Beaubien House, originally built as a residence in 1851, is listed on the National Register of Historic Places and is home to The American Institute of Architects (AIA) Michigan and Detroit Chapters. Its three-story reddish-orange brick walls are comprised of three wythes of brick supported by a fieldstone foundation wall. Designed in the Italianate Townhouse style, Beaubien House is one of the oldest remaining buildings in downtown Detroit. Situated at 553 East Jefferson Avenue, a major east-west artery into the city that runs parallel to the Detroit River, the historic building was purchased by AIA in the 1980s, demonstrating to the architectural community the importance of a presence in Detroit and maintaining relevant historic architecture. Multiple renovations and restorations have taken place over the years with the most significant renovation completed in 1987 by the AIA. Its structure remains in good condition with little settlement. Overall, the brick façade is still in excellent condition, although the history of repairs has created a patchwork of various mortar colors and types, with some brick replaced with a pigmented concrete patching mixture.

Creating a Plan SmithGroup’s Building Technology Studio (SmithGroup) has been an active participant in designing and implementing renovations and repairs to the modest seven room Beaubien House over the past eight years. In the fall of 2009, SmithGroup met with Rae Dumke, then executive director of AIA Michigan/Detroit, Dan Zechmeister, executive director of the Masonry Institute of Michigan (MIM), and Bob Henderson, project manager with Detroit mason contractor Dixon Inc, to evaluate repair and restoration needs. The East elevation was deteriorating due to years of water draining onto the face from a neighboring roof. Immediate repairs were required. Many brick faces in that location had deteriorated, mortar joints were soft, with evidence of former incorrect repointing work. At that time it was decided that a plan for future repairs was required. This plan would include a survey of the exterior façade, recording of former known repairs, identification of future repairs prioritized and organized on a timeline and identification of a mortar mix design and matching brick. This would minimize investigative work in the future and create a uniform program for masonry repairs. Most importantly, it would also help AIA plan and budget for future repairs.

Petrographic Analysis Because there were no written records containing details of previous repairs, SmithGroup determined that the process of brick and mortar repairs needed to start at the beginning. The first step was to remove mortar from the building to analyze it for composition. For buildings from the 1850s, the mortar was most likely lime-based, but the analysis would tell for certain. The key in removing mortar is to remove it from deep enough in the wall to ensure samples are not of newer repointing mortar. In this case, multiple brick were removed and samples were taken from within the barrier-type masonry wall. Both brick and mortar were sent to the laboratory for analysis.

**Beaubien House Case Study:**

**PROACTIVE APPROACH TO MASONRY PRESERVATION**

Necessary for Extending a Building’s Life

by Meredith Steckling, AIA, CDT, LEED Green Associate

This article originally appeared in MasonryEdge/theStoryPole Vol 6 No 2.
There are two tests generally performed: petrography and chemistry (both were used for Beaubien House). For petrography, the cost may run from $300 to $1,600. For chemistry, the cost may run from $300 to $3,000. The range of prices may also be related to the expertise of the person analyzing the results. In this case, a less expensive test may not yield the same results as a more expensive one.

Wiss, Janney, Elstner Associates performed a petrographic and chemical analysis of the mortar for its exact composition (see sidebar, p 46). While waiting for the results, SmithGroup performed an at-home mortar analysis based upon instructions from the article Selecting Mortar for Historic Preservation Projects. The article stated that lime-based or cement-based mortar composition could be determined by dissolving a pulverized mortar sample in muriatic acid. If the foam generated was amber in color, it indicated a lime-based mortar. If the foam generated was green, it was a cement-based mortar. After performing the experiment, the foam generated appeared to be a yellow color, indicating a lime-based mortar. Another useful result of the experiment was that after the acid was washed away, the aggregate remained. The aggregate was given to the contractor who was more easily able to match the new sand to the existing by eye, as well as by the results of the petrographic analysis.

Beaubien House Mortar Mix Results

Petrographic analysis describes the samples, analysis process and results. The most valuable information provided to the mason matching the mortar mix was the aggregate size, aggregate composition and the hydrated lime-to-aggregate ratio. In this case, the mortar mix was sanded, with a 1:2 ¾ lime to aggregate ratio. Results also indicated that the mortar was a hydrated lime-siliceous sand mortar. It included the ratio of sand to lime, which was imperative for creating the new mortar mix. It described the sand’s mineral compositions and sizes that were used, which is helpful for duplicating the mortar and is more specific than visually comparing the sand to the aggregates gained from the muriatic acid test.

Historic Brick Procurement

It is unknown whether the brick used in Beaubien House was locally made. There are buildings throughout Detroit that appear to have been built with similar brick, therefore there was a chance that a match could be found from locally salvaged brick.

**Petrographic Analysis**

**The Art and Science of the Match**

Historically, mortars were not prepared to narrowly defined specifications. These mortars usually incorporated locally derived materials and relied heavily on the experience of the mason to produce a good quality mortar. Today, compositional analyses of historic mortars are most often performed to aid in formulating a replacement or repair mortar that is compatible with the original mortar. Installation of an improperly formulated replacement or repair mortar could irreparably damage historic masonry. Compositional analyses are performed in accordance with the standard test method, ASTM C1324, Test Method for Examination and Analysis of Hardened Masonry Mortar, which requires petrographic examination and chemical methods of analysis.

Mortar analysis must begin with a thorough petrographic examination to identify constituents of the fine aggregate and paste/binder system, evaluate the air-void system (entrained or non-air entrained) and estimate air content. Thin-section microscopy is preferred because it allows for easier and more precise identification of constituents and because the thin section preserves the condition of the mortar and the relationships between mortar constituents. Poor condition of the mortar, especially extensive alteration, can adversely affect chemical analysis. In some cases, chemical analyses cannot be performed so the petrographic description of the mortar provides an approximate analysis of its composition.

The chemical analysis portion of the test method combines wet-chemical methods and instrumental analysis to determine the crystalline components, soluble silica, calcium oxide, magnesium oxide, magnesium hydroxide, insoluble residue and losses on ignition. The total of insoluble residue, soluble components and loss on ignition should be close to 100%. If it is, the chemist calculates the mortar proportions in accordance with ASTM C1324. If the total is more than 5% greater or less than 100%, the possibility of interferences or biases should be examined. Mortar compositional analysis relies heavily on the experience of the petrographer and chemist to recognize materials that might interfere with or bias the chemical analysis since the proportions of mortar components are calculated from data obtained by the chemical analysis methods.

Laura J Powers, Associate Principal and Petrographer
Susanne Papas, Senior Associate and Chemist
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**References**

Annual Book of ASTM Standards, Vol 4.03.
Repairs and Documentation

After mockups were evaluated and mortar formula determined, repairs were made to Beaubien House. The repair area was roughly 100 sf. The majority of the repair involved repointing joints. Multiple brick were replaced due to cracking. Another portion of the wall contained obvious repointing with a mortar mix that did not match the surroundings. Those joints were raked and repointed with the new mortar. Areas of repair were documented photographically along with the method used, brick supplied and formula for the mortar mixture. A full architectural specification was not written as the petrographic analysis report was included in the documentation of the process. This information was compiled into one document to be kept by the AIA.

As with any structure, Beaubien House must be maintained and repaired. The brick masonry structure continues to function and look beautiful after more than 150 years of use, while having had multiple owners and uses. Brick is capable of lasting for thousands of years with proper maintenance. There is always the potential for a change of occupants, so documentation of work is important. In the future, a mason contractor should not need to perform a petrographic analysis or take mortar samples. Instead, they can rely on the documentation to develop a mockup and complete a repair.

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