



Custom Mortar Matching Report

Project: USHG# [REDACTED]

Analysis Date: 7/22/2016

Project: [REDACTED]

Client: [REDACTED]

[REDACTED]

Phone: [REDACTED]

Client Requirements: Match Mortar / Package B

Mortar Dating: 1860

Location/Function in Building: Exterior masonry mortar

INTRODUCTION

The findings and recommendations presented in this report are premised on the results of tests performed on a mortar sample in our laboratory on July 22, 2016.

The scope of testing was limited to the determination of the physical mix proportions of the major ingredients used in the mortar sample. The testing included visual examination, both with and without magnification, as well as analysis of the aggregate color, particle shape and grain size distribution.

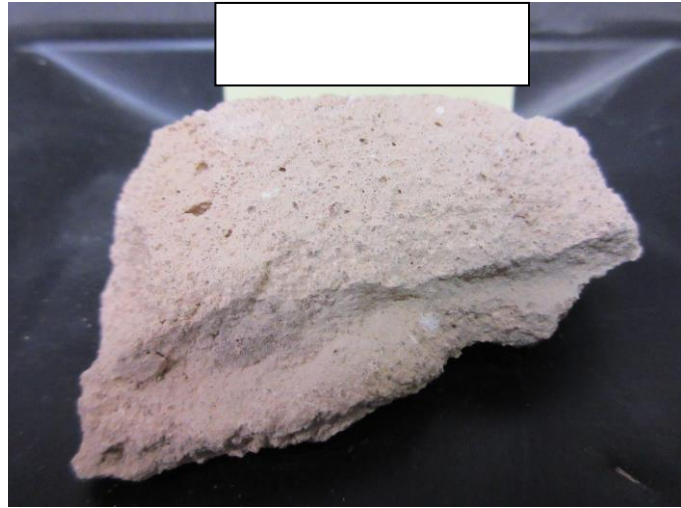
The sample's physical characteristics, original date of construction, and guidelines from the U.S. Department of the Interior National Park Service were used to determine the proposed mortar component recommendations as well as the aggregate ratios for the replacement mix.

U.S. Heritage Group interpreted and adjusted the proposed mortar formulation recommendation based on the information provided to us regarding: current site conditions; present condition and type of masonry; the function of the new mortar; and the degree of weather exposure. Assuming the sample provided is representative of the original mortar, the analysis and mortar-matching diagnosis detailed in this report here will give a reliable indication of the original ingredients and allow U.S. Heritage Group to recommend a historically correct mortar formulation for your project.

PRELIMINARY TESTING

Sample received consisted of several pieces of cured mortar. Total sample weight was 50.3 grams. The largest piece of mortar was measured at 2 1/2" x 1 1/2" x 1".

Based on the consistencies in color and texture, it appears that all mortar pieces represent similar material. Direct pressure testing of received sample revealed low compression resistance. This, along with subsequent findings, suggests that the original formulation is unlikely to contain portland cement.



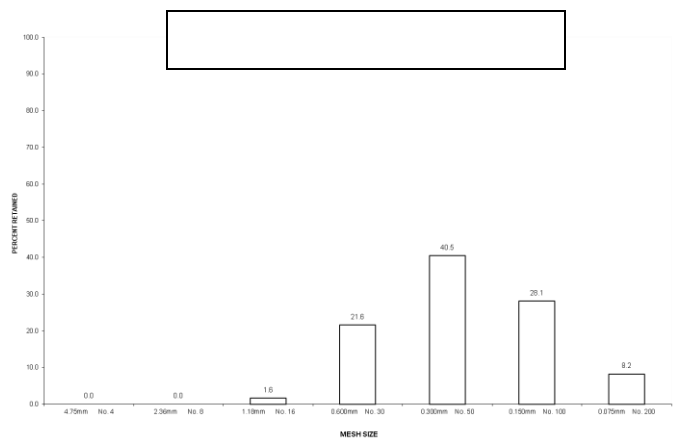
AGGREGATE ANALYSIS

Our laboratory technicians crushed the sample and chemically removed the binder from the aggregate using a dilute acid solution. After drying the aggregate, we viewed it under 40X magnification to determine the characteristics of the particles.

A sieve separation process established the distribution of aggregate particles by a percent of total weight. We prepared a gradation chart to graphically display the color, shape and size of the aggregate particles. This chart can be used to assist in the selection of a new aggregate to match the original material.

The aggregate sieve sizes requisite in ASTM C144 meet ASTM E11 specification requirements. The sand weight retained on each U.S.A. Standard Testing Sieve was as follows:

Testing Sieve Size	% of sand retained
4.75mm, No. 4	0.0%
2.36mm, No. 8	0.0%
1.18mm, No. 16	1.6%
600micro, No. 30	21.6%
300micro, No. 50	40.5%
150micro, No. 100	28.1%
75micro, No. 200	8.2%
Total sand weight	100%



The sand grain distribution chart illustrating the sand isolated from your sample is attached.

The aggregate was well distributed throughout the mess sizes. The material is classified as medium sized aggregate. The aggregate appears to be sub-angular and sub-round in shape. Under magnification, the majority of the aggregate is transparent white with tan particles scattered throughout the material. The binder is buff in color.

The aggregate was found to be 60.9% of the total weight of the sample; the binder makes up the remaining 39.1% of the mix. This mix design would be considered as a binder rich formulation. The results of this calculation can be affected by the presence of calcium carbonate in the aggregate which would have been dissolved out during the chemical wet process. This factor was considered in the evaluation of the proposed replacement formulation.

SUMMARY OF TEST RESULTS

The mix was observed to have high rate of water absorption which is typical for mortars with high lime content. Direct pressure testing indicates low compressive strength for the sample mortar. The material reaction noted during chemical wet process did not indicate presence of hydraulic component. These results, coupled with the sample's appearance, suggest that it was originally mixed using a non-hydraulic lime putty and sand.

Lime inclusions, which were identified in the material, indicate that type of lime used in the original mix was slaked lime putty. Since dry hydrated lime in bags was not available on US market until 1930, slaked lime putty was used in most mortar formulations dated before 1930.

PROPOSED REPLACEMENT MIX

In light of these findings and the intended use of the replacement material, U.S. Heritage Group has prepared a 10-pound site-ready mortar sample, using 1 part lime putty and 2.5 parts sand selected from the USHG sand library. Mineral-based color pigments were used to match the original color.

Above recommendation was made in accordance with Preservation Brief 2:

"The new mortar must be as vapor permeable and as soft or softer (measured in compressive strength) than the historic mortar."

Note: Masonry work using this formulation must be completed 28 days prior to freeze thaw cycles occurring. Do not perform any masonry work unless air temperatures are between 40 degrees Fahrenheit (10 degrees Celsius) and 90 degrees Fahrenheit (32 degrees Celsius) and will remain so for at least 4 weeks after the completion of the work.

Building elements such a chimney or foundation wall may require addition of hydraulic component in the mortar. Type and amount of hydraulic additive used in a new mortar should be established based on the condition of the existing masonry units to make sure that new installed mortar is softer with greater rate of water absorption.

JOBSITE MOCK-UP SAMPLE

The replacement mortar sample should be field-tested through a jobsite mock-up. The mock-up sample should be installed by a qualified craftsperson who understands the curing and application details of traditional mortars. Once the mock-up sample is installed, appropriate precautions should be taken to ensure that the mortar is protected from wind, sun, rain and frost to enable slow curing (i.e. carbonation) to take place.

The sample should be allowed to cure in the wall for a minimum of seven days before final color match is approved. Please see the U.S. Heritage Group guidelines on installation procedures of Type L mortar formulations.

Thank you for seeking our advice and entrusting these important details to U.S. Heritage Group. We are always available to discuss these findings with you in detail. Please contact me directly at 773-286-2100 if you have any questions.

We look forward to providing you with a custom, ready-to-use, historically correct mortar for your project.

Respectfully,

U.S. Heritage Group, Inc.

A handwritten signature in cursive script that reads "Tai Olson".

Tai Olson

Laboratory Manager

Note: This information is held in confidence and becomes a permanent record at the U.S. Heritage Group laboratories located at 3516 North Kostner Ave., Chicago, IL 60641. It can be referenced at any time in the future by the property owner named above or by an authorized mason contractor involved with the restoration work. When inquiring about this match please use the project number USHG # [REDACTED].