

WHY USE *ROSENDALE NATURAL CEMENT PRODUCTS*[®]?

Authenticity, Compatibility, Sustainability and ECONOMY

Natural cement was reintroduced into the North American marketplace in 2004 for the purpose of enabling repair/rebuilding in-kind to be performed on the tens of thousands of existing natural cement buildings and structures. Natural cement was the predominant hydraulic binder used in the United States and Canada during the 19th Century, and most of the buildings and structures built with this material remain in service today. As some become due for maintenance for the first time, and others face secondary repair cycles following interventions with substitute materials, debate has been renewed over best practices for the ongoing preservation of these structures.

This paper is intended to provide the specifier, owner, installer and other interested parties with a more complete understanding of the arguments favoring repair/rebuilding in-kind with natural cement. Closer examination on the basis of *Authenticity, Compatibility, Sustainability and Economy* will lead to the conclusion that use of natural cement has compelling advantages over alternative materials.



Figure 1. The American Museum of Natural History in New York City chose natural cement repointing mortar, replicating the original 1892 material, consciously embracing Authenticity and preserving the building's historic integrity.

AUTHENTICITY

Perhaps the most basic consideration favoring the use of natural cement in repair/rebuilding of historic natural cement structures is Authenticity. Buildings and structures built with natural cement are not just stone, terra cotta, concrete or stucco buildings, they are also *natural cement buildings*.

Historic buildings are diminished in authenticity and historic integrity when substitute materials are used without good cause. Are the original materials available? Did they perform effectively? Do they perform as well in restoration applications as they did in original construction

applications? If so, then original materials should be favored, and in the case of natural cement, the answer to all three is a resounding "YES!"



Figure 2. Once a prime example of late 19th Century natural cement architectural construction, Milwaukee City Hall's use of portland cement in restoration has practically eradicated the record of the unique construction technology originally employed.

Among the bases on which a building or structure can be designated as historic, is its representation of a building technology unique to a particular period. Natural cement construction was unique to a roughly 80-90 year period in the 19th and early 20th Centuries. No new natural cement buildings or structures are likely to ever be built. As natural cement in existing structures is replaced with historically inaccurate substitutes, the built record of this unique technology is being gradually eradicated.

economic development and defensive infrastructure of our country during its time. *It is worthy, in and of itself, of being preserved*, and that requires a commitment to repair/rebuilding in kind when maintenance work is needed. It is not portland cement, it is not hydraulic lime, it is a distinct class of historic material, and in North America it is what we used to build with during the 19th and early 20th Centuries.

Natural cement as a building technology was instrumental to the

COMPATIBILITY



Figure 3. Use of incompatible portland cement stucco at Fort Phoenix accelerated damage to original materials, which were lime-based. The damage took years to develop.

While it may seem intuitively obvious that replication of original materials is the simplest way to assure compatibility between remaining original materials and those being newly installed, this case is even more compelling for structures built with natural cement. In particular, natural cement is known to maintain low modulus of elasticity (flexibility) and high moisture vapor permeability over the long term.

Specifically, when moisture vapor transmission testing was performed on 150-year-old mortar at Fort Jefferson, Dry Tortugas National Park, it was found that the 150-year-old mortar had retained 80% of the moisture vapor permeability of a 28-day-old replication mortar. The same is not to be

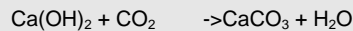
expected with modern cements. Portland cement continues to cure, strengthen and densify as it ages, reaching strengths approaching double their 28-day strengths after perhaps twenty years or so. With that continued densification comes reduced moisture vapor permeability. Accordingly, a

natural cement structure repaired with portland cement mortar may appear to be working compatibly for a number of years, but the longer it remains in place, the less compatible it becomes. Eventually, portland cement mortars can become significantly incompatible with existing materials, contributing to structural damage.

What is Carbonation?

Carbonation occurs in concrete because the calcium bearing phases present are attacked by carbon dioxide of the air and converted to calcium carbonate. Cement paste contains 25-50 wt% calcium hydroxide (Ca(OH)₂), which mean that the pH of the fresh cement paste is at least 12.5. The pH of a fully carbonated paste is about 7.

The concrete will carbonate if CO₂ from air or from water enters the concrete according to:



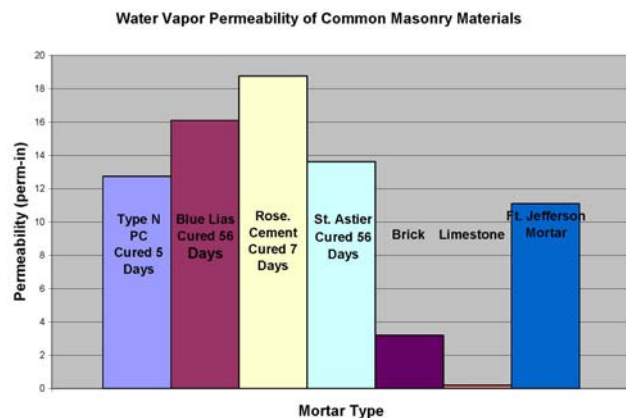
When Ca(OH)₂ is removed from the paste hydrated CSH will liberate CaO which will also carbonate. The rate of carbonation depends on porosity & moisture content of the concrete.

The carbonation process requires the presence of water because CO₂ dissolves in water forming H₂CO₃. If the concrete is too dry (RH <40%) CO₂ cannot dissolve and no carbonation occurs. If on the other hand it is too wet (RH >90%) CO₂ cannot enter the concrete and the concrete will not carbonate. Optimal conditions for carbonation occur at a RH of 50% (range 40-90%).

Normal carbonation results in a decrease of the porosity making the carbonated paste stronger. Carbonation is therefore an advantage in non-reinforced concrete. However, it is a disadvantage in reinforced concrete, as pH of carbonated concrete drops to about 7; a value below the passivation threshold of steel.

The same case can be made in regard to modulus of elasticity, the property that allows materials to deform under stress and relax forces which may build up between mortars and masonry units or between different structural elements. At Fort Jefferson, it had been observed that the outer brick veneer, set in natural cement, had been pushed out from the original natural cement concrete structure by as much as 12 inches or more, in some locations, without cracking the

mortar. This movement, resulting from corrosion of cast iron shutters embedded in the masonry, would have occurred continuously over the course of 150 years of salt spray exposure, indicating that the natural cement retained its low modulus/high creep capacity continuously over that period of time.



Portland cement, on the other hand, is known to embrittle as it carbonates over time, and is therefore more prone to cracking and delaminating in masonry joints over the course of several decades.

SUSTAINABILITY

The known limitations of replacement materials such as portland cement engender a need for more frequent maintenance interventions. Historic buildings must be viewed using a different frame of reference from buildings of less enduring value. Unlike many functional modern buildings, historic buildings should be expected to endure for as long as they are practically maintainable. Yet each maintenance intervention causes damage to historic fabric, however carefully that intervention may be executed.

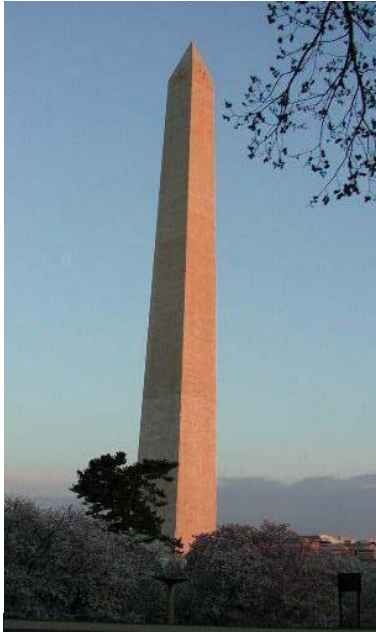


Figure 4. Increasing frequency of repointing may result from the use of less compatible substitute materials. Damage occurs with each repointing.

Over the long run, if we are to be able to maintain our historic buildings and structures for generations yet to come, maintenance work must be programmed in a more sustainable manner, designed to minimize such damages. Minimizing the frequency of these interventions is one of the simplest means available for assuring that outcome.

The use of materials proven to provide long-term durability beyond that which is achievable with modern materials is therefore justified on the basis of sustainability. If repointing in-kind with natural cement allows a service interval of 100-150 years between repointing campaigns, as opposed to 50 years or so with portland cement, the condition of the structure several centuries hence will substantially better by virtue of using natural cement. Given the minimal cost difference, *if any*, the more sustainable approach of using natural cement is compelling.

ECONOMICS

Much has been made of the relatively high cost of natural cement compared with substitute materials. This will only be the case, however, if the narrowest, short-term cost analysis is applied.

a. Material Cost vs. Labor Costs as Components of Project Cost

In a typical repointing campaign, labor, tools, scaffolding and site protection will account for perhaps 99% of project cost, while repointing materials will account for perhaps 1%. If natural cement mortars cost 10 times what alternative mortars cost, the difference as a component of overall cost is approximately 10%.



Figure 5. Natural cement mortar saves labor costs by allowing single-lift build-out, regardless of joint width and depth.

Natural cement, on the other hand, does not require the installation in lifts that is typically necessary with portland cement or lime mortars. The reason for installing portland cement and lime mortars in lifts is to reduce the effects of plastic shrinkage, much of which occurs in the first hours after mortar placement, until initial set has occurred. Due to the relatively fast initial setting time for natural cement, and its tendency toward low shrinkage, natural cement need not be applied in lifts.

Although the material must be placed gradually so that it can be properly compacted, it is simply built out fully in a single application without waiting to achieve thumbprint hardness.

This process is documented in historic publications describing natural cement stucco work. Initially, joints were raked out to a depth of 1 inch and then the mortar was placed into joints and scrubbed onto the masonry surface. The natural cement-sand mix was then simply built all the way out to the final profile and was immediately finished. These systems have provided up to 150 years of service.

The labor savings associated with this simplified application can be substantial, and in some recent project work, contractors expressed a willingness to absorb the material cost difference between portland cement-lime mortar and natural cement mortar without extra charges to the owner, on the basis that labor savings were greater than the material cost difference.



Figure 6. Corrosion of cast iron shutters at Fort Jefferson caused masonry to bow outward more than 12 inches, in some areas. The low modulus/high creep of the natural cement mortar used in original construction accommodated such movement for up to 150 years.

b. Life Cycle Cost

Differences in initial cost for natural cement are also mitigated by life cycle cost. Given the long-term durability of natural cement mortars, the avoidance of more frequent repointing campaigns makes natural cement a bargain. In constant dollars, ignoring inflation, the 10% premium for material cost is paid back 10 times over once the less durable materials must be replaced for the first time. Over the course of 150 years, this could amount to a 1000% return on investment, and the structure will be in better condition for having avoided two subsequent repointing campaigns.

c. Cost Changes

The cost of portland cement is rising, and is particularly influenced by rising fuel costs. Natural cement requires far less energy for its production, and the only reason for its current relatively high cost is the relatively low volume at which it is being produced.

As production volumes for natural cement increase, its cost will decrease sharply. Now five years into its reintroduction, the improved process efficiencies and increasing production volumes for natural cement will allow the first major price decrease to occur this Spring (2010). Eventually, natural cement can cost less than portland cement, opening the door to its use in certain types of new

construction, particularly green building areas. To get there, however, the restoration industry will have to exercise some leadership and specify its use.