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Custom Mortar Matching Report

Project # USHG303

Analysis Date: 6/2/03

Site: Emily Dickinson Homestead, Amherst, Massachusetts

Client: Jim McKinney, Sacco, McKinney Architects, PC, 2 Union Street, Schenectady, NY 12305 Phone: 518-374-8743 Fax: 518-374-8631

Client Requirements: Match Mortar / Package B

Mortar Dating: 1815

Location/Function in Building: Brick joints - spot repointing

Condition of Sample Received: Sample received consisted of 35 grams of mortar, largest piece measured 1"x 1/2 "x 3/8".

INTRODUCTION

The findings and recommendations presented in this report are premised on results of tests performed on a mortar sample delivered to our laboratory on May 30, 2003.

The scope of testing was limited to determination of physical mix proportions of major ingredients used in the mortar sample. The testing included visual examination, both with and without magnification, as well as aggregate void ratio and grain size analyses of sand extracted from the mortar sample. The sample's physical characteristics and the original date of construction were used to determine the proposed mortar components and aggregate ratios for the replacement mix.

U.S. Heritage Group interpreted and adjusted the proposed mortar formulation based on the information provided to us regarding: current site conditions; present condition and type of masonry (i.e., stone or brick); the function of the new mortar; and degree of weather exposure.

Assuming the sample provided is representative of the original mortar, the analysis and mortar matching diagnosis detailed below will give a reliable indication of the original ingredients and allow U.S. Heritage Group to prepare a historically correct mortar match for your project.

PRELIMINARY TESTING

Following preliminary cleaning to remove any accumulated coatings, U.S. Heritage Group technicians visually examined the sample to determine whether the pieces represented one or more mixes. Based on the consistencies in color and texture, it appears that all the sample pieces were from the same mix. We then compared the sample against other high lime content mortars of a similar age by measuring their relative compressive strengths. Direct pressure testing revealed that the compressive strength of the sample is very low. This suggests the formulation contains no Portland cement.

AGGREGATE ANALYSIS

Next, 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 was then used to select a suitable replacement aggregate from the USHG National Sand Library. Adjustments were made to the gradation based on the replacement mortar's intended use.

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%
2.36mm, No. 8	1%
1.18mm, No. 16	4%
600micro, No. 30	14%
300micro, No. 50	42%
150micro, No. 100	30%
75micro, No. 200	9%
Total sand weight	100%

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

As indicated in the chart above, the majority of the aggregate found in the sample is primarily 0.300mm making up 42% of the total aggregate used. The material is well distributed throughout the mesh sizes. The material is classified as a medium sized aggregate. The aggregate appears to be sub-angular in shape. This suggests the aggregate was obtained locally, likely from a river or lake. Under magnification the majority of the aggregate is transparent in color with an assortment of gray and white particles scattered throughout the material. The binder is white.

The aggregate was found to be 67.5% of the total weight of the sample; the binder makes up the remaining 32.5% of the mix. The void ratio of the aggregate was determined to be 32%. Our technicians took these calculations into account in preparing the new mortar formulation, in order to insure the proper proportioning of hydrated lime and sand. This will help to deliver a better performing mortar that is balanced, cohesive and homogenous.

SUMMARY OF TEST RESULTS

Direct pressure testing indicated a relatively low compressive strength for the sample mortar. This, coupled with the sample's appearance, suggests that it was originally mixed using a non-hydraulic lime putty and sand. Lime putty was most definitely the primary binder used in the formulation, which was confirmed by the visual identification of lime inclusions in the sample.

The use of a hydrated lime product would have been unlikely since it was not commercially available until 1935. Based on the various tests detailed above, the sample appears to be composed of carbonated non-hydraulic lime putty, and a medium river or lake sand.

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 non-hydraulic lime putty and 2.5 parts sand selected from the USHG national sand library. The sand matches the original sand as closely as possible in terms of color, size, shape and gradation. The ready-mixed sample needs no additional ingredients.

JOBSITE MOCK-UP SAMPLE

The replacement mortar sample prepared by U.S. Heritage Group should be field-tested through a jobsite mock-up. The mock-up sample should be installed by a qualified craftsman who understands the curing and application details of traditional lime 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 but preferably fourteen days** before final color match is approved.* Please see the U.S. Heritage Group guidelines on installation procedures for lime putty 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.

John Speweik
Historic Masonry Specialist
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Custom Mortar Cost

Your custom mortar is packaged in 3.5 gallon buckets at a cost of \$43.95 per unit plus shipping. A 3.5 gallon bucket will cover approximately 200 lineal feet of repointing with 3/8" wide joints cut out to a depth of 1 inch.

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 USHG303.

USHG # 303 - Sacco & McKinney Architects

