THE LIME CHRONICLES:

REPOINTING AND REBUILDING STONEWORK WITH LIME PUTTY MORTAR, A PRIMER:

Editor's note: This Primer focuses on mortars made with non-hydraulic or feebly hydraulic lime putty and their use in restoration projects. Future installments of The Lime Chronicles *will explore mortars made with 1) NHL, natural hydraulic lime, 2) site-batched lime putty made from hydrated lime and, 3) self-slaked quicklime.*

"Rock Mechanics in Extreme Environments" was the title of a 2002 workshop held at DC ROCKS (the American Rock Mechanics Association Symposium). Among presentation topics such as tunneling in NYC bedrock and deep drilling on Mars was one titled *Stone in Architecture*. Architecture is a truly extreme environment for stone.

For such a durable material, stone does not always do well when removed from the safe environs of the earth and exposed to the elements. In an architectural setting, it is at its most vulnerable. Stone needs to be protected. Yet it cannot be effectively sealed, waterproofed, or consolidated, even with contemporary technology. The ancients had an answer that is as applicable today as it was 2000 or more years ago: Lime.

A soft, 'sacrificial' element, lime mortar is yielding and permeable. It absorbs movement due to temperature-related expansion and contraction, and its permeability allows moisture to pass through and exit a structure. So the next time you see an old stone wall and remark upon the poor condition of the mortar, remember that it is performing exactly as it was designed to do.

Once one arrives at the conclusion that only lime mortar should be used to set or point stone, the actual challenges begin. For it is quite possible to compromise the process through a lack of understanding of the workmanship aspects of the material.

1) Mortar mix design:

In 10 BC, Vitruvius, the Roman architect, engineer and writer, codified the 1:3 proportion of lime to sand in mortar, and it is still the standard today. Mixing lime mortar ought then to be supremely straightforward. But it isn't.

Mortar is batched by volume. Damp, loose sand will fill a bucket to the top whereas the same sand in a dry state might only fill it two-thirds. This phenomenon is known as 'sand bulking.' Correct mortar proportions rely on sand being in a state called SSD (saturated, surface dry). This means that the individual sand particles have each absorbed as much moisture as they can hold, but there is no free water on the surface or between the particles.

When overly wet sand is used, two factors affect the quality and durability of the resulting mortar. First, the actual volume of sand in the mix decreases since some particles have been displaced by water). Second, there will now be an excess of water in the mix.

Conversely, if completely dry sand is used, the proportion of sand to water will increase, leaving the mortar water-starved.

Traditionally there were no ovens available to dry the sand so, as it was empirically obvious that wet sand interfered with the workability of the mix, it was protected from the elements. If heat or wind had rendered it too dry, just enough water was introduced to the sand prior to mixing the mortar.

As important as the moisture condition of the sand is its gradation, color, shape [angularity] and overall aggregate size, as this affects the ideal proportion in relation to the lime binder. Smaller aggregate size results in more surface area and requires more binder. The converse is true of large aggregates. It is best to use sharp (angular) sand that contains both fine and coarser particles.

Sand is graded by particle size, according to the size of the sieve through which they pass. The smallest sand particles are those which will pass through a #200 sieve (200 openings in a 1"x1" grid), and the largest those passed through a #4 sieve (4 openings in a 1"x1" grid.) Suppliers can provide the gradation for their products. Avoid poorly graded sands (i.e. silica sand with all particles between a #60 and #80 sieve) and remember that, for thin joints, the largest particle size should be no larger than #40 or #50.

2) Mortar mixing:

Lime putty mortars are worked in a condition that seems too dry to modern masons familiar with contemporary cementitious materials. While lime mortars can be mixed in some modern mixers, it requires a good deal more mix time to achieve a thorough mix. Traditionally, these mortars were mixed by pounding and beating the sand and lime binder together in a mortar box with a ramming rod made from a small section of tree trunk with a wood handle. Nowadays a hoe is often used to aid in the mixing process. By mechanical means, a mixing drill can be used for small pointing batches in a five-gallon pail. Whatever method is used, it is critical that enough energy is imparted to mix the sand and binder thoroughly.

Ideally the material to be used for pointing should have the consistency of brown sugar. It should be possible to pick up the mortar off the hawk with the pointing tool with only a slight hint of moisture left behind. With lime putty mortars, subsequent mixing will 'wake' the mortar to a workable state, without the addition of more water. Understanding the fact that lime putty mortars can maintain their workability for a 24 to 36 hour period without any remoistening is critical. Control the urge to add water to the mix!

Lime putty was traditionally made by placing burnt (quick) lime in a water-filled pit at the project site; the pit was covered to protect workers from the heat produced during the process and the resultant putty was allowed to mature. This was known as 'slaking' (as in slaking one's thirst). Under water, thus protected from reacting chemically with the air, this lime putty could be kept indefinitely. (Another method employed was using 'hot lime'—directly mixing the quicklime with the sand without the intermediary step of creating a putty.)

The use of lime putty was largely displaced when Portland cement-based mortar became the norm. Even so, for craftsmen who prefer to work with traditional materials, or are obliged to do so because of the specifications of a project, sources of slaked lime putty exist (i.e. US Heritage Group, Virginia Lime Works, Graymont Materials and others).

Although hydrated lime is mainly used to make Portland mortars more pliable, it can also be used to make lime putty. However, as stated at the outset, that topic will be explored in the next installment of *The Lime Chronicles*.

3) Work Site Access:

It is the nature of lime putty mortar that it needs to be both protected from extreme heat or cold and accessible for misting to promote carbonation (more on this later). While ladders and lifts are useful for the installation process, scaffolding often proves to be the most efficient method to access the work areas. The scaffolding should be designed so that it does not bear on the masonry or rely on it for structural support.

Historically, masons would drape cloth on the outside of the scaffolding when neces-