



Characterization of Historic Mortar:

Old Town Hall

8 East St.

Southampton, MA 01073

Prepared for:

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Pioneer Valley Planning Commission

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Section 1.0: Purpose Statement

The purpose of a basic acid digestion mortar analysis is to determine the approximate proportions of the three principal components of historic mortars: aggregate, binder, and fines. Certain additives may also be detected through this method, though their proportions cannot always be accurately determined. This type of analysis is particularly useful for gaining general insights into a mortar's composition—either to simulate a historic blend or as a preliminary step before further instrumental testing. As a result, this test is most effective for identifying whether cement, lime, and sand are present and in what approximate quantities. Acid digestion plays a key role in planning repairs and maintenance for historic structures.

While this test helps distinguish general characteristics associated with different binders, it is inherently subjective and does not provide the same level of accuracy as an ASTM C1324 instrumental analysis. Additionally, this method cannot determine several key factors, including the original water mix, mixing and pointing method, drying rate, or the original condition and source of the aggregate. For further details on methodology, please refer to Section 4.0.

LimeWorks®.us personnel conduct these analyses with care to produce the most accurate results possible. However, clients should consult with owners, conservators, masons, or installers to assess material suitability, installation methods, and performance testing of recommended products beyond the data provided by the manufacturer. Based on the findings from this test, LimeWorks®.us will recommend a compatible material from our product line, along with any additional steps or services as needed or requested. These recommendations can be found in Section 3.0.

Section 1.1: Background

Mortar samples were sent to LimeWorks®.us by Shannon Walsh of the Pioneer Valley Planning Commission. Samples were extracted on March 20, 2025 from the historic portion of the Old Town Hall in Southampton, MA. The building is undergoing repointing as part of a National Park Service grant project. Built in 1904, the Old Town Hall is a contributing resource to the Southampton Center Historic District, listed in 1991. However, no additional details on the building were provided or could be located in the brief research done for this report.

Four samples were provided, labeled A-D. Samples A, B, and C came from the north, west, and east elevations, respectively. Sample D was taken from the south elevation, but this section is not historic. None of the samples had enough material to test alone, but cursory review of the samples suggested A-C were all likely the same material and so these samples were combined to form one sample for testing. Sample D was not tested.

**Section 1.2: Executive Summary**

Because the details of this report are lengthy, this executive summary section has been prepared in order to summarize the relevant conclusions and recommendations. Reading the full detailed report is highly recommended to understand these conclusions and recommendations to ensure accuracy and agreement with the goals of the project before proceeding.

In this section, “Test Results” summarizes the data from the mortar analysis, “Mix Recommendations” summarizes the kind of mix the client should look for in a replacement mortar, and “LimeWorks®.us Products” lists the products available through LimeWorks®.us that meet or are analog to the recommendations.

Recommendations are based on data from testing and information provided by client. Additional testing may necessitate revised recommendations, and it is the responsibility of the client to arrange such tests if desired or required. Mixes and products are to be considered substitutes for the historic mortar. If the historic mortar needs to be precisely replicated, additional testing according to ASTM C1324 would be required. It is the responsibility of the client to read this report in its entirety and, in consultation with stakeholders or other authorities, determine the suitability of recommended products. Color recommendations are based on submitted samples and may not reflect weathering conditions or variation present on the building. Mock ups are recommended to determine color suitability.

	Test Result	Mix Recommendation	LimeWorks®.us Products
Mortar	1 part feebly hydraulic lime to 3 parts moderately fine sand by weight. Approximately 1:2-2.5 by volume. Color is likely due to pigment.	1 part NHL 3.5 to 2-2.5 parts clean, coarse sand conforming to ASTM C144. Color with choice of materials or a UV and alkali stable pigment.	Ecologic™ Mortar SCG(G) 10% DGM Red / 90% DGM 050

Section 2.0: Analytical Summary

The physical and reactive properties of this sample suggest it contains a binder based on feebly hydraulic lime with an aggregate of moderately coarse sand in an approximate ratio of 1 parts binder (hydraulic lime) to 3 parts aggregate by weight with pigment added for color. This conclusion was based on the following observations:

Sample Composition (by weight):

Component	Values from Digestion
CaCO_3	~ 15.593%
$\text{CaMg}(\text{CO}_3)_2$	~ 1.414%
Solubles	~ 7.709%
Insolubles	~ 71.201%
Fines	~ 4.083%

Sample Observations:

- **Initial Observations:** The sample is in sound condition with a fine texture and a deep pink interior and a slightly dark crimson weathered face. Lime nodules, the remnants of quicklime, are visible but are quite fine and relatively evenly sized suggesting an aged or well-strained putty was used.
- **Color:** The weathered face corresponded to Munsell 10R 6/3 *pale red*.
- **Hardness:** The sample was moderately soft with a Mohs rating of 5, requiring little force to pulverize with a mortar and pestle.
- **Reactivity:** The sample had a vigorous strong reaction characterized by foamy effervescence, moderate off-gassing, and a minor increase in temperature when exposed to a 25% dilution of hydrochloric acid. Calcimeter capture indicated a high amount of calcium carbonate, likely from the lime binder.
- **Solubles:** The moderate solubles compared to the moderate hardness, minor temperature increase in acid, and high carbonate suggests a hydraulic material, likely a weak hydraulic lime.
- **Insolubles:** Some calcareous material may have been present in the aggregate based on pre-digestion microscopy. However, if present, the material represents a relatively small fraction of the aggregate and so insolubles essentially correspond to the sand. Sand was moderately coarse and but did not meet grading standards found in ASTM C144. The average color was 5YR 7/1 *light gray*. For more information on extracted aggregates please see Section 2.1.
- **Fines:** Fines extracted from the mortar were an average color of 7.5YR 5/6 *red*. The aggregate was clean with just over 4% fines. Fines appear to be pigment used to color the mortar.
- **PSQ Analysis:** Because potentially calcareous material was observed prior to digestion, supplementary assisted point-counting was performed. Binder-to-aggregate ratio was visually estimated at approximately 1:2½, a common historic ratio supported by the weight ratio from digestion. This suggests that if calcareous material was present, it was not a significant portion of the sand and did not contribute to meaningful distortion of the data.
- **Other Notes:** Acid digestion, already imprecise, is unable to adequately distinguish between hydraulic limes, lime-rich cement-lime, and natural cement mortars. The presence of hydraulic lime is inferred from experience and comparison to other materials of known composition, but is not certain. Given the potential presence of calcareous portions, hydraulic lime, and pigment further petrographic analysis is recommended.



Photograph of a portion of the sample before acid digestion showing clean breaks on the left and weathered faces on the right (fluorescent light, color corrected).

Section 2.1: Characterization of Extracted Aggregate

Prior to digestion, semi-lustrous white particles were observed in the sample partially obscured by the binder. These grains were initially suspected to be marble or another calcareous mineral, but many of the particles survived digestion intact. Visual examination suggests they are non-calcareous, possibly a white plagioclase feldspar. PSQ analysis of the binder-to-aggregate ratio supports the idea that very little if any calcareous material was present. However, given the geology of the originating area, the presence of a minor amount of calcareous material in the aggregate cannot be fully ruled out.

The extracted sand was dominated by clear to smoky white quartz, with a significant portion of feldspar, likely plagioclase. Subordinate quantities of lithic fragments, mica, and ferriferrous minerals — including some with weak magnetic properties — were also present. A small number of black, lustrous grains were observed, but without petrographic analysis, their precise mineralogy remains undetermined.

Once separated from the fines, the surviving the aggregate had an overall average color of 5YR 8/1 *light gray*. Average particle shape ranged from very elongate to equant in sphericity and angular to subrounded in roundness. The sand appears typical of a natural sand sourced from glacial deposits or fluvial origins.

Sieve analysis showed a particle distribution on an increasing curve skewed right from a #8 to #200 mesh (2.36mm to 75 μ m), with a majority of particles captured on a #100 mesh (150 μ m) followed by a sharp drop off between the #100 and #200 meshes. Trace amounts of material fell outside this range. The distribution of particles and sharp drop off suggests the aggregate may have been screened or washed prior to use.

The aggregate's fineness modulus was 1.918 indicating a moderately fine to medium sand. The sand fell just outside grading standards found in ASTM C144 primarily due to an excess of fine particles and uneven gradation. However, historical aggregates rarely meet modern standards. For detailed definitions of these terms, please see section 5.0.



Photomicrograph of a polished section before digestion with examples of lime nodules indicated by red arrows (incident daylight-balanced light, 10x magnification).



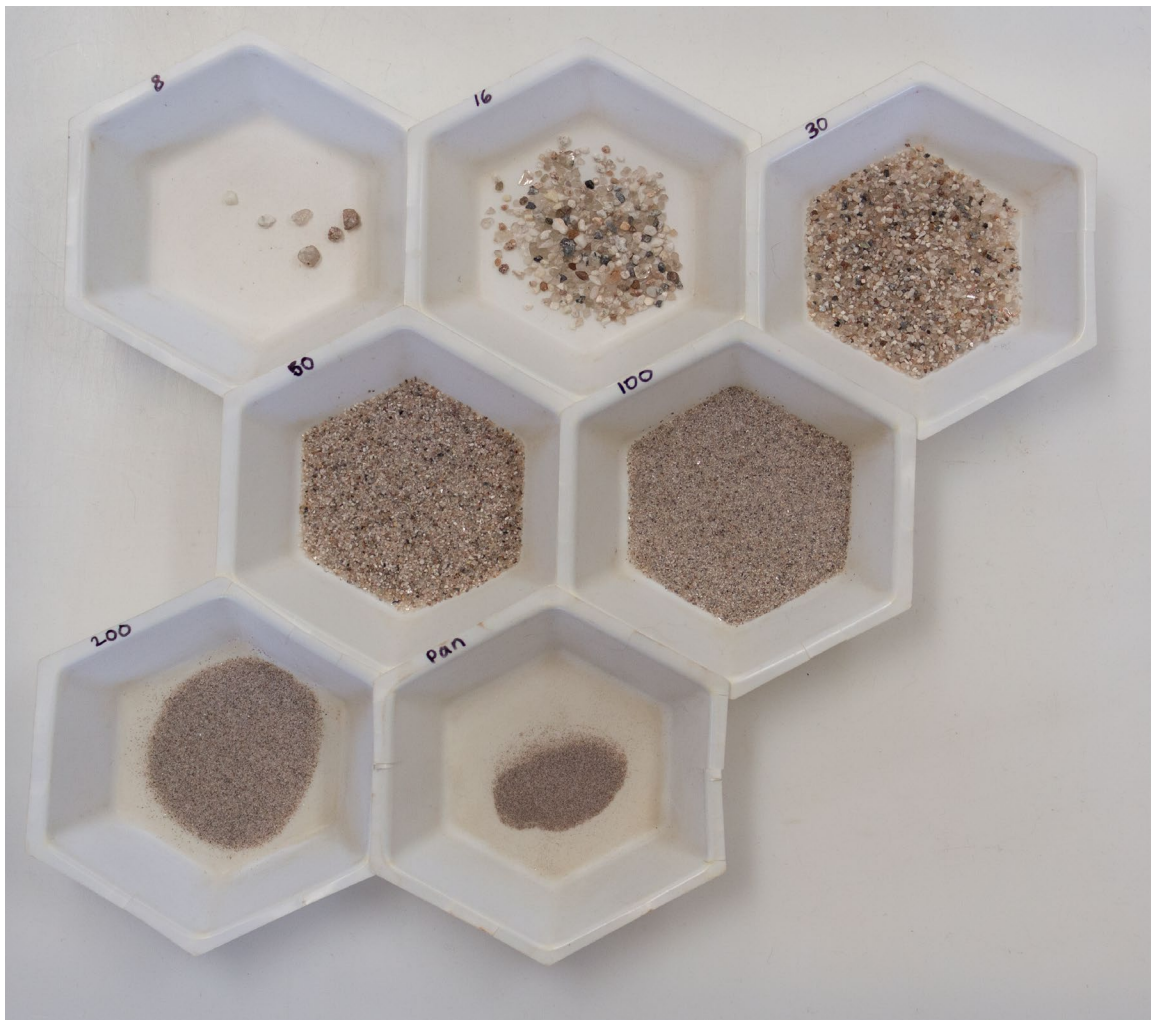
Photomicrograph of the extracted aggregate before sieving (incident daylight-balanced light, 10x magnification).



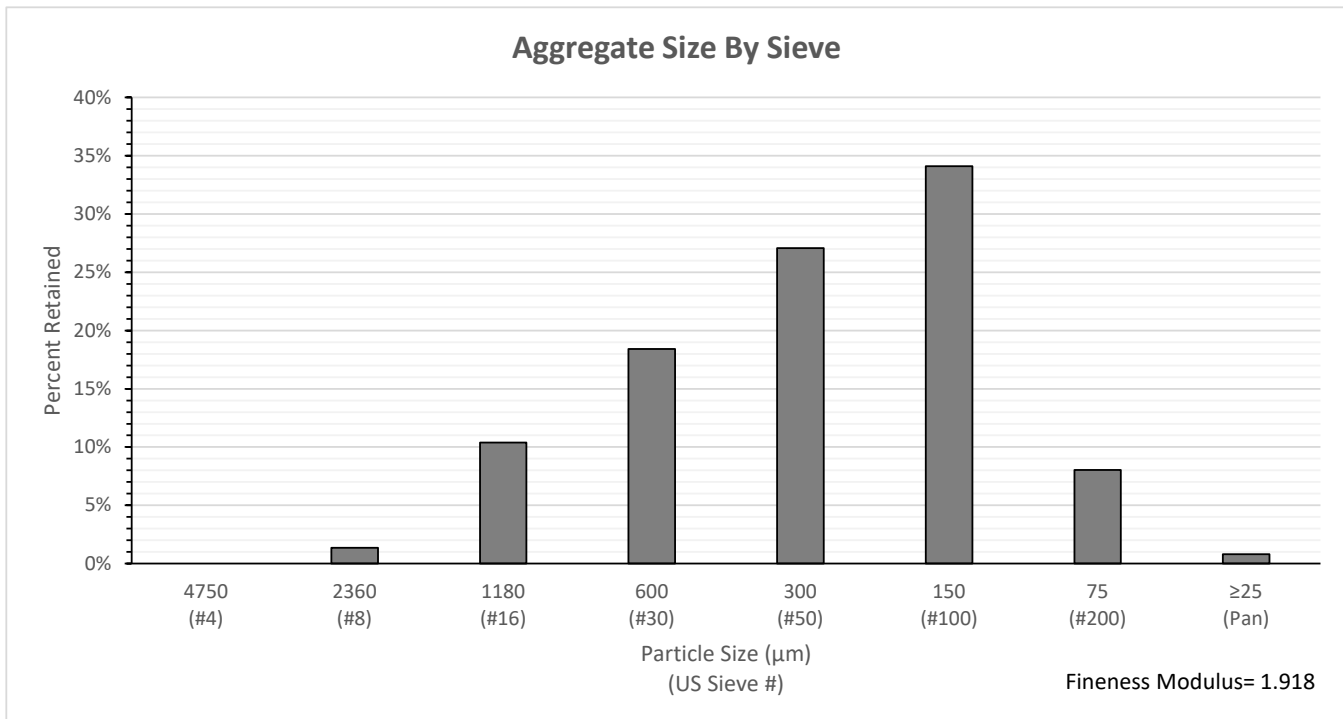
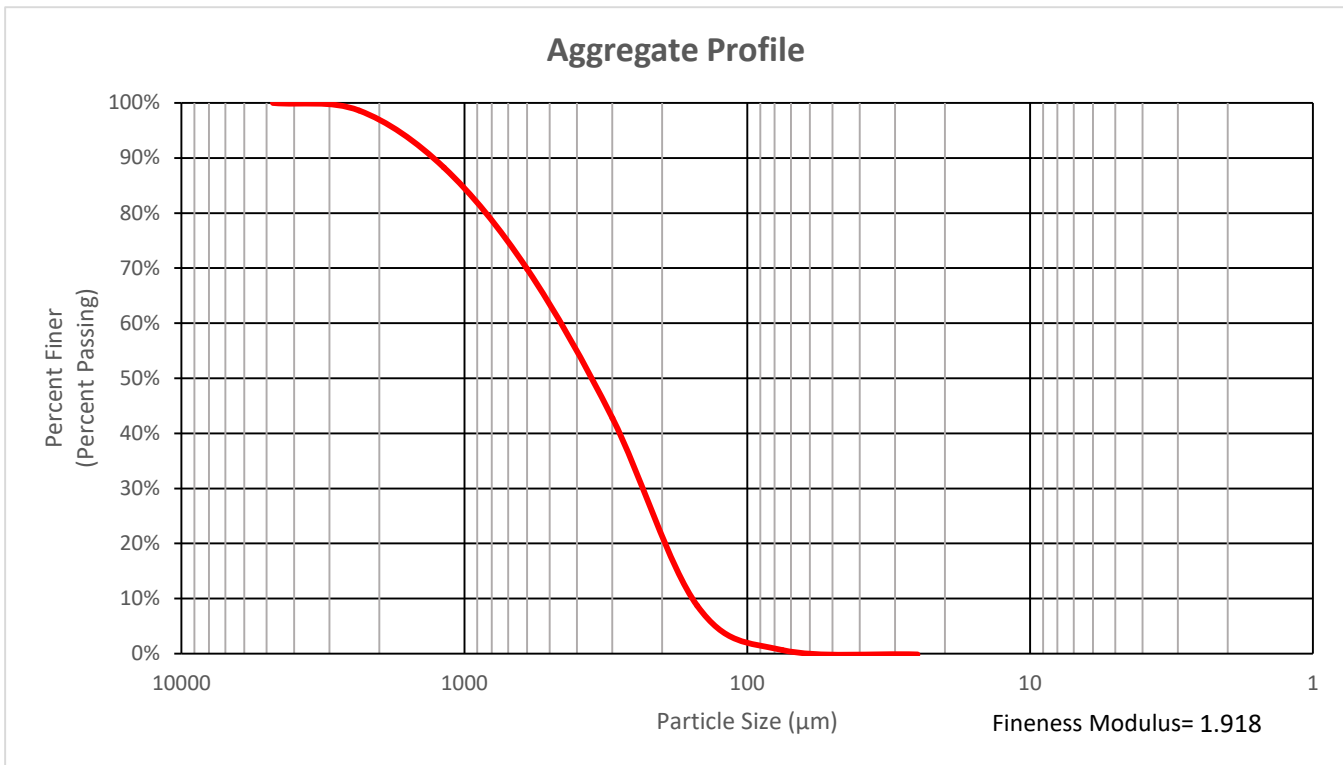
Extracted aggregates were sieved according to ASTM C136. Material was passed through a US Standard Sieve Stack (as governed in ASTM E11) and material retained on each mesh was recorded by weight and expressed as a percentage of the whole to determine approximate grading of the aggregate. Results are as follows:

Aggregate Grading:

Sieve Mesh	#4	#8	#16	#30	#50	#100	#200	Pan
Minimum Particle Size	4750µm	2360µm	1180µm	600µm	300µm	150µm	75µm	≥25µm
Aggregate Retained	0.000%	1.363%	10.388%	18.411%	27.076%	34.096%	8.023%	0.797%



Washed and sieved sands sorted according to sieve size (color corrected fluorescent light).



Profile of extracted combined aggregate showing particle size distribution in percent passing (top) and percent retained (bottom).

Section 3.0: Discussion and Product Recommendations

A.) Introduction

Though testing can suggest a composition and potentially appropriate substitute materials, material selection should not be based on limited testing of a few samples. Appropriate interventions result from comprehensive investigations of the context of the structure's environment and materials. The following discussion is provided as a means of starting a conversation on planning appropriate interventions and should not be regarded as objectively or conclusively authoritative by itself.

The Secretary of the Interiors' *Standards for the Treatment of Historic Properties* recommends replacing a historic mortar with one similar to or less dense than the original for restoration and rehabilitation projects. However, the standards acknowledge that changes in material preparation, new understanding of material properties, and weathering over time may necessitate a mix different than the original.¹ These standards were taken into account in the following recommendations. All mortar selections should conform to ASTM C1713, with pointing practices conforming to ASTM E2260.

B.) Discussion

The tested mortar appears to be a feebly hydraulic lime mortar with a moderately fine local sand. The color for the mortar comes primarily from what is assumed to be a red iron oxide pigment. While 1904 is relatively late for a pure lime mortar, their use persisted in rural areas where familiarity with cement was less common or in cost-sensitive projects due to the higher expense of portland cement at the time.

C.) Recommended Mix Design

Given the feebly hydraulic nature of the mix, a mortar no stronger than an NHL 3.5 is recommended.

NHL 3.5 should be mixed with sand in a ratio of 1 part lime to 2-2.5 parts sand. Sand should be clean, coarse, and conform to ASTM C144. Color with choice of ingredients or a UV and alkali stable pigment. Pre-mixed mortars meeting these recommendations are also acceptable.

D.) Available LimeWorks.us Products

From the LimeWorks.us product line, a blend of Ecologic™ Mortar in color combination 10% DGM Red / 90% DGM 050 mimicked the look of the tested sample while conforming to the previous recommendations. Please speak to a LimeWorks.us representative to obtain pricing and lead times if any further products or services are desired.

Please Note: LimeWorks.us assumes no responsibility for the implementation or success of any work completed based on this report. While analysis suggests the recommended products are appropriate replacements for the tested material, further testing or information not made available to testing parties, specific site conditions, or engineering considerations may necessitate significant deviation from these recommendations. Product recommendations are provided as a good faith courtesy and are not assurances or guarantees. Color recommendations are based on submitted samples and may not reflect in-situ weathering or variation. It is the responsibility of the client and any relevant stakeholders to perform mock ups and determine product suitability. Please speak to a LimeWorks.us representative to discuss timetables, pricing, and additional testing options if any additional services or products are necessary.



Portions of the tested sample compared to a tile of colored Ecologic™ Mortar (fluorescent light, color corrected).

¹ United States, Department of the Interior, National Park Service Technical Preservation Services, The Secretary of the Interior's Standard for the Treatment of Historic Properties, ed. Anne E. Grimmer, 2017, (accessed November 4, 2020, <https://www.nps.gov/tps/standards/treatment-guidelines-2017.pdf>), 84.



Section 4.0: Testing Methodology

Basic Acid Digestion Mortar Analysis:

Testing is completed by an architectural conservator specializing in masonry and with sufficient education and experience to meet the American Institute for Conservation's qualifications for a conservator and bound by the AIC's Code of Ethics; or an experienced lab technician under the observation and review of an architectural conservator. Reports are written by the same and reviewed according to LimeWorks®.us strict quality control standards. All testing is performed in a laboratory conditioned to ASTM C511 specifications for a mortar mixing room.

The approximate composition of the material was determined by referencing the Jedrzejewska analytical method with a calcimeter and techniques conforming to the specifications outlined in ASTM D4373.² This technique essentially dissolves a mortar to free its aggregate and provides data on the nature of the binder by gauging the extent of its reaction with hydrochloric acid (HCl). As HCl dissolves bicarbonates of calcium carbonate (CaCO_3) and magnesium calcium dicarbonate ($\text{CaMg}(\text{CO}_3)_2$) compounds found in lime and (to a lesser extent) cement binders, carbon dioxide (CO_2) is produced. While not absolute and open to a degree of interpretation, by using standard gas/temperature/pressure laws, it is possible to calculate approximate amounts of carbon dioxide released during the acid digestion of the sample providing a reasonable estimation of the amount of carbonates present in the binder of the sample. Data obtained during experimentation was compared with published experimental standards based on known mixes to arrive at conclusions about the composition of all samples.³ This method has its limits, as it can only give an approximation which can be skewed in the presence of certain additives like gypsum, and cannot differentiate between calcium carbonate and magnesium carbonate. Aggregates made of acid soluble material such as shells, marble, or limestone may also not be adequately characterized or may produce inconclusive results. A certain amount of error can be introduced by the process of crushing the sample for acid digestion, especially in mortars that require a great deal of force to pulverize.

Insoluble portions of the aggregate were retained and washed, while fine particulates of the material were captured in 20-25µm filter paper and retained. The aggregate was dried and weighed, and evaluated according to particulate size with a Standard U.S. Sieve Stack corresponding to ASTM E11 as outlined in ASTM C136. Sorted aggregate was then examined microscopically for particle sphericity, roundness, color, sorting, and other physical properties. Fine particulates, once filtered, were dried, weighed, and examined visually and microscopically. Color classification is performed using the Munsell Color System in accordance with ASTM D1535.

All microscopic examination was conducted using a Nikon® SMZ-2T trinocular reflected light microscope, illuminated by an AmScope™ 312W-2GOP LED daylight-balanced illuminator. Photographs of samples were captured using a Canon® EOS T5 DSLR camera with a special lens designed to make use of the microscope's trinocular bay. All photographs were then color corrected using Adobe® Photoshop™.

The degree of testing discussed herein is sufficient to establish a basic understanding about the composition of the materials supplied to our laboratory. That said, gravimetric analysis and tests which utilize acid digestion constitute an inexact science, relying substantially on the experience and interpretation of the analyst as well as comparison with materials with known composition. As such, this report should not be interpreted as providing absolute objective composition data on the material. Petrographic analysis including examination of thin sections in transmitted polarizing light and/or elemental analysis would be required to identify mineral phases which are specific to different types of cementing material and to unequivocally quantify the amount of lime and/or cement present. If analysis in accordance with testing procedures described in ASTM C1324 is desired, micro-chemical characterizations may be expanded upon with elemental analysis using techniques such as X-Ray Diffraction (XRD), petrography, and/or physical characterizations of thin sections using transmitted and polarized light microscopy.

² Hanna Jedrzejewska, "Old Mortars in Poland: A New Method of Investigation," *Studies in Conservation* 5, no. 4 (November 1960): doi:10.2307/1505237.

³ James Christopher Frey, *Exterior Stuccoes as an Interpretive and Conservation Asset: The Aiken-Rhett House*, Charleston, SC, Master's thesis, University of Pennsylvania, 1997 (Philadelphia, PA: University of Pennsylvania, 1997); John Stewart and James Moore, "Chemical Techniques of Historic Mortar Analysis," *Bulletin of the Association for Preservation Technology*, Vol. 14, No. 1 (Washington: APT, 1982), 11-16.

Photoshop Quantification (PSQ) Analysis:

Photoshop Quantification (PSQ) Analysis is a method of visual analysis of textural features of a specimen through the powerful software features of Adobe® Photoshop™. The process is similar to other visual analysis methods using software such as the more common but less feature rich Image J or manual point-counting under a microscope. A thin section of mortar is prepared and photographed under an appropriate level of magnification in order to capture a large enough surface area to be representative while still having textural features clearly visible. For smaller samples, this may require photographing multiple sections and stitching them together via photogrammetry. The sample photomicrograph is then loaded into Photoshop™ where features of interest are isolated and color coded on separate layers using the wide variety of automated and manual tools available in the program, which can include AI assistance in version of Photoshop™ issued after May 2023. Following feature isolation, the histogram tool is used to tabulate the amount of pixels occupied by each color of each target featured. These are then compared to the total pixel count of the image to calculate an approximate proportion of the target visual feature versus the entire photographed sample.

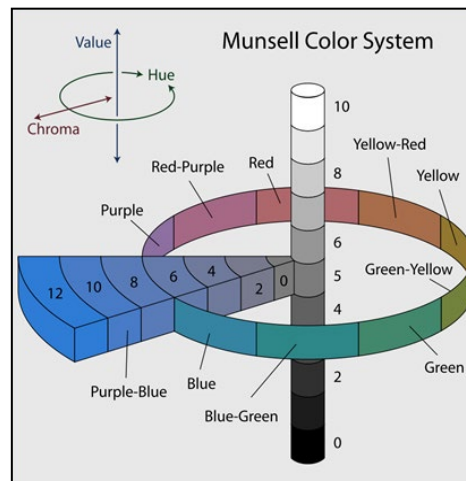
While useful to help clarify material proportions when other tests are inconclusive, PSQ analysis is at best a supplementary process relying on comparative data from more invasive physical or chemical testing. The accuracy of PSQ analysis is also dependent on the ability of the person manipulating the image to properly use the software to correctly and fully isolate targeted features, meaning a certain level of human bias and error is inevitable. Samples containing components that are similarly colored greatly impact the accuracy of PSQ analysis in normal incident lighting. The addition of photomicrographs taken in plane-polarized light (PPL) or cross-polarized light (XPL) can enhance measurement accuracy but are not commonly used for simpler tests such as a Basic Acid Digestion Mortar Analysis.

Though PSQ analysis is an evolution of earlier visual quantification techniques using different programs, the method of using explicitly Adobe® Photoshop™ was first proposed by X. Zhang et al. (2014) who found that in visually heterogeneous samples representing at least 10% of a whole specimen and processed by an experienced user, the proportion estimate discrepancy rate was usually under 3% than the actual proportions verified by more objective methods. Errors are generally much higher for visually homogeneous samples or difficult to visually isolate textural features.⁴

⁴ Xuefeng Zhang et al., “Adobe Photoshop Quantification (PSQ) Rather than Point-Counting: A Rapid and Precise Method for Quantifying Rock Textural Data and Porosities,” *Computers & Geosciences* 69 (August 2014): 62–71, <https://doi.org/10.1016/j.cageo.2014.04.003>.

Section 5.0: Definitions⁵

- **Aggregate:** Coarse to fine grained particles that, when bound together, form the body of a mortar and help control important properties like shrinkage, water content, strength, and durability. They may be manufactured from crushing or recycling materials or extracted from naturally occurring sites such as sand pits or waterways. In mortars, aggregate should not typically interact chemically with other components of the mix and should be appropriately graded for the specified application. Common aggregates include but are not limited to sand, gravel, crushed stone, and inert fillers.
- **ASTM:** Founded in 1898 and originally known as the American Society for Testing and Materials, ASTM International is a standards organization that develops and publishes technical standards. While ASTM has no means to require or enforce standard compliance, many organizations consider conforming to ASTM standards as mandatory. ASTM standards use an alphanumeric system with a classification letter, a serial number, and the last two digits of the issue date.
- **Binder:** A binding agent is an essential component of mortar that holds all other materials together to form a cohesive whole. Mortars generally have two binder classes—hydraulic binders, which harden due to interaction with water, and non-hydraulic binders, which harden through other means such as crystallization or exposure to air. Non-hydraulic binders can sometimes be made hydraulic by adding a pozzolan. A binder's mechanical and chemical properties play an important role in a mortar, including its physical properties, anticipated service life, and response to environmental factors like temperature, pollution, moisture, and salt.
- **Color:** Color is the perceived spectral composition of light as it interacts with an object or medium. Because perception is subjective, the Munsell Color System classifies color based on hue, lightness, and chroma. These values apply only to opaque samples viewed by individuals with normal color vision under daylight conditions. This method provides a cost-effective alternative to analytical procedures such as spectrophotometry. Munsell notations are given in the form of a number-letter-number combination representing Munsell hue (H), Munsell value (V), and Munsell chroma (C). The Munsell color guide also assigns each value an official name. Color classification using the Munsell Color System follows the procedures outlined in ASTM D1535.



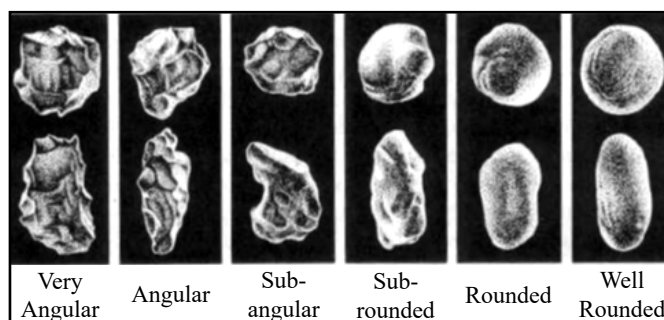
- **Filtrate:** Liquid that passes through a porous medium while separating insoluble solids from liquids. In a mortar analysis, the filtrate is generally composed of dilute hydrochloric acid and soluble compounds freed from the mortar. Filtrate color varies due to interactions between the mortar and the acid used in digestion.

⁵ Some definitions and figures adapted from: "Characterization of Granular Samples by Sieve Analysis," Graduate Department of Historic Preservation, HSPV 555, Spring 2016 (Philadelphia: University of Pennsylvania, 2016)

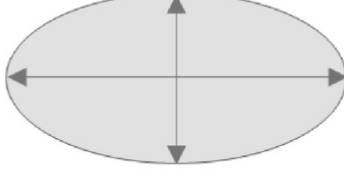
- **Fineness Modulus:** A numerical representation of the coarseness of an aggregate. The fineness modulus is determined by adding the percentage of aggregate particles retained on the #4-#100 sieves and dividing by 100. The resulting number is an empirical figure characterizing the coarseness of an aggregate sample. Generally, the higher the number, the coarser the aggregate. However, because this number can be acquired by different particle size distributions, the fineness modulus alone is not enough to adequately characterize the suitability of a given aggregate.
- **Fines:** Fines are particles retained on a filtration medium after washing solids released during mortar digestion. These particles are typically smaller than those captured on a sieve. In mortars, fines usually consist of clays, silts, pigments, and other rheological additives. The amount and nature of fines can impact the working properties, color, and final cured properties of a mortar. Unwashed aggregates and pigmented mortars typically have a high amount of fines.
- **Grading:** A measurement of how well distributed particulate sizes are within the aggregate of a sample. Aggregate with a broad, even distribution of grains from small to large is considered well-graded. Grading of materials helps regulate certain properties of a mortar, such as shrinkage, porosity, permeability, and curing behavior. Appropriate grading for modern mortars is governed by ASTM C144, but historic mortars will vary widely from modern specifications. Typically, modern mortar sands will have a fineness modulus between 2.1 and 3.2, with smaller numbers indicating a finer sand and larger a coarser sand.
- **Hardness:** The Mohs Hardness Scale ranks minerals by their resistance to scratching. A material with a Mohs rating of 5 can be scratched by a 6 but will scratch a 4. The scale is based on comparisons to known minerals, with lower numbers indicating softer materials and higher numbers indicating harder materials. Generally, more hydraulic materials are harder, meaning cement is usually harder than lime, gypsum, or clay. Hydraulic limes and cement-lime blends often fall between these extremes.

Hardness	1	2	3	4	5	6	7	8	9	10
Mineral	Talc	Gypsum	Calcite	Fluorite	Apatite	Feldspar	Quartz	Topaz	Corundum	Diamond

- **Pozzolan:** Minerals composed of siliceous and aluminous compounds that when combined with calcium hydroxide ($\text{Ca}(\text{OH})_2$) found in limes and certain cements will react with water to impart or increase cohesive properties. Pozzolans may be natural or artificial, and a wide variety of pozzolans have been used throughout human construction history.
- **Reactivity:** In a mortar analysis, reactivity refers to how a sample responds to hydrochloric acid. Carbonates, such as lime mortars and calcareous aggregates, produce carbon dioxide (CO_2) when exposed to acid, while cement-based mortars and gypsum release very little. Limes high in dolomite ($\text{CaMg}(\text{CO}_3)_2$) will have a secondary reaction after the primary calcium carbonate reaction (CaCO_3).
- **Roundness:** An observation of the sharpness of the edges and corners of a particle. A particle that is significantly worn by abrasion to the point that it appears smooth is considered *well-rounded*, while a particle that appears cleaved with very sharp edges and little abrasion is considered *very angular*.



- **Sphericity:** Sphericity compares the size of individual particles to how close they approach a perfect sphere. Samples very close to a sphere are said to be “very equant,” while samples that are more distant from spherical are said to be “very elongate.”

<i>RATIO</i>	<i>DESCRIPTION</i>	
<i>under 0.60</i>	<i>Very Elongate</i>	
<i>0.60 to 0.63</i>	<i>Elongate</i>	
<i>0.63 to 0.66</i>	<i>Subelongate</i>	
<i>0.66 to 0.69</i>	<i>Intermediate</i>	
<i>0.69 to 0.72</i>	<i>Subequant</i>	
<i>0.72 to 0.75</i>	<i>Equant</i>	
<i>over 0.75</i>	<i>Very Equant</i>	<i>width A / width B = ratio</i>

- **Solubles:** Substances which dissolve to form a solution with another substance, usually water or hydrochloric acid (HCl) in a mortar analysis. In an acid digestion mortar analysis, solubles are usually detected by the amount of weight lost on exposure to HCl that cannot be quantified by other tests. Pure lime mortars generally have high carbonate but few solubles, while products in cement are acid soluble but do not evolve CO₂. Whereas carbonate generally indicates the presence of lime, solubles generally indicate the likely presence of a hydraulic material like cement or pozzolans. So a mortar with low carbonate but high solubles indicates the probable presence of a cement, while moderate solubles and low hardness could indicate a hydraulic lime.
- **Sorting:** Sorting describes the distribution of particle sizes within a sample. Well-sorted samples have uniform particle sizes, while poorly sorted samples contain a mix of various sizes and shapes. The degree of sorting influences the properties of the mortar, including porosity, workability, and durability.

