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# LIMEWASH: COMPATIBLE COVERINGS FOR MASONRY AND STUCCO*

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## Abstract

Limewash is a versatile, accommodating, and robust surface covering that is compatible with a variety of building surfaces. It is maintainable, beautiful, stable, and long lasting. It is an aesthetic statement to many cultures, from the white houses of Greece, to earth tones of the southwest United States. This paper takes an on-site look at the practical aspects of limewashing on a wide variety of substrates and in a wide range of climates, including:

- Types of compatible substrates;
- Preparation of the substrate for lime washing;
- Use of pigments and additives;
- Application techniques on different substrates;
- Application techniques in different climates; and
- Maintenance.

The authors combine their experiences from both the science of lime and the practical application of lime, stone, and earth construction in Europe, America, and Australia--from lime plastering the Globe Theatre in London, England to lime washing modern three-coat stucco in Las Vegas, Nevada.

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# 1 Introduction

Limewash is an effective surface covering for a wide range of water-absorptive surfaces. Limewash is vapour-permeable and allows a building to "breathe." Limewash is robust and, in the proper number of coats, may consolidate and improve the condition of the underlying substrate. Limewash is stable and long lasting. Limewash is beautiful in either its brilliant white, non-pigmented native state, or when pigmented with compatible oxides to complement architectural colour schemes. Limewash has always been, and remains, a most effective way to protect, maintain and beautify the surface of historically-significant structures. Additionally, limewash can be an effective and innovative method to finish more modern surfaces. Limewash is materially inexpensive and well suited to professional or do-it-yourself application. Surface preparation for sound, previously limewashed surfaces is straightforward, generally only requiring a washdown with water to remove accumulated dirt and growth, or with a mixture of diluted vinegar to remove scale.

By taking an on-site look at limewashing, we hope to give a broad outline of its practical use and its advantages, limitations and qualities. By doing so, we hope to take the mystery out of limewash and advocate its return to commonplace use.

# 2 Using limewash: a general background

## 2.1 The substrate

The success of limewash application is dependent upon the quality of the surface, or substrate, to which it is applied. There are 3 major factors associated with the substrate: 1) mechanical key, 2) absorbency, and 3) chemical compatibility.

### 2.1.1 Mechanical key

A coarsely-textured surface provides the skeleton for a series of repeated thin coats of limewash that can build up to thicker and thicker depths with minimal or little cracking. Examples of coarsely-textured surfaces include stone, brick, adobe and concrete block, as well as clay, lime- and cement-based mortars and renders. . For new render, we may design the render mix with mechanical keying in mind. For example, using clay, lime or cement-based renders mixed with angular and coarser, well-graded sand (having sand grains of many different sizes) may improve the mechanical keying of subsequent thin coats of limewash. Additionally, the use of wood floats during the render finishing stage can also increase the texture of the surface.

Smooth surfaces may be limewashed; however, they can often benefit from a “roughening-up” using fine-to-medium abrasives, steel wool, or simply wire brushing, as the job allows. Examples of smooth surfaces include hard-trowelled renders and plasters, dense stones, timber, rusted steel, and glass.

### 2.1.2 Absorbency

Limewash needs an absorptive surface so it can penetrate into the substrate and exploit the potential for mechanical keying. The common test for absorbency is to apply water and observe whether the moisture is absorbed or not. If the moisture is absorbed by the substrate, the surface is a good candidate for limewashing. If, however, the wall has been treated with a non-absorbent material (e.g.

paint), the only real way to overcome this problem is to remove all of the non-absorbent material. Limewash is only as good as the substrate to which it is applied.

### 2.1.3 Chemical compatibility

Whereas we may mechanically change or enhance a substrate to be more limewash-friendly, we cannot necessarily change the substrate's chemical compatibility. The lime in limewash is applied as a very thin slurry suspended in water. Safe use of limewash can generally be expected on traditional materials such as lime, stone, soft brick, plaster, stucco, render and earth. Likewise, limewash can adhere to and be compatible with glass, but not plastic. Limewash will adhere to a rusty corrugated tin roof, but not the areas in which the tin has been treated. Limewash is not compatible with paints or other materials sensitive to high pH of 12 or more. If in doubt about compatibility, it is always best to try out some test panels on the material under consideration, or to contact the substrate manufacturer and inquire about the material's properties when exposed to high pH in a solution of water and/or moist environments during both application and during periods of high relative humidity (i.e. rain).

Cement- and lime-based mortars and renders have high values of pH in the presence of moisture. This alkaline nature is compatible with limewash. Regarding "limewash suitability", there is a difference between hand-applied cement render and concrete. In particular, cast concrete (and indeed any hard-trowelled or polished surface) will have developed a surface glaze, or laitance, which is less absorbent and, therefore, more difficult to limewash. For example, in the U.S. desert southwest, traditional plaster renders (stucco) based on lime and cement are commonly coarsely textured, porous and ideal for limewash. Contrary to this, smooth tilt-up concrete walls may prove more difficult to limewash.

## 2.2 Mixing and applying limewash

### 2.2.1 Sources of lime

The raw material for limewash may be available in one of three forms, depending on geographic location. The first form, quicklime, is calcium oxide, which is different than hydrated lime (calcium hydroxide). To make limewash from quicklime, the quicklime must first be carefully slaked (by adding water) in the approximate ratio of 8 gallons of water to 38 pounds of quicklime. Slaking converts the oxide to a hydroxide (National Lime Association, 1955). Manufacturer's instructions and safety precautions should always be followed before attempting to slake quicklime. Additional guidance is available from ASTM International in their standard, ASTM C 5-03, Specifications for Quicklime for Structural Purposes (ASTM, 2003). Slaking quicklime is hazardous and can cause severe bodily harm if proper safety precautions aren't followed. The chemical reaction is exothermic (generates tremendous heat) and the resulting hydroxide is very basic (has a high pH) that can cause chemical burns to skin, eyes, and other tissue.

Once slaked, the resulting putty is often left to age for some period of time. This period of time may last from 1 day to several months, depending on the quality of the quicklime. During this period of aging, the particle sizes of the individual grains of lime continue to decrease (Hansen, et.al, 1999). Regardless, at the end of the aging process, the putty is customarily sieved through a fine screen to remove any leftover grit and other impurities.

The second form of lime that may be available is lime putty. Lime putty is the end product of slaked quicklime. (Lime putty can also be made from hydrated lime powder, simply by adding water. This can both extend storage life of the lime and, in the case of hydrated high-calcium lime, may increase workability of the lime mortar.) Lime putty is often a thick lime paste that is approximately 50% lime and 50% water. This ratio may be slightly different depending on the manufacturer, but lime putty is always sold in a wet condition. Like lime that has been slaked, lime putty may have undergone a period of aging to reduce the particle size. It may have been pre-screened or it may need to be screened. A good general guide to lime putty that is sold commercially may be found in ASTM C 1489-01 Standard Specification for Lime Putty for Structural Purposes (ASTM, 2001).

The third commonly available form of lime is hydrated lime. Hydrated lime is generally sold in bags as a dry powder. Hydrated lime is made by adding just enough water to quicklime to satisfy the water demand of the chemical reaction that converts the calcium oxide (quicklime) into calcium hydroxide (hydrated lime). In many parts of the world, hydrated lime is made from limestone with a very high calcium content (95%+) and is known as high-calcium lime. Uniquely in the United States, hydrated lime for building construction applications is made from dolomite (magnesium-containing limestone) and is slaked in pressure hydrators or by secondary steam processing that results in a lime of the very finest particle size. This lime is ready for immediate use and is so special that it is given an ASTM designation of Type S, Special Hydrated Lime. High-calcium hydrated lime in the U.S. may be designated as Type N, for Normal Hydrated Lime, and will require a soaking period of at least 24 hours in water prior to use. Two ASTM standards, C 206-03, Standard Specification for Finishing Hydrated Lime and C 207-04, Standard Specification for Hydrated Lime for Masonry Purposes, provide good guidance on the specification of hydrated lime (ASTM C 206-03, 2003; ASTM C 207-04, 2004).

### 2.2.2 Making limewash

In general, limewash may be made from lime putty or hydrated lime by the addition of water to make a slurry with the consistency of whole milk. In terms of solids (lime) content, this works out to be a mixture that is approximately 15 to 20% lime and 80 to 85% water (one gallon of water, at 20 °C weighs 8.33 lbs.). For example, in our experience, using a 50 lb. bag of hydrated lime and 30.5 gallons of water gives the approximately correct ratio for a 20:80 mixture based on the weights of lime and water. Thinner slurry, for a 15:85 mixture, would require a 50 lb. bag of hydrated lime and 40.5 gallons of water. Lime putty already contains an excess of water and, therefore, an allowance must be made for adding just enough water to lime putty to achieve the above-mentioned solids contents. Water accounts for approximately 50% of a lime putty and, therefore, each pound of lime putty may only contain ½ lb. of lime. When mixing by weight, more lime putty and less water would have to be added to achieve the whole milk-like ratios. For example, 100 pounds of lime putty contains 50 lbs of lime and 50 lbs of water. To achieve a 20:80 mix with lime putty, 100 pounds of lime putty should be added to approximately 24 gallons of water. (The water that is already in the lime putty displaces approximately 6.1 gallons of water needed for the proper ratio.)

The above designs are only approximations. Each lime that is encountered may have slightly different water demands and experimentation may be required to find the exact amount of water to add to the lime that is used. Limewash may be physically mixed by the aide of an electric or battery-operated drill motor in which a long-stemmed paddle stirrer has been chucked. While it is possible to mix by hand, the use of power tools speeds the process. Limewash should be mixed long enough to assure that all the lime is in suspension. Making one large batch of limewash in a larger container and then transferring the limewash into more easily transported containers for application is beneficial. For example, a 32-gallon plastic rubbish bin (trash can) is a good container for a whole 50 lb. bag of hydrated lime mixed with 30.5 gallons of water. From this container, the limewash can be transferred into 5-gallon (or smaller) containers for work.

**NOTE:** Limewash can damage skin, eyes, and other tissue. The lime manufacturer's recommendations regarding safety and health should be followed.

### 2.2.3 Application of limewash

The importance of mixing limewash to a thin, whole milk-like consistency cannot be overemphasized. Limewash made too thick may appear to cover better when first applied, but will surely crack and craze upon drying, especially in the recesses of rougher-textured substrates. Like any fine-quality surface coating, many applied layers of thinned material build up a superior and, hence, more durable finish than fewer and thicker coats. Do not be tempted to thicken the mix. As a milk, limewash is superbly workable, easy to apply and very effective.

Practically speaking, when transferring limewash from the mixing vessel to the more manageable application containers (say from a 32-gallon mixing drum to a 5-gallon pail), the mix should be given a quick stir with the drill motor. This keeps the solids in suspension and makes the most of the previous efforts. During the transfer, pouring the transferred limewash through a 30 mesh (0.600 mm. openings) sieve, or similarly sized window screen, into the application container has been found to be advantageous. A good way of doing this is to use the lid of the 5-gallon bucket from which a circle has been cut to fit the screen, and then pouring through it. This method allows both hands to be used for scooping limewash out of the larger container with another 5-gallon bucket especially set aside for that purpose. Between uses, storing limewash in the mixing container for indefinite periods of time is possible as long as a lid is kept on the container to minimize evaporation of the water. (The thin layer of crystalline material or "scum" that forms on top of limewash stored for a period of time [even overnight] is pure calcium or calcium/magnesium carbonate. This layer is harmless and easily mixed back into the limewash upon the next stirring prior to further use.)

Depending on location, traditional limewash brushes may or may not be available. Limewash brushes are a matter of personal preference, but a brush with soft- to medium-stiff bristles that will hold limewash should be sought. Some countries have a good selection of limewash brushes that are commonly available at building supply or hardware stores (i.e. Greece), but in a pinch, a 4-inch to 6-inch ordinary paintbrush will work. Other brushes may be acquired by research on brush manufacturers via the Internet. There is no generally-accepted individual limewash brush for all application situations and different brushes may be experimented with to find one that suits the applicator best. Common stiff-bristled scrub-type brushes should be avoided since they just don't pick up and transfer the amount of limewash necessary for a good job.

Limewash can also be applied with a spray-type apparatus (e.g. a hand-pumped garden or insect type sprayer or a pneumatic or airless sprayer). When applying by sprayer, however, the limewash should be pre-screened to avoid plugging the nozzle. Nevertheless, we do not recommend the use of sprayers because sprayers make it very difficult to properly work the limewash into the substrate and the work has to be gone over again with a brush to smooth things out. (Additionally, even with pre-screening, there are inevitable nozzle plug-ups and extra time will be spent cleaning the nozzle.) For us, using a sprayer just adds one unnecessary step and increases the time needed to put on the limewash.

When limewash is first applied, it is translucent. But as it dries, limewash becomes opaque. As additional coats are applied, the hiding power and full beauty of the treatment becomes apparent. Keep the mix stirred while applying limewash with the brush. During application with the brush, use a scooping and swirling motion in the pail to keep the mix suspended. Work in patterns that assure full coverage.  Mark the last position on the wall by using a free hand to point to the next area to be covered.  Apply the limewash liberally and work it into the surface with strokes in many directions (up, down, and diagonal).  Expect the limewash to splatter off of the brush and be rather messy.  Drop clothes and masking should be used for areas that will not be covered by limewash.  On high walls, scaffolding, as opposed to ladders, provide advantages for both comfort and efficiency during application.  In some cases, use of a longer handle for the brush may help reach those otherwise hard-to-get-at areas.

### 2.2.4 Climate and other considerations for application of limewash

Working with lime in a wide range of climates can push the limits of application.  From the unpredictable Atlantic climate of southwest England, to the hot desert climate of western Australia and the high desert of the southwest U.S.A., protection and carbonation need to be considered.  The two are linked and necessary to ensure the highest quality of durability and beauty.  Very broadly, the carbonation of lime involves the chemical alteration of the hydroxide back into a carbonate (Figure 1).

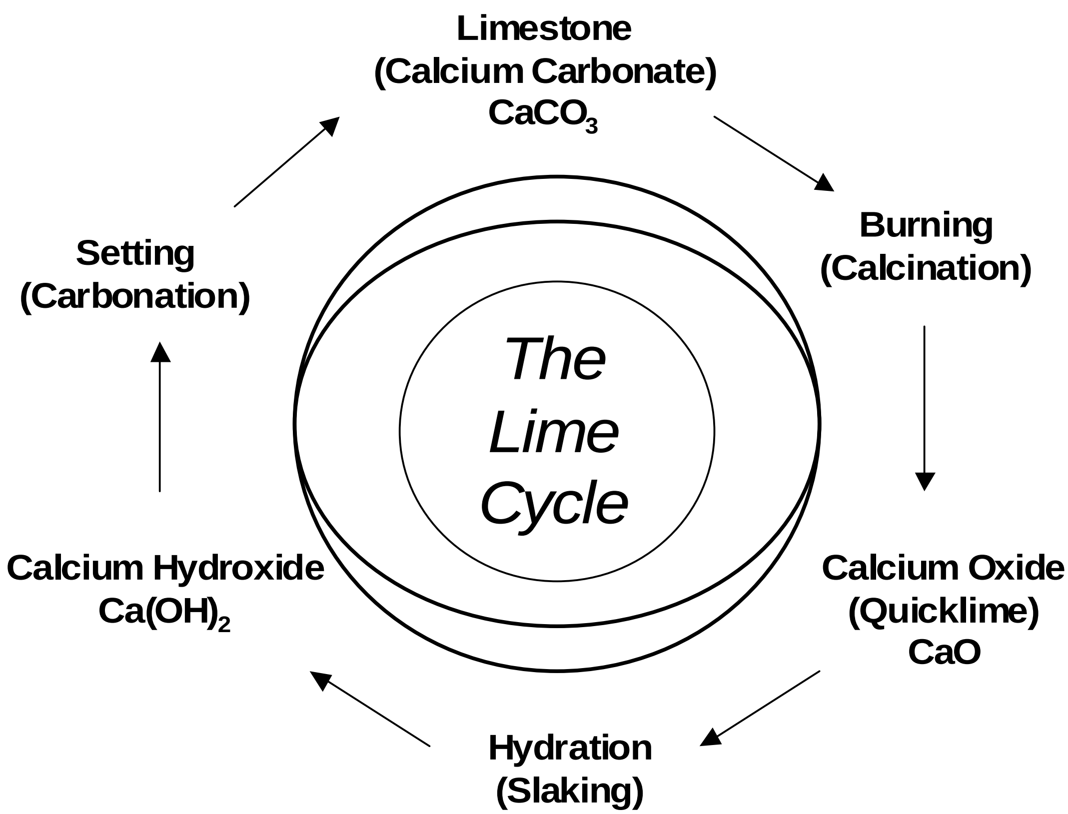


*Figure 1. The lime cycle: from stone, to lime, to stone.*

Carbon dioxide, dissolved in water, is one of the key components of the transformation from a chemical hydroxide back into a mineral of carbonate.  On site, encouragement of carbonation is best achieved under conditions of wet/dry cycles.  In climates with naturally-occurring cycles of wetting and drying, such as the Atlantic coastline, nature does some of the work for us (indeed, necessity sometimes forces us to work in the fog and rain!).  In drier climates, the focus is on lightly wetting down the limewash between - and even during - applications.  While the limewash should not be applied to a surface so soaked that a "sheen" of water is visible, a damp surface in a dry climate is both necessary and beneficial.   Add altitude and a rarified atmosphere, and drying can be very rapid. Time and work contracts do have their own momentum, but exterior surfaces should be worked outside the extreme times of any local climate; both avoiding times when frost is possible and times when temperatures may be too hot (40°C+).  When possible, work on the shaded side of the building to avoid a too-quick drying from the full sun.  In some climates, the spring and fall may be well suited to limewashing, as summer or winter may be in others.  To extend a limewash season, sheeting protection can be installed to create a microclimate next to the building.  This is always useful in unpredictable climates and can offer some protection in extremes.

### 2.2.5 Beauty

Limewash is uniquely beautiful, incredibly bright and gives off such a depth of colour that it appears to shine.  It is impressively vibrant at night and can lighten up the darkest of interior rooms or heavily-shaded courtyards.  On the Atlantic coast, lighthouses have been limewashed white in living memory, as have day marks for shipping.  Whether used on stone and earth houses, cathedrals and dry stone walls, or palaces and field barns, limewash has stood the test of time and has protected and decorated the structures of the world.

So what gives limewash these wonderful qualities?  The beautiful luminosity of a limewashed surface is due primarily to the reflection and refraction of light.  The intense brightness of non-pigmented limewash is largely due to the reflection of light back into the viewer's eyes.  A more subtle, but startling quality, is the refraction or bending of light through crystals of calcite (the carbonate mineral that forms through the process of carbonation).  Light refracted through calcite splits into two rays, one fast, one slow, and the visual effect is a doubling or twinning of the light emitted by the crystal. The intensity of the light itself is not changed, but when compounded by millions of microscopically-small calcite crystals increasing over time as the surface continues to carbonate, the effect is a surface that appears bright and vibrant with subtle internal texture and variance.  This mottled effect provides depth and interest to the viewer.

### 2.2.6 Pigments

Because limewash has a high pH, many organically-based pigments are destroyed and incapable of being used to impart colour to the mix.  If an organic pigment is desired to be used, the manufacturer should be contacted to assure compatibility in high pH (approximately 12 to 13).   Oxide-based pigments (e.g. iron oxide) are both alkaline pH compatible and available in a wide range of colours (e.g. yellow, red, brown, tan, green, pink, blue, etc.).  A good source of compatible oxides is available where pigments for masonry mortar are sold.  If a pigment is deemed compatible with masonry mortar (ASTM C 979-99,1999), it is a good candidate for coloring limewash.

Pigmented limewash is best mixed to subtle and pale pastel shades.  Darker colors are possible, but may overwhelm the very nature of limewash, a bright and light material.  Care should be taken to avoid adding too much pigment to limewash (e.g. more than 5% or so of the mix) because, in our experience, the pigment will tend to fall out of suspension and it will be difficult to achieve uniform colour.  Regardless of pigment choice, the first few coats for a pigment-colored job should be made with unadulterated limewash.  These first few coats of white provide the base and the proper adhesion to the substrate for the following colored coats.  The pigmented coats should go on thinly to build up the colour that is expected.  When wet, the pigmented limewash will look darker than when it dries on the wall.  The best way to achieve the desired result is to make some test panels on a section of substrate that has been limewashed white. Experimentation is the best way to achieve the desired look and can be accomplished quickly with a little planning beforehand.

For example, say that a yellow pigment has been chosen for the project; a pastel shade that complements the fenestration and trim. Using a gallon of wash from the storage container, add 1/4 gram of pigment, mix it up and apply it to a 1 sq.ft. area of test panel. While that experiment dries, add 1/4 gram more pigment to the same gallon of test material and apply it to a separate 1 sq.ft. area. Proceed in this stepwise fashion until the result is satisfactory. Using the best test panel as a touchstone, mix up another gallon of that mix design and apply a second coat to the touchstone test panel to see how the colour stabilizes. Does the panel darken too much or is it just right? If it is too dark (or not dark enough) then go back to the previous (or the next "one-up") panel, try a second coat of that mix design. Is this the result you wanted? If so, apply a third coat to that panel and decide if it yields the desired effect. Once the desired result is achieved, scale up the weight of the pigment to the required batch size. For example, if 1/4-gram pigment addition to 1 gallon of limewash produced the desired result, add 1 and 1/4 grams of pigment to 5 gallons of limewash, etc.

### 2.2.7 Additives

Additives are sometimes advocated for areas of the structure that are exposed to extremes of the weather and where water falling as rain has the tendency to erode the surface (e.g. parapets, splash zones near the ground, areas hit by sprinklers, etc.) While there are arguments for and against the use of additives in limewash in these types of areas, it is sometimes best to look at the overall structure for methods to prevent the damage caused by running water (e.g. flashing on top of parapets, gutters to minimize eave drip, re-positioning of sprinkler heads, etc).

However, when additives are preferred, they can range from the common to the regional. Common additives include linseed oil, tallow, and casein. Regional additives include mucilage from the Nopal Cactus, Alum, animal blood, urine, salt, formaldehyde, and a host of other concoctions. We believe that the use of additives should only be considered when other options of protection have been eliminated. Be aware that in areas where additives have been used, additional maintenance applications will require the use of additives as well. In general, this is because raw limewash will not adhere well to limewash or substrates adulterated with additive.

Additives to limewash can affect the limewash porosity and permeability, its tolerance to UV light, the surface skin behaviour and the general workability of limewash in application. Therefore, additives can affect the adhesion of limewash to the substrate. There is a balance to consider before choosing additives. As with pigments, the first few limewash coats need to be applied additive-free to provide the base and the proper adhesion to the substrate. The final coats may then be adulterated with the additive as desired.

### 2.2.8 The right number of coats

The biggest question people have regarding limewash is how many coats it will require to cover the surface. Again, properly-applied limewash must go on in a number of thin coats. As a protective and beautifying surface coating, limewash must adhere and "key" into the substrate. When put on thin and built-up, the various layers undergo more rapid partial carbonation during each period of wetting and drying, both prior to and during the application of the next coat. The end result is a surface that does not chalk when rubbed with the hand or other object. Properly applied and given a little time, limewashed surfaces will not chalk.

For example, Pete Mold repaired an eroded Cob barn (Moortown Farm, Dartmoor, England-a wet upland region with more than 39 inches annual precipitation) eight years ago (1996) using lime mortar and 3 to 4 coats of limewash. Without additives, there is no chalking and the limewash has remained in serviceable condition without recoating. Likewise, the erosion has ceased. As another example, a 6-year old rammed-earth limewash project remains trouble free in the extreme climate of Western Australia.

In terms of coverage, at least 3 to 5 coats of un-pigmented limewash can be expected for a typical rough-textured absorbent substrate. If the job is to be pigmented, expect to apply at least two more coats to achieve an even coverage of colour. Remember one very important point: all future work to maintain the original protection and beauty will only require an occasional freshening-up with very little preparation effort: a penny-saved and a pound earned!

## 3 Limewash: a case study

In 2004, Peter Mold was contracted to limewash a laboratory building in Henderson, Nevada, in the heart of the Mojave Desert. The laboratory building was a combination of 1960's era wood frame/ cement-lime stucco and 1940's smooth-finished cast-in-place concrete with a 10-foot (3 m) wall height above grade level. The laboratory building is located in an industrial complex and the stucco had been stained light brown from years of proximity to a manganese-producing facility. The stucco was integrally colored and had never been painted. The concrete had been painted several years before and was in poor, flaking condition.

The climate of the Mojave is second only to the Sahara in terms of dryness and heat. Because of time constraints, work began right at the end of the most optimal limewashing season, spring, and the beginning of the least desirable season, summer. Daytime temperatures were already reaching 100 F° (38°C), but the evenings were cooling off to a pleasant 70 F° (21°C). Winds during the time of the contract were generally unsettled and gusty up to 25 mph (40 kph). There was no precipitation during the time of the work.

An orbital pressure washer was determined to be most effective for cleaning dirt and grime from the stucco, as well as (in a more concentrated fashion) removing (blasting) paint from the concrete (caution: pressure washers may not be compatible with some soft historic surfaces). The stucco cleaned up well, but the manganese stains remained. Stucco cracks in some minor structurally-damaged areas of the wood frame section (where a vehicle had backed into a corner of the building) approached ¼" in width and extended in depth to the support lath below. Although minor in terms of structural importance, extensive surface hairline crazing and cracking was also evident in some areas of the original installation. The stucco had a few areas that required a parging repair using cement-lime mortar to a similar heavy lace stucco texture.

The concrete was more challenging, requiring nearly a week's worth of effort, but was successfully cleaned. The concrete had severe surface crazing in some areas, and also some areas needing a parging repair where the underlying structural steel rebar had corroded, expanded and "popped" off some surface material. However, after reducing the surface laitance by pressure washing, the concrete, though smooth, proved porous and permeable enough to continue.

Following cleaning and repair, a fresh batch of limewash was mixed up in a 32-gallon plastic rubbish bin (trash can) to a milk-like consistency using one 50 lb bag of Type S hydrated lime to 30 gallons of water. Test patches were completed on each surface to determine compatibility, absorbency, crack coverage and the best brush for each surface. Additional experimental patches of pigmented limewash were applied for the building owner's approval.

The initial coat on both materials was absorbed well and the stucco turned out to be quite easy to work with. All told, 5 coats of un-pigmented limewash, followed by two coats of pigmented limewash, covered that portion of the stucco wall that the owner wanted colored. For the front of the building, the owner decided that the limewash should be left unpigmented and a full 7 coats covered that section. The result was a very impressive consolidation of the surface cracks and filling of the larger, ¼" cracks. The concrete was more difficult because of uneven absorption, but by sticking at it, 13 coats finished the job. The concrete was pigmented as well, but never reached the same level of solid coverage as did the stucco. In all, the job required over 250 gallons of limewash. The tall areas of the building were worked from scaffolding, which allowed a more efficient application of material by avoiding many repeated trips up and down ladders. The entire job took one month to complete from start to finish, including cleaning, repair, experimentation and limewashing. The ragged, stained, and dirty building has been refreshed. (Figure 2)

*Figure 2. Front laboratory limewash, not pigmented.*

The most challenging aspect of this job was the climate. With daytime temperatures exceeding 100 F°, the limewash would flash dry and was impossible to keep constantly wet. Up until this job, Peter Mold had always been concerned with keeping things wet down and damp. Here, the Mojave Desert gave him no choice. What he learned from this job on these substrates was that frequent cycles of wetting and drying improve the rate of carbonation and that it is all right for a limewash to dry out between the cycles. He wet this system down at least 4 to 5 times a day in those areas that he had covered previously, but he let the system dry out overnight and flash-dry during the day. This has changed his mind regarding limewashing in the desert sun. Not only is it possible without shade protection; it has given one of the most durable finishes he has ever seen. The building owners say that there has been no erosion after the summer rainy season, and the surface does not chalk at all. The job was a complete success.

## 4 Conclusion

Today, limewash remains a proven, versatile and beautiful material to protect and maintain a wide range of building surfaces. It is materially inexpensive, easy to apply, and durable. Limewash can be pigmented to a variety of colors or be left pure white. Limewash can beneficially consolidate damaged substrates. Limewash is vapour-permeable, allowing a building to breathe from the inside to the outside. Carbonation of the surface over time, and encouraged during application by cycles of wetting and drying, increases the beauty and durability of the limewashed surface. We hope that this paper, which combined the experience of application and science, will encourage more people to consider the use of limewash on their next project, whether it is for protection and beautification of a historic structure, or as a compatible and beneficial application to a more modern surface.

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