Lime 101: A Brief Introduction

If you are restoring a historic building over 100 years old, you should be familiar that lime is probably what was used as a binder or a glue in your mortar or plaster. If you are building a new eco-friendly building, you might be familiar with lime's great eco-properties, such as absorbing Carbon Dioxide from the atmosphere. But for some of you, you might need a starting point, which is what this information bulletin is here for.

First off, lime has been used in the construction of buildings for over 6000 years. The Greeks and Romans used it to build their monumental structures and lime only fell out of vogue as a stand alone building material with the invention and widespread manufacture of Portland Cement just over 100 years ago.

Lime is made by taking calcium carbonate and burning it in a kiln. The forms of calcium carbonate can be quite varied, encompassing such materials as limestone, oystershell, marble, marl, or coral. All of these can be burned to make lime. Many different fuels can be used in the manufacture of lime including gas and coal, but also traditional fuels are used such as wood or peat. The burning process (also known as "calcining") reduces the calcium carbonate to calcium oxide and reverts an insoluble material (limestone) into a soluble material (quicklime). The burning process which takes place over 18-30 hours (maintaining a kiln temperature between 1250°F and 2150° F to make traditional building lime) releases water and carbon dioxide from the stone. The resultant quicklime is much lighter (due to the absence of $H2O$ and $CO2$) and is chalky to the touch, but still maintains the same size and shape as the raw product.

To get this lime into a usable form, it must be hydrated or slaked, to be used in mortars, plasters, and paints. The quicklime combines with water to form a hydrate. During the slaking process a tremendous amount of heat is released and the material reduces down. If the quicklime is slaked with a minimal addition of water the result is a powder or "hydrated lime". If an excess of water is used in slaking, the lime is reduced to a paste which is then aged to form "lime putty". When making lime putty, the mixture of water and quicklime can gain so much heat that the mixture can begin to boil within 10-20 seconds.

Now that we are now working with "LIME", we can add sand and water as necessary to make a mortar, plaster, or stucco, or we can add marble dust to make a Venetian plaster, or just reduce with additional water to make a simple limewash. After the material is applied, moisture evaporate out of the material and carbon dioxide (combined with water vapor from the atmosphere) is absorbed into the lime converting the material back into a form of calcium carbonate.

Possibly the most common method of making lime mortar (not plaster) was by firing the calcium carbonate and taking the resultant quicklime and combining it with sand and water fresh to form a "hot lime mortar". These hot lime mortars perform a bit better than "putty" mortars as they tend to dry out and set faster. If lime particles or "blips" are observed in a historic mortar sample, it is often indicative of a "hot lime" mortar.

This process is how “Non-Hydraulic Limes” are made and is commonly known as The Lime Cycle.

If the limestone contains naturally occurring silica and/or aluminates, the resultant lime would be hydraulic (or water setting). Depending on the amount of silica/aluminates in the stone, you can get a variety of compressive strengths and degrees of hydraulicity. These are classified by the European standard into three categories based on the materials compressive strength. Slightly (or to use the traditional term: Feebly) Hydraulic Limes are known as NHL2, moderately hydraulic limes are categorized as NHL3.5, and strong or “eminently” hydraulic limes are known as NHL5. Each of the numbers describe the materials compressive strength after 28 days in laboratory conditions measured in newtons per square millimeter. Each “newton” equates to approximately 145 pounds per square inch. Therefore for a NHL to be classified as a “2”, it should reach a compressive strength in 28 days of approximately 290 PSI. The entire classification system is a bit more complex, but as a rule of thumb this is how NHLs are classified. To be considered a Natural Hydraulic Lime the lime must be manufactured from a hydraulic limestone and cannot contain any artificial or “added” pozzolans or cement. As a rule of thumb, NHL2 can be used in many of the situations that a standard “TYPE O” masonry mortar might be used, NHL3.5 can be a good substitution for “TYPE N”, and NHL5 in many applications can take the place of “TYPE S” mortars.

The manufacture of Natural Hydraulic Limes is very similar to the manufacture of non-hydraulic lime. The limestone is calcined in a kiln to produce quicklime. However, at this point, the material cannot be slaked into a putty (which would hydrate the hydraulic compounds causing the putty to set). Traditionally the quicklime would be made into a hot lime mortar, or as in modern manufacture, the quicklime is slaked to a powder, adding a controlled amount of moisture to hydrate the “lime”, but monitoring the slaking so that the calcium silicates and aluminates do not initiate a set. Commercial manufacture of hydraulic limes began in the United States in the latter half of the 19^{th} century as industries boomed. Prior to this time, hydraulic lime production was a “cottage industry;” in other words, masons made their own lime from locally available raw materials. Hydraulic Lime was used in the construction of such structures as James Madison’s Montpelier (1831?) and Virginia Polytechnic Institute “Virginia Tech” (as late as the 1960s). NHL has also been used in the restoration of many structures including the Metropolitan Museum of Art, New York City and the Virginia State Capitol. Natural Hydraulic Limes offer a variety of properties all of which work perfectly for historic preservation and sustainable new construction, such as high degrees of vapor permeability, flexibility, and a wide range of compressive strengths.

We hope that this introduction to lime has been informative and invite you to take a look around www.virginialimeworks.com to see what lime has to offer you and your application. Together we can preserve our built heritage, construct new healthier homes and sustainable structures, and just begin to build better…naturally.