to the hardening process.

The classes of Calcium Lime and Dolomitic Lime are defined by their % lime content and the classes of Natural Hydraulic Lime and Hydraulic Lime are defined by their minimum compressive strength in MPa.

The standardisation process is a complex series of technical discussions, followed by lobbying and negotiations at national and European level. The Building Limes Forum and the British Lime Association are represented at the British Standards committee B516/11 "Building Lime", which is in turn represented at the European Standardisation committee TC51/WG11 "Building Lime" and its sub committees. Standards are reviewed every five years and the review process can take anywhere from one year to several years.

It is important to understand that the Building Lime standard is designed to allow manufacturers to make consistent quality products, rather than to reflect how those products will perform in use. For example, the strength of a lime mortar made with either lime putty or hydraulic lime will rely heavily on the type and grading of sand used, together with mix ratios and good working practice. The strength measurements used in the Building Limes standard are tested using a mortar made from a standard sand and predetermined measured amount of water, a mix which would not be chosen on site, but which allows consistent mortar prisms to be made and enables the manufacturer to compare strength between batches of Building Lime. Laboratory strength measurements are made at 28 days and in controlled high humidity storage conditions, whereas strength of a mortar on site will depend on drying rates and will increase up to and beyond 90 days.

The compressive strength bands for Natural Hydraulic Lime and Hydraulic Lime are based on 28 day results and have wide tolerances, due to limits on the accuracy of the measurement equipment and testing error.

Type of Building Lime	Type Classification	Compressive Strength (MPa) At 28 Days	Vicat Classification
Natural Hydraulic Lime or Hydraulic Lime	NHL2 or HL2	≥ 2 to ≤ 7	Feebly to Moderately hydraulic
Natural Hydraulic Lime or Hydraulic Lime	NHL3.5 or HL3.5	≥ 3.5 to ≤ 10	Moderately to Eminently hydraulic
Natural Hydraulic Lime or Hydraulic Lime	NHL5 or HL5	≥ 5 to ≤ 15	Eminently hydraulic to cement

As a user, it is important to understand the performance characteristics of not only the Type of lime you are using, but also of the brand. Products may have a greater or lesser degree of hydraulic set even within a Type Classification, leading to very different short term setting and long term performance characteristics in use. If in doubt, your lime supplier should be able to give guidance on product performance characteristics.

What has changed in the new Standard - BS EN 459 :2010
The 2001 version of the Building Limes standard has been completely revised to produce the 2010 version. This revision takes account of product and market developments.

In order to make the standard easier to use, part 1 (BS EN 459-1:2010) has been separated into two main sections containing Air Lime and Lime with Hydraulic Properties. These two families of products are then divided into sub families as follows:

Family of Building Lime	Sub Family of Building Lime	Type
Air Lime	Calcium Lime	CL90, CL80, CL70
	Dolomitic Lime	DL90, DL85, DL80
Lime with Hydraulic Properties	Natural Hydraulic Lime	NHL2, NHL3.5, NHL5
	Formulated Lime	FL2, FL3.5, FL5
	Hydraulic Lime	HL2, HL3.5, HL5

In addition, the Air Limes, which are Calcium Lime and Dolomitic Lime are classified according to the form of the product, quicklime (Q), hydrated lime (S), lime putty (S PL) or milk of lime (S ML).

i.e. CL90-Q is a quicklime with at least 90% calcium and magnesium oxide.
CL90-S is a hydrated lime with at least 90% calcium and magnesium oxide (pro rata).
CL90-S PL is a lime putty with at least 90% calcium and magnesium oxide (pro rata).

Each Family of Building Lime is fully described within its own section of the standard.

Once again, both types of Air Lime (Calcium Lime and Dolomitic Lime) are defined by their % lime content, the higher the number, the greater the lime content. Types of Lime with Hydraulic Properties are defined by their compressive strength in MPa, the higher the number, the stronger and faster the product will set.

The Air Lime categories remain relatively unchanged, however the scope of the standard now covers all of the following applications:

- preparation of binder for mortar (for example for masonry, rendering and plastering),
- production of other construction products (for example calcium silicate bricks, autoclaved aerated concrete, concrete, etc.),
- civil engineering applications (for example soil treatment, asphalt mixtures, etc.).

Reactivity and particle size distribution of quicklime are also described.

The Lime with Hydraulic Properties portion of the standard has changed significantly. The 2001 version of the standard contains class descriptions and chemical requirements that might allow cementitious products to be categorised as "Hydraulic

Lime". The current revision aims to address this by more clearly defining the sub families and compulsory declaration of contents.

There are now three sub families of Lime with Hydraulic Properties:

Natural Hydraulic Lime
"Natural hydraulic lime is a lime with hydraulic properties produced by burning of more or less argillaceous or siliceous limestones (incl. chalk) with reduction to powder by slaking with or without grinding. It has the property of setting and hardening when mixed with water and by reaction with carbon dioxide from the air (carbonation).
The hydraulic properties exclusively result from special chemical composition of the natural raw material. Grinding agents up to 0,1 % are allowed. Natural hydraulic lime does not contain any other additions." (8)

Natural Hydraulic Lime is the choice for building restoration and conservation. It is quarried for its composition and burned at lower temperatures in order to promote the formation of di-calcium silicates (belite) which have a slower, weaker hydraulic set than the tri-calcium silicates (alite) found in modern cements.

Formulated Lime
"Formulated lime is a lime with hydraulic properties mainly consisting of air lime (CL) and/or natural hydraulic lime (NHL) with added hydraulic and/or pozzolanic material. It has the property of setting and hardening when mixed with water and by reaction with carbon dioxide from the air (carbonation)." (8)

Formulated Lime is a mixture of Air Lime and/or Natural Hydraulic Lime together with hydraulic or pozzolanic additives from a specified list. The manufacturer is obliged to notify the customer of any cement inclusion or of any single additive above 5% or total additives above 10%. The NHL-Z grade products from the 2001 standard will become Formulated Limes.

These are designer products for specific applications and are likely to be used mainly in new build.

Hydraulic Lime
"Hydraulic lime is a binder consisting of lime and other materials such as cement, blast furnace slag, fly ash, limestone filler and other suitable materials. It has the property of setting and hardening under water. Atmospheric carbon dioxide contributes to the hardening process." (8)

Hydraulic Lime is a product which, whilst it contains lime, may also contain cementitious by-products or additions . It is important to note that the manufacturer is not obliged to disclose its composition to the customer.

Part 2 (BS EN 459-2:2010) of the revised standard describes test methods and equipment used in factory production control. The 2001 standard contains many references to external test method standards, specifically BS EN 196 Methods of testing cement. The revised standard has replaced many of the external references with test method descriptions, so that all the information is held within the standard.

How will the new Standard affect you ?

The 2010 version of parts 1 and 2 of the standard were approved by CEN on 30 July 2010 and was published in September 2010. Following a six month transition period, they are now mandatory throughout Europe.

Part 3 of the standard (BS EN 459-3 Conformity evaluation) has undergone the formal vote process and should be approved and published in 2011.

If you are a user of Building Lime, the new standard should make it easier to identify, specify and purchase the type of lime that you need.

Most building and civil engineering applications of lime are covered by the revised Building Lime standard.

If you are currently work with hydraulic lime and it is important to you to know what is in the products that you use, then choose Natural Hydraulic Lime or Formulated Lime. NHBC has published NF12, The use of lime-based mortars in new build[9], which is a useful reference document.

Speed of set and long term performance characteristics vary between manufacturers, even for the same Type, so ask your supplier for information.

Lime manufacturers will have to ensure that Natural Hydraulic Lime remains pure Building Lime and have a wide range of possibilities to develop blended products as Formulated Lime. CE accreditation audits will now be more frequent, with an audit every 1 – 3 years, depending on production volumes.

Factory Production Capacity (tonnes)	Accreditation Frequency
> 10,000	yearly
> 1,000 and < 10,000	2 years
< 1,000	3 years

The Construction Products Regulation

The Construction Products Regulation (CPR) was published in the Official Journal of the EU (OJEU) on 4 April 2011 and will enter into force in the UK and the wider European Economic Area (EEA) on 24 April. On 1 July 2013, it will repeal and replace the existing EU Construction Products Directive (CPD).

From 1 July 2013, CE marking will become mandatory for placing the majority of construction products on the UK (and wider EEA) market. CE marking applies where a construction product is covered by a harmonised European product standard [or European Technical Approval (ETA)], such as BS EN 459-1:2010 Building Lime and includes conformity procedures and formal declaration of performance prior to affixing the CE marking.

The *free movement of goods* provides the cornerstone of the Treaty of Rome, the EU and the creation of a single, internal market. The principal barriers to the *free movement of goods* are 'technical barriers to trade' which the European Commission (EC) is charged with removing. The current CPD has been the EC's primary means for bringing this about.

The CPR is a legal instrument whose objective is to provide appropriately reliable information for construction products:

- in the form of *declarations of performance*;
- covering a number of *essential characteristics;-*

- related to health, safety and comfort etc;
- as derived from EU Member States building regulations.

The CPR covers the great majority of construction products by requiring conformity to either harmonised European product standards or European Technical Approvals/Assessments. Conformity procedures may require some level of involvement of an independent third party. The 'visible sign' that all the conformity procedures have been followed correctly is the CE mark.

Building Lime - the future

Although the new version of the standard is a significant step forward, there is still room for improvement. Work has already begun in preparation for the next revision with a proposal to include tests for properties such as flexural strength. Developing test methods from the current cement based tests to better suit lime is also on the agenda.

Natural Hydraulic Lime NHL 1 was introduced to replicate the weakly hydraulic "grey limes" of the south east of England[10], but was not accepted for the 2010 version of the standard. There is a proposal to introduce a British Standard for this product in the interim period and re apply for its' inclusion in the next revision of EN 459.

The Building Limes Forum and the British Lime Association will continue to work within the standardisation process to ensure that future revisions of the standard reflect the needs of the Building Lime community on behalf of users, specifiers and manufacturers.

Building Lime - acknowledgements

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Building Lime - references

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