Exterior Stone Repair at the Minnesota State Capitol

Introduction

The exterior façade of the Minnesota State Capitol, with Minnesota Diamond Pink granite at its base and white Georgia marble above, is showing signs of distress and decay related to original stone carving techniques, prolonged exposure to natural weathering processes and daily use. Close-up condition assessment surveys have been performed for all exterior building stone. While the granite exhibits few problems, the marble shows extensive deterioration. The purpose of this White Paper is to provide background information on the evaluative process being undertaken in 2012 to develop and prioritize appropriate stone restoration strategies to follow in 2013-2014.

Background

In the fall of 2010, HGA Architects and Engineers reported a number of concerns regarding the condition of the white Georgia marble, including significant cracks, material loss, and stone unit displacement in several locations that were serious enough to raise concerns for public safety. At the State's request, HGA conducted a preliminary "hands-on" investigation to identify any façade conditions that were potential life-safety risks. Loose stone material and marginally attached sculptural elements were removed. One large, cracked and unstable unit at the east elevator tower was pinned in place as an emergency repair. HGA recommended that a comprehensive stone evaluation be completed to determine the nature and full extent of stone deterioration.

Wiss, Janney, Elstner Associates, Inc. (WJE), a firm that specializes in investigation, testing, and design of repairs for building facades, was then retained in 2011 to complete a comprehensive assessment of exterior stone and sculptural elements of the building façade. WJE investigators documented the nature and extent of visible deterioration. In several locations, where more advanced deterioration was apparent, stone was removed to assess the condition of back-up brick masonry and anchors. Conservation analysis was performed on stone samples collected at various locations. Based on these findings, two primary objectives were identified to guide stone restoration moving forward: 1) to resolve conditions that are, or may become, safety issues, and 2) to minimize further deterioration of façade materials to the greatest extent possible.

Stone Repair Strategies

Existing stone conditions at the Minnesota State Capitol are not surprising considering that the material has been in service in a harsh environment for over 100 years. Although Georgia marble is fairly durable, like virtually all stone, it too is vulnerable to decay and deterioration when exposed to outdoor environmental conditions.

The current exterior stone repair project is set to begin in the fall of 2012, and will address the high priority issues identified during the previous investigative phases. This work generally falls into one of three categories, each with a specific goal in mind:

1. Life Safety - Maintain Public Safety
2. Water Management - Restore Building Integrity
3. Building Stewardship - Preserve Historic Character

Though all façade stone will be addressed, it is the marble that will require the most repair and restoration. It is the condition of the marble that poses the most questions.

Marble Deterioration

- What causes advanced marble deterioration?

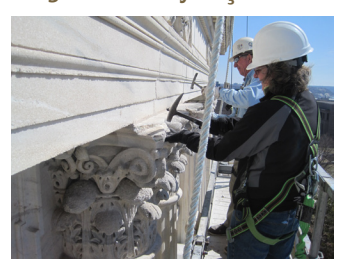
Laboratory analysis has confirmed that the primary reason for marble deterioration at the Minnesota State Capitol is a cyclical heating and cooling process that causes permanent damage to the stone. This process, known as, thermal hysteresis, is progressive and irreversible. Other causes of marble distress include: biological growth, original stone carving techniques, stone anchor corrosion, and water induced distress from water runoff and freeze/thaw cycling. Observed conditions of deterioration include: extensive sugaring or granulation, minor to severe cracking, surface erosion, stone unit displacement, material surface loss, delamination, and spalling.

- Why does white Georgia marble at the State Capitol require restoration now?

Although some level of weathering is expected on a building of this age, severe and/or advanced distress and decay can develop into life safety concerns. During the course of the stone assessment, several of the more decorative sculptural elements, such as the carved leaves on the column capitals, were often found to be unstable. The size of potentially unstable features, (some elements removed in 2010 weighed between 8-14 pounds), and their proximity to areas accessible to the public make repair imperative.

- Where are repairs required?

It is likely that some type of stone repair will be made at many locations throughout the full height of every façade at the state capitol.



Observed stone distress varies among façades due to differences in exposure to temperature extremes and weathering. However, many stone features, such as elaborately carved sculptural features with a high degree of exposure to wind and water, are prone to deterioration regardless of their location.

- How is this project different from past projects?

Stone deterioration is accumulative in nature so past projects encountered less severe conditions than those observed today. In addition, emerging yet unproven technologies for liquid-applied stone consolidation and engineered patching materials that were being tried as cost effective alternatives to stone replacement proved to be generally temporary in nature, with an expected service life of approximately 10 years. The current project, faced with more advanced deterioration, is exploring longer term solutions that utilize new stone for partial repairs and replacement. Removal of deteriorated surface material followed by refinishing techniques that provide sound, smooth, carved finish surfaces are also being evaluated for in-place refurbishment.

- Is white Georgia marble available today to complete repairs?

Stone used to construct the Minnesota State Capitol originated from the Amicalola quarry in Pickens County, Georgia, which is no longer in operation. A nearby quarry, opened exclusively for large scale restoration projects, will be the source for new stone. Although block size is limited by transportation restrictions, and lead times for ordering materials are great, quantity is not an issue at this time.

Repair Approach and Process

During the restoration process, some stone repair will be required to address life-safety concerns, some will stabilize deterioration, some will increase durability, and some repair will improve the appearance of an aging building. However, much of the aged and weathered material will, for a variety of reasons, remain largely untouched. Deciding what units receive repairs, determining the nature of those repairs, establishing guidelines for how new work is to be integrated with original material, and correlating the extent of repairs with the available budget are some of the challenging decisions facing the project team.

Stone restoration at the Minnesota State Capitol is a highly specialized undertaking. There are few precedents for extensive marble restoration at this scale. Original construction, unit size (some pieces weigh over 3,000 pounds), site logistics, schedule, budget, preservation issues, climate, aesthetics, visibility, proximity, physical properties, and material condition present a unique set of circumstances which must be carefully considered and evaluated in context. The only effective way to accomplish this is to execute a wide range of trial repairs and mock-ups on site to demonstrate the constructability of various techniques, the effectiveness of suggested repairs, and the visual appearance of the overall result. This "trial phase" gives the design team, stone masons, carvers, and suppliers a chance to evaluate and refine various approaches to stone restoration from procurement to final installation. More importantly, it provides all stakeholders an opportunity to evaluate the visible character of available options and weigh the desired outcome against the projected cost of various methods.

A number of stabilization repair techniques are available to address potential safety concerns; these include removing unsound material, mechanically securing loose or broken fragments, repairing cracks, and replacing failed mortar. Although it is difficult to prevent progressive marble deterioration caused by thermal cycling, some repair techniques like mechanical grinding, smoothing, and carving may help reduce the rate of deterioration. Regardless of the repair strategy selected, ultimately the overall historic character of the building must be maintained and preserved.

At the conclusion of the trial phase, answers to the following questions will help the design team finalize a comprehensive preservation plan that will provide direction for upcoming construction phases:

- What types of repairs are most effective?
- How will original material be preserved?
- When is replacement necessary?
- What are character defining features?
- To what extent is modification or reshaping of historic material appropriate?
- What determines an acceptable level of convincing detail?
- When replacement is required, how much historic material is removed?
- How is original material removed?
- How is new material anchored?
- Who decides the appropriate level of repair?
- Will different areas require different approaches?
- How will new work be distinguished from and/or fit in with historic material?

Repair Implementation

Due to the immense size of the building and limited time available for construction, the stone restoration work will proceed in four phases.

Phase 1- Stone Repair Trials and Mock-up Evaluations (2012)

This phase involves installing a variety of prototype repairs in order to evaluate, compare, and contrast a range of strategies from conservative repair to aggressive replacement. Areas selected for trials include two central bays of the west wing south and north façade, and both facades of the east elevator tower. Processes already underway include:

- A construction package for Stone Repair Trials and Mock-up Evaluation, along with extrapolated work scope for the entire restoration project, was issued August 2012.
- The process of field measuring stone units identified for trial repairs has begun. Rubber molds of select decorative elements are also being prepared. Models cast from these molds will provide off-site stone carvers a reference for size, form, type and level of detail.
- The selection process for stone masons, carvers, and stone suppliers is proceeding. Work for the whole project will be awarded to the prequalified firms with the lowest total cost.
- On-site preparation (additional scaffolding, construction staging areas) for repair trials will start mid-October.
- Activity levels will increase as new white Georgia marble begins to arrive on site early November.
- Work on site will continue until the Minnesota Legislative Session begins January 2013.

Phase 2- Stone Restoration and Repair (2013) – South, East, Quadriga Level

This phase involves implementation of recommended stone restoration strategies based on trial repairs and mock-up evaluations. Areas selected for Phase 2 work include: the south façade of both east and west wings, the main entry, loggia and elevator towers; the east façade, entry and loggia; the drum base pedestal up to and including the Quadriga level, and small beehive domes.

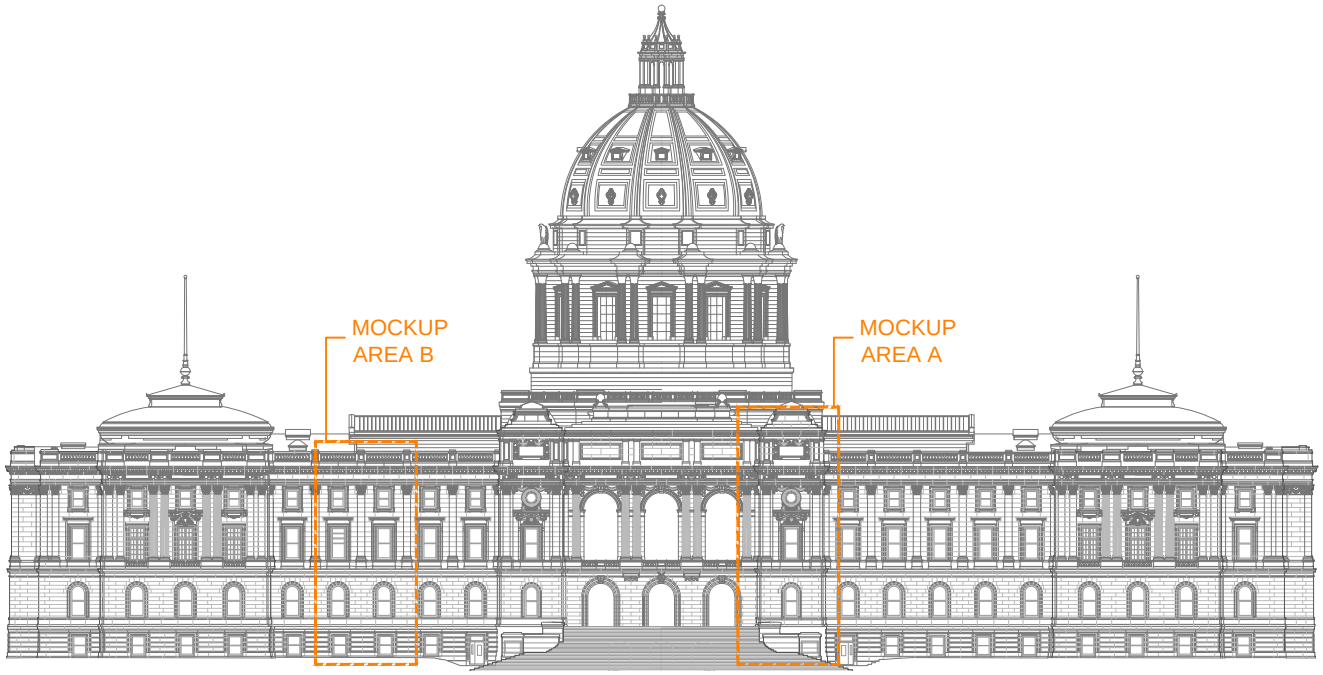
Phase 3- Stone Restoration and Repair (2014) – North, West, Drum, and Dome

This phase will incorporate refinement of recommended stone restoration strategies based on lessons learned from Phase 2. Areas selected for Phase 3 work include: the north façade of both east and west wings, the north wing, north entry, north roof pediment; the west façade, entry and loggia; the drum, dome, and lantern.

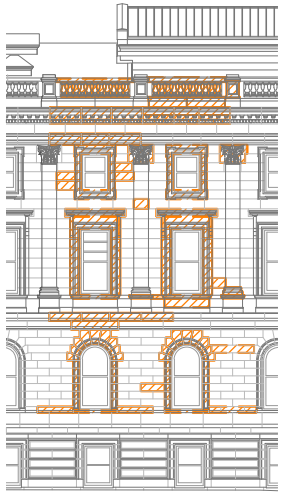
Phase 4- Stone Restoration and Repair (2015) – as required to complete any remaining work

Future Preservation Planning

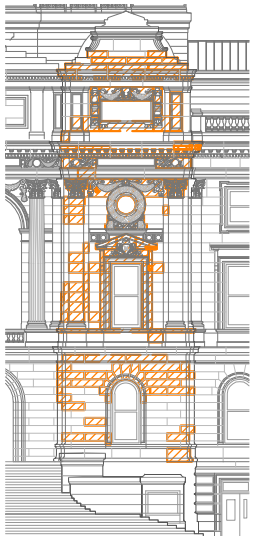
The marble on the façade of the Minnesota State Capitol Building will continue to age, weather, and deteriorate over time. The efforts to preserve this historic material will be an ongoing process. No repair can be considered permanent, and future restoration work – repair as well as replacement – will be required as conditions change and the marble continues to age. Understanding the mechanisms behind the resulting deterioration, and tracking the progression of marble decay over time is critical for developing the predictive modeling necessary to create effective maintenance schedules and to lay the groundwork for future restoration work.



SOUTH ELEVATION



MOCKUP AREA B -
West Wing (South)



MOCKUP AREA A -
East Elevator Tower

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SOUTH ELEVATION

WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

MINNESOTA STATE CAPITOL

EXTERIOR STONE REPAIR
STONE REPAIR TRIALS & TESTING

ST. PAUL, MINNESOTA
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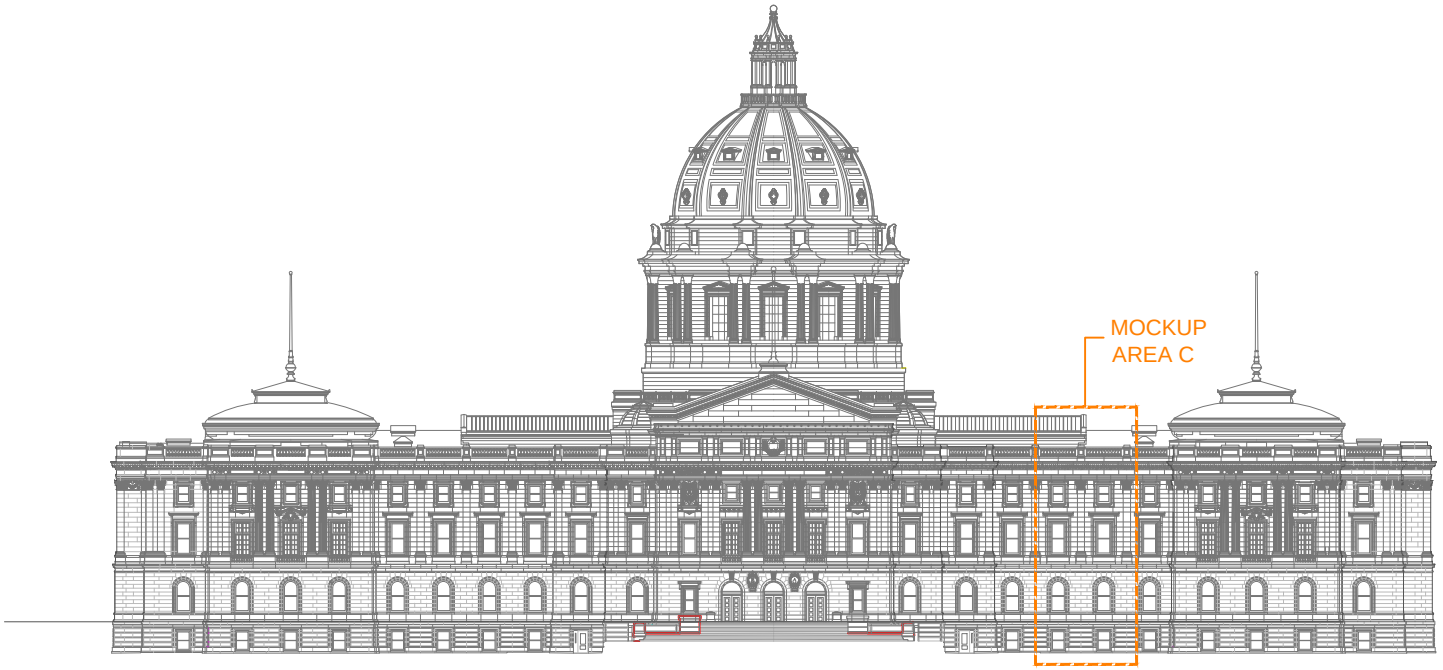
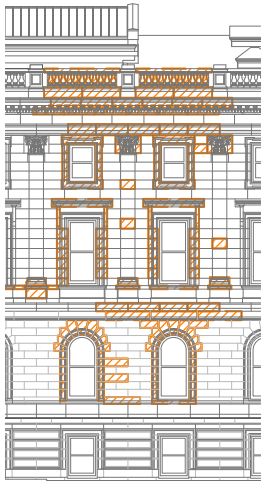


NORTH ELEVATION



MOCKUP AREA C -
West Wing (north)

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NORTH ELEVATION

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