Minnesota State Capitol Exterior Stone Repair Project

Stone Repair Trials Evaluation and Preliminary Preservation Planning

May 10, 2013

Fig. 1. Lion scupper at north roof pediment. The lower portion of carved detail and fascia drip edge are severely deteriorated. Because the location is far removed from public access, continued deterioration will not evolve into a life safety concern. Although this character defining feature functions to move water away from the building, its impact on building integrity and overall appearance is low compared to other primary or secondary water shedding features. For these reasons, this condition has been assigned a lower priority and is therefore not included in the current scope of work for the Project. As conditions worsen, the effectiveness of this feature to move water from the gutter system to the roof below will become more compromised, putting the stone below at higher risk for accelerated decay.

EXECUTIVE SUMMARY

The Minnesota State Capitol is one of the most magnificent capitols in the country and one of Cass Gilbert's most acclaimed masterworks. At the exterior stone facade, the Minnesota Diamond Pink granite base has fared well, but the white Georgia marble above is showing signs of distress and decay that have raised concerns from the perspective of public safety, building integrity, and preservation of historic character.

The State has assembled a collaborative team to investigate, and present options for repair strategies moving forward. The team includes architects and engineers from Hammel, Green and Abrahamson, Inc. (HGA) and Wiss, Janney, Elstner Associates, Inc. (WJE) with construction expertise by the Construction Manager, J.E. Dunn.

The purpose of this report is threefold:

1. **Summarize the investigation and conclusion from the 2012 Trial Repairs Phase of work**
2. **Present the State with repair options for upcoming phases of stone repair**
3. **Introduce the factors that will influence a long-term preservation strategy for the building**

2012 Trial Repair Phase

The Trial Phase gave the team a chance to evaluate and refine a recommend approach to the process of stone restoration, from design, through procurement to final installation. The scope of this phase of work was carefully thought out to test the full range of repairs that could be anticipated for the project, from Dutchman repairs, where new stone material is used in a partial replacement, to pin repairs to stabilize existing loose stone elements. The team used the Trial Phase to evaluate the constructability, effectiveness and visual appearance of the repair options. With this knowledge, the team established general repair protocols to be applied going forward. This phase of work also provided the State and other stakeholders an opportunity to see the actual outcome of repair options, both up close from on the scaffolding, and from street level.

A video titled "Minnesota State Capitol," dated December 2012, is available at the following website: http://www.admin.state.mn.us/recs/capitol/capbldg.html, and provides a better understanding of the current condition of the stone, as well as the repair options that were mocked up during the Trial Repair Phase.

Conclusion – Repair Options for Consideration

Based upon the knowledge gained in the 2012 Trial Phase of construction the team developed four optional tiers of stone repair scope. Each tier has a specific goal, and each successive tier includes the repairs of the previous tier in its scope. Together they cover a full range of construction options.

Tier 1– Life Safety (T1)
All unsound material is removed or stabilized to support life safety. Missing features are not replaced.

Tier 2 - Water Management (T2)
This tier provides added focus on restoring function to water shedding components of the building in order to slow future deterioration of adjacent exterior building material and to protect interior finishes from water damage. Repair incudes Dutchman replacement of some water shedding features. The building is cleaned, joints are restored, and cracks are repaired.

Tier 3– Historic Character (T3)
This tier provides added focus on the carved building elements which typically exhibit the most severe damage. Repair includes select Dutchman replacement of highly deteriorated character defining features of the building to aid in preserving the visual character of the original architecture.

Tier 4 – Restoration / Reconstruction (T4)
This tier adds more extensive replacement of deteriorated material, including full replacement of additional select character defining features in order to improve long term durability and preserve visual character.

The tier options are designed to treat all facades of the building. At any tier, evaluation and decision making to determine which stones are repaired occurs on a stone by stone basis depending on an assessment of the existing condition of the material. Detailed descriptions of the scope of work with each tier option, including photographs and drawings that help to describe the resulting outcome as well as case study comparisons at select building components are included.

Project construction duration varies by tier: 2 years with T1, 3 years with T2, 4 years with T3, and 7-8 years with T4. The design team has developed models to estimate the quantity and type of repairs associated with each tier option by building component and appropriate repair classification to support cost estimating and overall project planning. Unit pricing for each class of repair has been established, and the Construction Manager, has completed a cost estimate corresponding to each tier.

Preservation Planning

The historic value of the Minnesota State Capitol, and the magnitude of restorative work required, brings a host of preservation issues to the forefront. The team is sensitive to preservation concerns and remains committed to a preservation perspective in the development of repair options for the Minnesota State Capitol that follow the intent of the Secretary of the Interior's Standard Guidelines for Rehabilitation while simultaneously meeting the long-term goals of the State. Depending upon the repair tier option selected by the State, the team will use the information included in this report to inform an exterior Preservation Plan.

Fig. 2 (above). Investigators from HGA performed a preliminary conditions survey in 2010 to identify potential life safety hazards. One pilaster unit at the east elevator tower was found to be unsound. Emergency repairs were performed to stabilize the unit in place.

Fig. 3 (right). Investigators from WJE performed a full building condition assessment in 2011. More extensive inspection followed during the 2012 trial phase.

PRELIMINARY INVESTIGATION

In the fall of 2010, HGA reported a number of concerns relating to deteriorated white Georgia marble. Significant cracks, material loss and stone masonry unit displacement in several locations was serious enough to raise concerns for public safety. At the State's request, HGA architects and engineers conducted a preliminary "hands-on" investigation to identify 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. Given the extent and severity of masonry distress observed during the preliminary investigation, HGA recommended that a comprehensive stone evaluation be completed to determine the nature and full extent of stone deterioration.[1]

Wiss, Janney, Elstner Associates, Inc. (WJE), a firm that specializes in investigation, testing and design of repairs for buildings, bridges and other structures, was retained in 2011 to complete a comprehensive assessment of exterior stone and sculptural elements of the entire building façade. WJE investigators surveyed surface conditions of the white Georgia marble and granite and documented the nature and extent of visible deterioration. Conservation analysis was performed on stone samples and mortar collected at various locations.[2, 3]

Two primary objectives were identified to guide stone restoration moving forward:

- **Resolve conditions that are, or may become, safety hazards.**
- **Prioritize repairs to minimize further deterioration of façade materials to the greatest extent possible.**

Preliminary repair strategies addressing the most pressing safety, stabilization and preservation issues were developed and prioritized to generate a rough order-of-magnitude cost estimate for planning purposes. High priority issues identified during the investigative phase provided focus for mock-up trials in 2012. Details were developed, tested and evaluated for their effectiveness in treating various distressed stone conditions observed throughout the building.

These high priority conditions generally fall into three repairs categories, each with a specific goal in mind:

1. **Life Safety (Tier 1) – Uphold a safe environment for occupants and the visiting public**
2. **Water Management (Tier 2) – Restore functionality of essential façade components**
3. **Historic Character (Tier 3) – Preserve historic character**

1 Hammel, Green and Abrahamson, Inc. Minnesota State Capitol Preliminary Stone Investigation. Prepared for the State of Minnesota. April 30, 2011.

2 Wiss, Janney, Elstner Associates., Inc. Minnesota State Capitol Facade Inspection and Stone Assessment Report. Prepared for the State of Minnesota in collaboration with J.E. Dunn Construction. May 4, 2012.

3 Wiss, Janney, Elstner Associates., Inc. Minnesota State Capitol Marble Deterioration Assessment and Treatment Studies Prepared for the State of Minnesota in collaboration with J.E. Dunn Construction. May 4, 2012.

Fig. 4. West wing south facade. Mark 1 stone mason Jarek Sienkiewicz prepares a pilaster pedestal to receive new stone dutchman repair.

Fig. 5-6. Traditional Cut Stone master carver Robin Halton using a template to transfer pattern to a bracket scroll.

APPROACH AND OBJECTIVES

Accomplishing the goals established for a masonry repair project of the magnitude proposed for the Minnesota State Capitol requires a team of professionals with extensive preservation experience and specialized restoration skills. The State of Minnesota has assembled a team of experts for the Exterior Stone Repair Project.

The design team is a collaborative effort of architects, engineers and contractors:

- Hammel, Green and Abrahamson, Inc. (HGA): Executive Architects
- Wiss, Janney, Elstner Associates, Inc. (WJE): Restoration Architects and Engineers
- JE Dunn Construction: Construction Manager at Risk

The stone masonry skills required to execute the type of repairs required at the Minnesota State Capitol are fast becoming a lost art and the pools of masons possessing these highly specialized skills is limited. Through a stringent prequalification process, JE Dunn has assembled an international team with exceptional depth and talent to fill out the Exterior Stone Repair Project team:

- Mark 1 (Chicago, IL): Stone masonry restoration and installation
- Advanced Masonry Restoration (Minneapolis, MN): Masonry restoration
- Twin City Tile and Marble (St. Paul, MN): Local fabrication
- Traditional Cut Stone (Toronto, Canada): Stone carvers and shop fabrication
- Polycor (Quebec, Canada): Stone suppliers

The stone repair trials and testing phase, concluded at the end of 2012, was a critical step in the evaluative process. Comprehensive, full scale mock-ups enabled the team to validate preliminary assumptions in situ. Stone masons, carvers, suppliers and the design team were each allowed to test, react, experiment and respond directly to reality-based circumstances. Nearly every aspect of the process (including computer technology, information sharing, data management and repair tracking) was tested and is being refined based on the "lessons learned" from the trial phase.

Fig. 7. Plaster model of a fleuron compared to severely eroded stone feature. Plaster models were used to evaluate size, depth, character and level of detail prior to stone fabrication.

Approach and Objectives

The objective of the trial repair phase was to provide a wide range of technically viable solutions that addressed the life safety and water management concerns that have caused exterior damage to the Capitol building stone. Prior studies conducted on the building in 2010 and 2011 had been aimed at identifying types and locations of distress in an effort to develop an understanding of the causes of the deterioration. For this phase of the project, repair strategies were developed and mock-ups were constructed to address the deterioration. The various repairs included in the trials could then be evaluated for their constructability, visual impact and cost effectiveness. This review process could then develop a consensus as to the approach to be undertaken on the entire building. For the Phase 1 trial repairs, potential repair options were organized into two approaches:

- **Preservation approach** – retention of more of the original historic fabric
- **Restoration approach** – comprehensive repairs to remove deteriorated material

Both approaches included the removal of all unsound material. The preservation approach retained more of the original historic fabric and included a small number of dutchman repairs or grinding and smoothing at stone removal areas, depending on the extent of deterioration; grinding and smoothing of the stone at granulated surface areas and high-relief architectural features; and installation of lead weather caps at all upward facing joints.

The restoration approach also included repairs to architectural features that were perceived to have a strong visual impact on the character of the building. The restoration approach was characterized as being more comprehensive than the preservation approach. It included the installation of more new stone dutchman repairs at stone removal areas; grinding and smoothing of the stone at granulated surface areas, high-relief architectural features and all corner edges; and installation of metal drip edge flashing caps at projecting window hoods and cornice ledges.

The repair approaches were performed at adjacent selected bays on both the north and south elevations of the building. Thus, the two approaches could be evaluated in comparison to one another as well as in comparison to areas of the building that had not received repairs. The primary repair types included in the trial repairs included various dutchman repairs at a wide range of locations and architectural features on the building, grinding and smoothing of existing stone, crack repairs, installation of lead weather cap joint treatments as well as metal flashing caps, and application of chemical biocides and spot cleaners.

The process of turning natural quarried stone into remarkable architecture requires extensive coordination and cooperation of all involved parties. The opportunity to see how various roles and work flows dovetailed into one another provided much needed perspective for contractors, the design team and the State of Minnesota.

The trial phase was a highly effective way to demonstrate the following from both a design and planning perspective:

- **Constructability** of various techniques,
- **Expediency and effectiveness** of suggested repairs,
- **Visual appearance** of the overall result.

Fig. 8. Amicalola quarries, Atlanta Marble Company, Pickens County, Georgia (ci. 1900).


Fig. 8. White Georgia marble quarry, Polycor Stone Corporation, Pickens County, Georgia (2010).

CONSTRUCTABILITY

Until recently, white Georgia marble matching both the physical and visual qualities of the historic stone has been difficult to procure. Stone used to construct the Minnesota State Capitol originated from the Amicalola quarry in Pickens County, Georgia which is no longer in operation (Fig. 8). The Amicalola quarry was located about 1 mile southeast of the Southern Marble Company quarries. Stone was first mined on the property (formerly known as the Herndon property) in 1892. Amicalola Marble Co. bought the property in 1897 and opened the first quarry. The Amicalola was a relatively small outcrop which was used extensively for monumental buildings. It was said to be purer, whiter, and with fewer fissures than material obtained from neighboring quarries..[1] Several large dimension quarries operated by the Georgia Marble Company were located within a few miles of the Amicalola quarry. "The stone is white or light gray with a medium to coarse texture. Sometimes the marble has veins or dark material. " [2]

In 2003, Polycor Stone Corporation purchased a nearby quarry, formerly operated by Georgia Marble, in Tate, Georgia (Fig. 9). This is the only source worldwide for new stone matching the properties of the historic white Georgia marble on the Minnesota State Capitol. The quarry is only opened for large scale restoration projects. Although material quantities do not appear to be a limiting factor at the moment, there is no guarantee that resources from this quarry will be available in the future.

Execution of test repairs during the trial phase demonstrated that most technical issues related to acquisition, fabrication, removal and installation can be resolved. Design and implementation of proposed repairs will likely be influenced more by material, fabrication and construction costs than installation hurdles or technical limitations. However, there are still a number of construction issues to consider:

- Original construction sequencing: load-bearing conditions, inside corners, overlapping features, stacked elements
- Original unit size: lengths over 10 feet are not uncommon (original column shafts are carved from a single block of stone and are over 20 feet tall)
- Standard quarried block size (8 feet x 5 feet x 4 feet): limits length of replacement pieces (window hoods are carved from a single block of stone and are over 11 feet wide)
- Weight of material: Georgia marble weighs 180 pounds per cubic foot. Unit size and weight impacts scaffolding design and hoisting/crane requirements. To date, the largest installed replacement pieces weigh approximately 300 - 500 pounds. Shoring, moving, lifting and/or placement of units weighing over 600 pounds requires specialized equipment.
- Single supply source: pricing and fabrication are non-negotiable. Material accounts for ~40% of the cost.
- Stone quantity: not an issue at this time
- Procurement time: long lead times (3-6 months depending on the level of hand carved detail)
- Site logistics: Access, extensive staging area, scaffolding and hoisting requirements, winter conditions, shoring, field carving, color matching
- Schedule: Minnesota weather and restrictions on construction during legislative sessions shortens the construction season
- Tenant Impacts: parking, noise, dust, distraction

1 *A Preliminary Report on the Marbles of Georgia,* Bulletin No. 1, by S. W. McCallie, Assistant State Geologist, Geological Survey of Georgia, 2nd ed., 1907

2 United States Geological Survey, "Mineral Industries Surveys - Directory of Principal Dimension Stone Producers in the United States in 1995," prepared in January 1997.

TRIAL REPAIR EVALUATIVE PROCESS

Evaluation of the effectiveness of suggested repairs is a complex undertaking. A wide range of architectural features, variability of stone condition and dissimilar mechanisms contributing to the process of decay, create countless combinations that must be addressed by the design team. When these factors are overlaid with a long list of contextual influences, the task becomes even more daunting.

To organize the effort, comparative analysis of repair effectiveness takes place at five levels:

- Conservation Level – material specific: scientific, focus on preservation
- Technical Detail Level – unit specific: objective, focus on technical execution
- Preservation Level - heritage specific: philosophical
- Context Level – location specific: objective, focus on character and overall appearance
- Comprehensive Level – building inclusive: subjective valuation, focus on long-term durability

Fig. 9 (above). Cumulative effect of thermal hysteresis on a grave marker in Philadelphia.

Fig. 10-11 (above). Bowed white Georgia marble panels on the First Canadian Place Building in Toronto (constructed in 1975). Marble tiles were inspected every 6 months and had been routinely replaced once considered at risk. In spite of frequent inspections, a marble tile fell off the 55th floor in 2007. Nearly 40,000 panels were removed and the building was completely reclad (2010-2012).

Conservation Level

[First Filter - Compatibility] Prior to implementation, the suitability of a protocol or detail to resolve technical issues is the first filter for evaluating the effectiveness of the repair. The evaluation process is fairly straightforward - if a proposed detail was incompatible with conservation objectives, it was not considered for further development.

Design of appropriate repairs begins with a determination of the material properties of the marble and an assessment of attributes that are unique to the white Georgia marble at the Minnesota State Capitol. The following are some of the parameters that are typically considered:

- Material properties: density, water absorption, mineral composition, albedo, reflectivity, crystal grain size, thermal expansion
- Physical condition: soundness, surface loss, cracking, crazing, displacement, surface staining
- Design requirements: compatibility, structural capacity, anchorage, mortar mix design

New stone, extracted from a Georgia quarry opened exclusively for large scale restoration projects, is an excellent match for the historic material. The physical properties of freshly quarried Georgia marble are well documented.[3] However, recent testing and analysis of white Georgia marble from the Minnesota State Capitol have demonstrated that material properties change over time in response to weathering and climate induced stresses. [4, 5]

Measurement of the cumulative effect of the various mechanisms of decay can be accomplished through testing. Laboratory analysis has confirmed that the primary cause of observed deterioration of the marble at the Minnesota State Capitol is most directly related to a cyclical heating and cooling process that causes permanent damage to the stone. This process, known as thermal hysteresis, is progressive and irreversible (Fig. 9). Exposure to wind, water, snow and ice adds additional stresses.

Although there is no known treatment currently available to prevent progressive marble deterioration caused by fluctuating thermal cycles, there are some repair techniques (mechanical grinding, smoothing and carving) that may help reduce the rate of deterioration for thicker dimensioned stone at the State Capitol. For thin veneer systems, or delicately carved detail, replacement is often the only option for long-term repair. White Georgia marble panels have been replaced on a number of buildings, including First Canadian Place (Toronto) and the Amoco Building (Chicago), as a result of ongoing issues related to thermal hysteresis (Fig. 10-11). [6]

Direct observation can establish the cause and help predict patterns of deterioration, however, very little is known about the actual processes and rate of decay. Additional investigation to define building dynamics and the effects that movement, moisture and temperature have on weathered Georgia marble would be advantageous. Scientific data collected over several years, during which stone is exposed to a wide range of seasonal temperature and moisture extremes, would help investigators better understand the rate of marble deterioration and how these processes affect this particular stone, on this particular building. Measurable data and analysis of specific in situ conditions plays an important role in determining appropriate conservation strategies and would assist planning efforts both now and in the future. This information is particularly valuable when recommending inspection and maintenance schedules.

3 Stone Bibliography
4 "Marble Consolidation Testing and Evaluation: MN State Capitol," Integrated Conservation Resources Report, prepared for Miller Dunwiddie Associates, Minneapolis, MN, September 2001.
5 Wiss, Janney, Elstner Associates., Inc. Minnesota State Capitol Marble Deterioration Assessment and Treatment Studies Prepared for the State of Minnesota in collaboration with J.E. Dunn Construction. May 4, 2012.
6 http://www.buildingscienceconsulting.com/presentations/documents/0103_First_Canadian_Place.pdf

Fig. 12 (left). Pilaster base field marked by the design team This is done prior to implementation to communicate to masons the intent or extent of repair.

Fig. 13 (below). A typical corner wash ledge detail for a pilaster base. The inside corner condition shown in Fig. 12 is much more complex. Modified and/or additional detailing is often required to address unique conditions or construction.

Technical Detail Level

[Second Filter – Technical Feasibility] The ability of a proposed protocol or detail to resolve technical issues is the second filter for evaluating effectiveness of the repair. The evaluation process is fairly straightforward - if an executed detail meets the technical objective of the repair category, it is considered a viable option.

Not all stone damage can be repaired nor can the natural processes of decay be prevented. The mechanisms of decay begin as soon as stone is installed and will continue over time. As a naturally occurring resource, marble demonstrates tremendous variability in composition and durability. Conditions, circumstances and requirements for repair can vary dramatically from one unit to the next, or even within the same piece of stone. Strategies that are appropriate to address one condition or element may not be effective to treat another.

This section describes results from the trial process in more detail as well as the conclusions that led to specific decisions that ultimately resulted in the Construction Documents being prepared for the Stone Repair Project.

Repair strategies are executed at the detail level. The comprehensive building assessment identified and quantified visible distress and made preliminary assumptions as to the types of repairs that would be required to accomplish the objectives of the project. Anticipated repair types were divided into eleven general repair classes:

Class A - Dutchman Repair (New stone, partial replacement)

Class B - Crack Repair (Surface filling, patching)

Class C - Redressing (Surface grinding and smoothing)

Class D - Pin Repair (Stabilization)

Class E - Protective Barrier (Applied surface coating)

Class F - Reconstruction (New unit masonry, backup)

Class G - Full Replacement (New stone, unit replacement)

Class H - Anchor Removal (Miscellaneous metal fasteners, abandoned electrical equipment)

Class I - Unit Protection (Metal flashing)

Class J - Stone Cleaning and Chemical Biocide (Comprehensive building treatment)

Class K - Joint Treatments

There are dozens of viable technical solutions for every repair class. The type of architectural feature, along with varying levels of deterioration, can result in highly variable recommendations for repair. To demonstrate and help resolve these complexities, repair protocols and details developed for the trial phase were designed to test a range of appropriate repair options (Fig. 12-13). The trials demonstrated that some repair protocols were more successful than others at mitigating the cumulative effects of decay and distress.

Objective evaluation, based solely on the ability of a repair to resolve issues technically, is fairly limited. A technical solution may accomplish the primary repair objective, but, if the overall visual appearance of the completed repair detracts from the character of the building, it may not be the right approach for a given feature or location.

Fig. 14 (above). Stepped corner at east elevator after dutchman repairs are executed in the trial phase. The inside corner was left in place for comparison. A dutchman repair will be installed during the construction phase.

Fig. 15 (right). Stepped corner at east elevator prior to repair. Pronounced deterioration at drip edges is typical and is often severe at outside corners.

Repair Class A - Dutchman Repair (New stone, partial replacement)

The dutchman trial repairs consisted of a set of technically viable repair options and techniques for repairing various architectural features. Each dutchman repair type was specific to an architectural feature, such as a scroll, column acanthus leaf or drip edge unit, and was intended to cover the full extent of distress typically observed on each feature. Thus, the size and shape of the typical dutchman units were standardized, with each dutchman unit for a similar architectural feature being identical in profile, to reduce cost and streamline constructability. Each dutchman was carved and profiled during fabrication and then shipped to the site for installation. During installation, unsound material was fully removed and the area was square cut and prepared to receive the dutchman. Dutchman units were cut in the field to match the removal depth and pinned with blind anchors, spring pins or through face anchors.

Dutchman repairs were highly effective, from a performance stand point, at addressing life safety and many water management issues across the building. In many instances, the dutchman had a positive visual impact on the building, such as where installed as repairs at spalled and ragged edges along drip edges at the cornice, water table, window hood, and pilaster base. The dutchman repair technique was also beneficial at modillion blocks, scrolls, and other projecting units with well-defined geometric shapes. Details for over 40 different architectural feature have subsequently been developed and refined to response to specific conditions and/or to meet the unique requirements for anchorage or attachment.

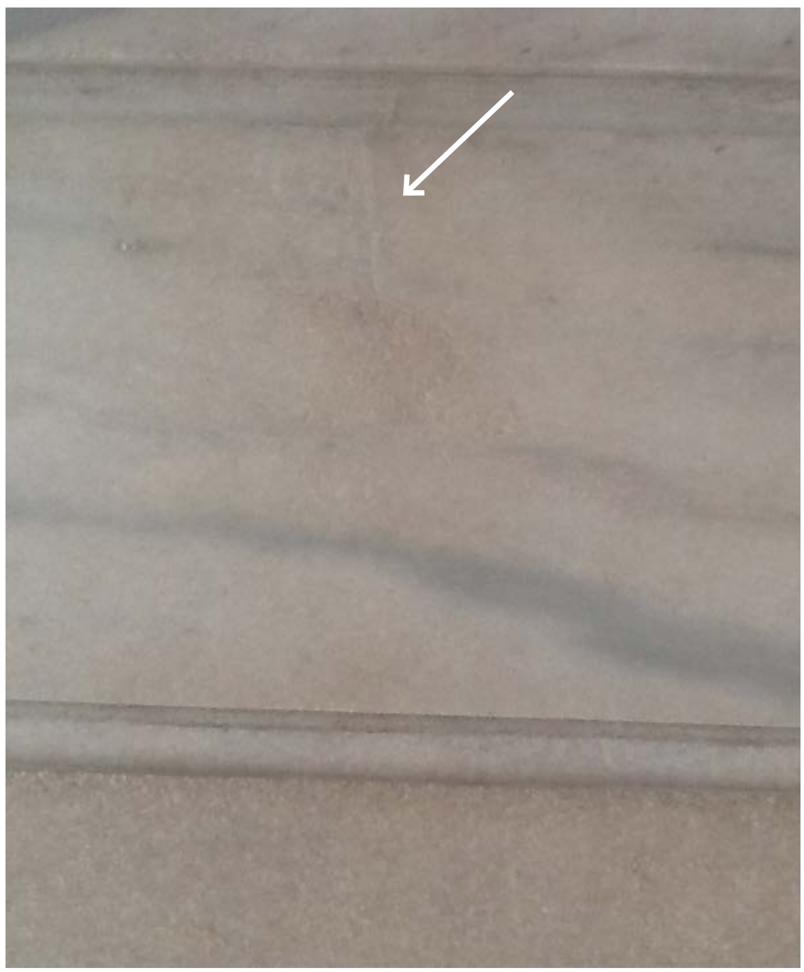
Dutchman repairs were less successful at improving the visual impact of low-relief elements such as dentils. At these locations, dutchman units were difficult to blend with the existing historic fabric and, given the labor-intensive nature of these particular repairs and the lower visual impact of these features, considered less likely to be a cost effective solution.

During the trial repairs, field conditions were identified that significantly impacted both execution and schedule. These included variability in dimensions between similarly profiled stone architectural features and an increase in the extent of unsound stone material as compared to previous surveys. As a result of these conditions, revisions were made to the standardized dutchman details and the importance of the field measuring process prior to fabrication was emphasized. Because of the variability in the existing stone profiles and extent of stone deterioration, specific locations requiring dutchman units were measured in the field prior to fabrication of the dutchman. For each unit, the profile was verified and the length of the dutchman measured from joint to joint, regardless of the perceived extent of deterioration.

The extent of deterioration and constructability of certain repairs required the size, shape and installation procedure for some dutchman units to be modified. Revisions consisted of individual dutchman units being combined to form larger dutchman units that could more effectively cover the deteriorated area and also be installed with reasonable constructability. Installation procedures for installing adjacent dutchman units, such as those at corners (Fig. 14-15), were also more clearly defined.

Fig. 16 (below). Example of a previously routed deep crack repair, type B2, following removal of the patch material. The width of the natural stone crack is visible in the image.

Fig. 17 (top right). A short, but deep crack at the east elevator tower. The blended patched repair (arrow) is shown below (Fig. 18).



Additional Observations:

- Original construction sequencing at the Minnesota State Capitol can pose significant challenges. Stacked, load-bearing and/or overlapping stone units are difficult to replace unless partial repairs are implemented. Partial repairs result in additional joints that over time could become avenues for water penetration.
- The Minnesota State Capitol is constructed with massive blocks of marble; this makes true replication difficult if not impossible. Length of available replacement stone is limited by the maximum size of a standard quarried stone block. Where replacement of larger pieces is required, repairs are accomplished using multiple pieces of stone fitted tightly together. This results in additional joints.
- Although it is always desirable to try to avoid additional joints, masons were consistently able to execute seamless transitions with careful fitting and blending. There is still some concern over how seams will weather over time.
- Freshly quarried stone will perform differently than weathered stone and this too must be taken into consideration when designing repairs.
- Situations do arise where the objectives for desired outcome are mutually exclusive. For example, whereas work required to mitigate life safety issues tends to involve removal of historic material, a sensitive preservation approach favors retention of historic material.

Repair Class B - Crack Repair (Surface filling, patching)

Surface filling or patching may be an effective strategy for reducing water infiltration at cracks or fissures in otherwise sound material. Corrective work will not be performed in every case where surface imperfections are observed. Hairline cracks and/or crazing crack patterns are not good candidates for repair. In these cases, the technique itself can actually cause more damage than leaving the condition as is. Even though repair may not be practical at the moment, cracks will worsen over time. Current conditions are photo documented and added to the data base. A watch list could be developed as part of a recommended maintenance strategy.

Where repair is warranted, this repair class has been subdivided into two types:

- **B1**- Typically narrow or virgin cracks. There was limited success with narrow crack repair techniques tested during the trials. The installation technique, as implemented, requires further modification. However, preliminary results indicate that a protective barrier against water intrusion can be achieved with minimal visual impact.
- **B2**- Wider cracks or previous routed repairs. Removal of previous repairs is recommended for two reasons:
    1. Removal gives investigators an opportunity to assess the severity of the cracks obscured by the previous repair material.
    2. Previous patch material will not likely match cleaned stone.

Fig. 18 (above). Example of grind repair that effectively improved water runoff by smoothing the surface. The profile and character of the feature was not altered. The contrast between the rough weathered surface and the repaired surface, which is very similar to the original finish, is clearly visible (arrow). The second baluster from the right was replaced in an earlier project with white Cherokee marble.

Fig. 19 (far left). Severe deterioration at a typical second floor window surround. Grinding to remove decay alters the profile and creates a scalloped pattern.

Fig. 20 (left). Even after truing the edge (Fig. 20), significant material removal is noticeable.

Repair Class C – Redressing (Surface grinding and smoothing)

The grind and smooth process consisted of grinding the surface of the stone to remove granulated surface material. Surface granulation was perceived to be a water management issue and was often accompanied by subsurface biological growth. At some locations (i.e., building wall corners and window surround corners), the grinding and smoothing trial repair was also a means of redefining architectural detail.

This repair class had mixed results but can be an effective strategy for improving water run-off. The grind and smooth technique is best suited for minor corrections that remove shallow imperfections, or rough, eroded surfaces that trap dirt, water, snow and ice (Fig. 18). Improving water-shedding capabilities reduces the potential for freeze-thaw damage and eliminates conditions favorable for sustaining biological growth. Improvements would effectively slow the rate of marble decay. Grind and smooth repairs were most effective at front facing units, such as at the field of the wall, and at high-relief elements where subsurface biological growth could be removed without altering perception of the architectural feature. The grind and smooth approach also proved successful as a blending technique between dutchman units and adjacent historic stone.

This repair protocol was less successful for sharpening profiles at continuous edge conditions (i.e. building corners and window surrounds) or at repetitive features (i.e. dentils) where the extent of deterioration is highly variable. Irregularities were readily perceived at a distance and at oblique angles. Visual impact was most noticeable in situations where it was important to maintain a continuous edge between units. To effectively remove unsound material and keep a true line, the grinding and smoothing technique often required substantial removal of intact material when located adjacent to units with more severe decay. This significantly altered the profile and still left deteriorated material in place. As a result, this repair protocol is not recommended as a strategy to improve character. (Fig. 19-20)

Additional Observations:

- To effectively remove deeper levels of decay, there is significant risk that the profile or character of a feature will be irrevocably altered. Once that threshold is passed, replacement may become necessary. This in effect doubles the repair effort, thereby increasing time and cost.
- For some features (balusters) the technique was highly effective for improving water-shedding capabilities of the stone without altering historic character. In other cases (window openings) the technique accentuated imperfections at corner margins, resulting in a much more noticeable scalloped effect. Although this pattern appears naturally in the weathered state, the softer eroded margins are less objectionable than the artificially induced pattern.
- It is nearly impossible to predict or assess the extent of deterioration or residual unit integrity based on visual observation alone. Techniques appropriate for repair of mild deterioration could easily lead to a more aggressive second round of repairs if deterioration is found to be more pervasive. Trueing up margins is labor intensive (a single baluster takes about four hours to complete). Adding new material replacement on top of this would lead to significant cost and schedule overruns. Employing this technique to simply improve character is no longer considered a viable strategy due to historic preservation concerns and the potential for excessive cost overruns.

Fig. 21. Cornice at east elevator tower. Significant cracks and vein erosion cut diagonally across the unit. Because of the orientation of the cracks, the size of the unit (3000 +lbs), and the location (over the main entry) this is assigned to the highest priority repair class, Life Safety (Tier 1). The unit is currently sound but will be stabilized in place as a protective safety measure.

Fig. 22. West wing baluster cap.

Repair Class D - Pin Repair (Stabilization)

Stabilizing stone units in place is an effective way to mitigate potential life safety issues where replacement is impractical (Fig. 21), where remaining material is sound (Fig 22). or in situations where high value is placed on retaining historic material.

Repair Class E – Protective Barrier (Applied surface coating)

A category for surface applied coatings (i.e. acrylic based, PMMA) was created as a responsible, cost effective alternative that provides limited protection against water infiltration on upward facing surfaces where metal flashing is not practical. These materials are typically not visually compatible and are only recommended for discreet locations that are not readily seen. This recently introduced protocol was not tested in the trial phase. A small trial area will be tested as weather conditions and temperature allow.

Repair Class F - Reconstruction (New unit masonry, backup)

Backup brick masonry reconstruction is required to mitigate potential life safety hazards at a number of locations. During the trial phase, several roof parapet balustrade piers were partially dismantled to assess conditions: one intermediate west wing parapet pier (south façade); and three larger west wing corner piers (one at the south pavilion, one at the north pavilion and one over the northwest entry). In all cases, prolonged water intrusion, failed masonry joints and damage due to miscellaneous mechanical fasteners had caused sufficient damage to necessitate full replacement of backup masonry.

Installation techniques used to anchor the current lightning protection system have caused substantial damage to the stone masonry. Damage is severe enough to require full unit replacement in many locations (i.e. stone panels at roof parapet piers). Provisions for temporary lightning protection will be made while stone and backup masonry repairs are being executed. Prior to reinstallation, options for a less intrusive permanent system could be explored.

To accomplish backup masonry repairs, stone panels must first be removed. The condition of brick backup masonry and stone anchorage is then assessed. New brick masonry is selected based on compatible physical properties such as water absorption and compressive strength. The backup assembly is then reconstructed. New stone anchorage systems are designed and the repaired stone is reinstalled. This repair class has been subdivided into three types based on type of backup masonry construction:

- **F1**- Rebuild backup at field of wall unit
- **F2**- Balustrade reconstruction (2nd floor loggias, pavilion balconies, roof parapets)
- **F3**- Parapet pier reconstruction

Repair Class G - Full Replacement (New stone, unit replacement)

Although relatively rare, full unit replacement is sometimes required to mitigate a potential life safety hazard. One pilaster unit, pinned in place as an emergency repair in 2010, was replaced at the east elevator tower during the trial phase. Although the helical pin repair was performing well, concern for the condition of backup brick masonry justified removal. The severely distressed stone veneer panel was replaced with new stone as a preferred solution for long-term durability.

Several stone units associated with transition walls on the north roof have sustained irreparable damage from miscellaneous steel anchors or from prolonged exposure to water due to roof flashing deficiencies. Although not considered life safety concerns, these units have been identified for full replacement to protect the building against additional water infiltration.

Fig. 23 (top left). Window hood flashing at second level. From street level the metal flashing repair is minimally intrusive.

Fig. 24 (below). Metal flashing repairs are designed to be reversible. Cleats for attachment are inserted at joints, original stone material is not altered.

Fig 25 (bottom left). Deteriorated ledge material is protected in place.

Repair Class I - Unit Protection (Metal flashing)

Sheet metal flashing caps consist of interlocked sheet metal that covers the full surface of the cornice or window hood. The intent of the flashing cap was to promote water run-off from these low-slope areas and preserve the historic stone and profile of the ledge. (Fig. 23-25)

This repair class has been subdivided into two types based on feature type:

- **I1**- Ledge flashing protection at second floor window hoods
- **I2**- Ledge flashing protection at cornice ledge

The sheet metal flashing cap was determined to be an effective repair technique. Although somewhat noticeable from grade, sheet metal flashing caps were successful in shedding water from the cornice and window hoods, as well as redefining the horizontal line of these architectural features that had been lost due to the condition of the stone. The sheet metal caps will soon patina and most likely be less noticeable from grade. Slight modifications were recommended to the drip edge of the flashing caps so that the profiles more closely resemble the stone.

Repair Class J - Stone Cleaning and Chemical Biocide

Preliminary cleaning trials of chemical biocides and spot cleaners were also performed. Trials were conducted for spot cleaner products to determine a process and the extent to which the stone can be effectively cleaned. Spot cleaners were intended to be applied on existing stone units adjacent to dutchman and areas repaired by grinding and smoothing, as a method to blend repair areas with the existing stone. Chemical biocides are used to reduce biological growth, one mechanism contributing to stone deterioration, at selected water table and cornice zones on the north elevation.

Not all cleaning application protocols were effective in removing surface residue and conservators are concerned that the relatively high concentrations, non-neutral pH and lengthy dwell times required for noticeable improvement may be potentially harmful to the marble. Additional testing will continue in the spring of 2013 prior to recommending a cleaning protocol.

Due to the extent of the repairs and the difference in appearance between the new stone dutchman and the patina of the original stone, a full building cleaning will be implemented for the Stone Repair Project. The cleaning will improve the appearance and visual impact of the repairs and may have a positive effect on slowing the rate of stone deterioration. The cleaning will be performed in lieu of spot cleaners and biocides assessed during the trial repairs, but will include a biocide to address biological growth.

Passive biocide treatment was rejected for several reasons:

1. Actual degree of effectiveness is not known.
2. Potential for halo effect. Protection would likely be better in close proximity to metal strip.
3. The length of time required to achieve significant results with in situ testing are incompatible with the project schedule.

Repair Class K – Joint Treatments

Upward facing joints, projecting hoods and ledges were observed to be severely deteriorated during previous surveys. Repair options implemented at these locations during the trial phase repairs included installation of lead weather caps in joints. Lead weather caps, a joint treatment that provides a weather proof barrier, were installed on the dome several years ago. During the trial phase, lead caps were installed at upward facing joints at the cornice and water table zones of the building to protect joints with high exposure to water, snow and ice.






Preservation Level

[Third Filter - Preservation] The ability of a proposed protocol or detail to meet the Secretary of the Interior's Standard Guidelines for Rehabilitation is the third filter for evaluating effectiveness of the repair. If an executed detail does not follow the intent of Standard Guidelines, the repair is not considered viable.

The historic value of the Minnesota State Capitol, and the magnitude of restorative work required, brings a host of preservation issues to the forefront. Interpretation of the Standards is somewhat subjective and personal bias can lead to different opinions on the same topic. A concern voiced by one may not be considered a cause for alarm by others. The bottom line is that there is no right answer. Given this inherent subjectivity, opportunities to engage a host of preservation practitioners to openly discuss key issues were an extremely important part of the process for building consensus on approach to repair.

The design team has identified those areas and features of the building that are most significant to the historic character and integrity of the building. The State Department of Administration and Minnesota's lawmakers are taking steps to ensure long-lasting preservation of the Minnesota State Capitol. An important part of this process is the development and ongoing review of a historic exterior Preservation Plan to help ensure that preservation is considered as an integral part of institutional activities, rather than in competition or conflict with other activities for time and limited resources.

While the repair trials provided a great deal of useful information, additional factors – such as available funding for preservation- must be considered when setting priorities for actual preservation action. As this critical information becomes available, analysis can be finalized and detailed recommendations made. Building on the information presented in this report, the exterior preservation planning document will provide the specific framework for both ongoing historic preservation work and future decision making. The key item in the preservation plan is a list of high priority actions that are achievable and a timetable for implementing them.

Presentations and open forum discussions were held with the State of Minnesota and preservation professionals from Minnesota State Historic Preservation Office (SHPO), the Minnesota Historical Society (MHS) and representatives of the Capitol Area Architectural and Planning Board (CAAPB).

The Secretary of the Interior's Standard Guidelines for Rehabilitation

In addition to the technical aspects of repair that were taken into consideration, detailed specifications and repair protocols for the Phase 1 trials were conceived and developed with sound preservation practice at heart and follow the intent of Secretary of the Interior's Standard Guidelines for Rehabilitation:[7]

- **Identify, retain and preserve** masonry features that are important in defining the overall historic character of the building. Removing or radically changing masonry features which are important in defining the overall historic character of the building is not recommended.
- **Protect and maintain** masonry by providing proper drainage so that water does not stand on flat, horizontal surfaces or accumulate in curved decorative features. Clean masonry only when necessary to halt deterioration or remove heavy soiling.
- **Repair** masonry features using recognized preservation methods. Repair may also include the limited replacement in kind--or with compatible substitute material--of those extensively deteriorated or missing parts of masonry features when there are surviving prototypes.
- **Replace** in kind an entire masonry feature that is too deteriorated to repair--if the overall form and detailing are still evident--using the physical evidence as a model to reproduce the feature. Removing a masonry feature that is unrepairable and not replacing it; or replacing it with a new feature that does not convey the same visual appearance, is not recommended.

7 http://www.nps.gov/tps/standards/rehabilitation/rehab/masonry01.htm

Fig. 32. West wing, north facade. Second level windows following trial phase.

Fig. 33. West wing, north facade following trial phase.

Context Level

[Fourth Filter - Perspective] The expediency and appearance of field executed repairs is the fourth filter for evaluating effectiveness of the repair. If the end result can be practically installed and does not visually detract from the historic character, it is considered a viable option.

Trial repair strategies were developed to explore a range of repair options. A preservation-based approach, involving minor intervention or disruption of original material, was developed along with details for partial or full replacement of original material, biased toward long-term durability. Moderate impact protocols filled the gap between the conservative and more liberal approaches. Conceptually, the goal was to compare and contrast the effort, expense and effectiveness of progressive repair options to restore the integrity of the building while retaining as much of the original stone material as reasonably possible.

Appropriate and technically viable solutions were next evaluated within a broader context that considered the effect a repair had on the surrounding material. The focus shifts away from specific repair at the detail level and moves toward a more strategic approach that consider the impact implemented repairs have on the overall character of the building.

Field evaluation of specific repair techniques and general repair strategies occur at two levels:

- **Close range** – technically biased. Focused, critical assessment of individual repairs and the impact they have on immediately adjacent material. The effectiveness of specific repair techniques is considered on a case-by-case basis.
- **Street view** – aesthetically biased. General overall impression of collective repairs. The effectiveness of specific repair techniques is reviewed relative to grouped repairs at general locations.

The trials demonstrated that overall impression of a repair can vary significantly with distance and viewing angle. Something that "looks good" up close may be objectionable at a distance or perhaps the reverse is true. Changing one's viewing perspective (head-on vs. oblique angle, looking direct vs. looking up, outline profile vs. framed view) also influenced perception. To fully evaluate the effectiveness of proposed repairs it is imperative that they be reviewed in context, preferably at several locations, from different perspectives, over the course of time. Variability associated with the following parameters is thereby taken into account:

- Time of day - morning, afternoon, evening, night
- Changing light levels - direct sun, shadows
- Atmospheric conditions - sunny, overcast
- Moisture - wet stone, dry conditions

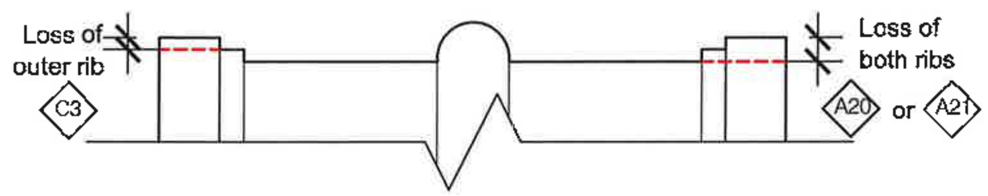
Assessment protocols and specific condition parameters have subsequently been established for some of the more challenging architectural features: S-scroll window hood brackets; column capital features (abacus caps, volutes, fleurons and acanthus leaves); and modillions. Certain condition "triggers" have been identified that can be used as criteria to establish thresholds for various levels of repair. Once a designated threshold is crossed, the next level of repair is recommended. (See Exhibit A-D).

REPAIR ASSESSMENT PROTOCOL:

1. Attempt to determine depth of unsound material through close-up visual inspection, including sounding with hammer.

2. Life safety considerations shall guide repair assessment.

3. If deterioration results in loss of profile of both outer and secondary ribs of scroll (see diagram), specify dutchman.



4. Review repair assignments in the context of scroll pairs at same window surround.

5. Edit repair assignments as necessary after contextual review.

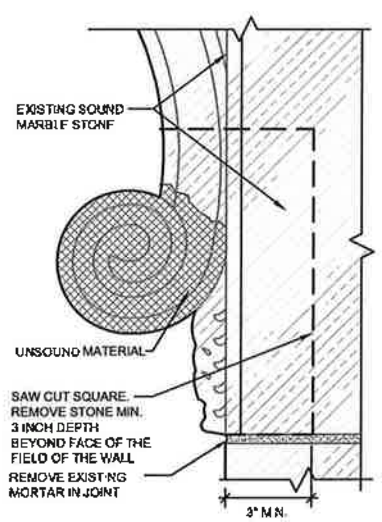
Example of scroll unit requiring carve and smooth repair

Examples of scroll units requiring partial scroll dutchmen repair, pending loss of profile assessment on upper portion of scroll

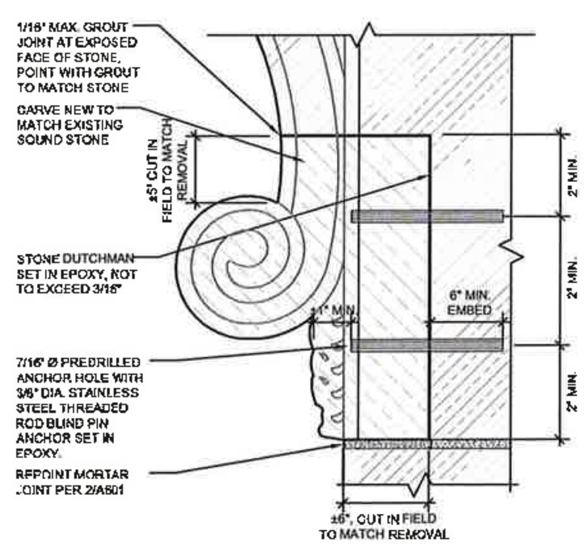
Example of scroll requiring partial or full dutchman repair, based on context and loss of profile assessment

Example of scroll unit requiring full face dutchman repair, regardless of context

PHOTO EXAMPLES OF SCROLL UNITS
NTS

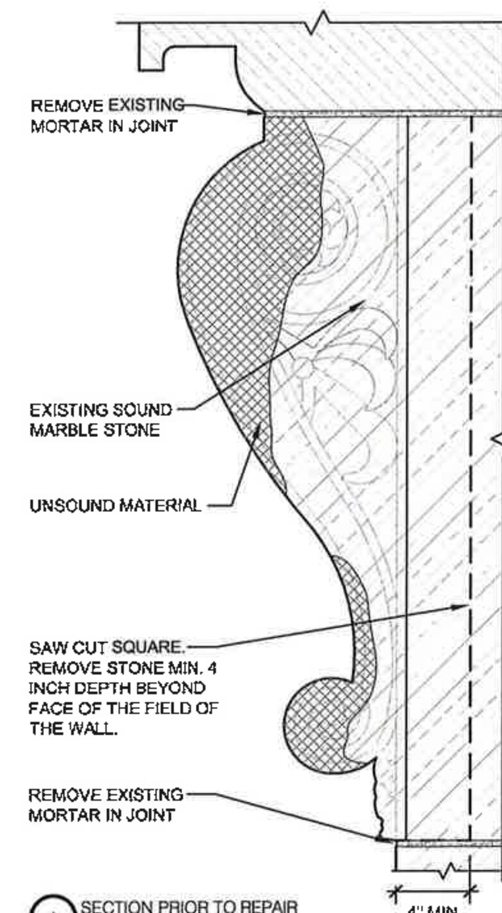


A SECTION PRIOR TO REPAIR
1-1/2"=1'

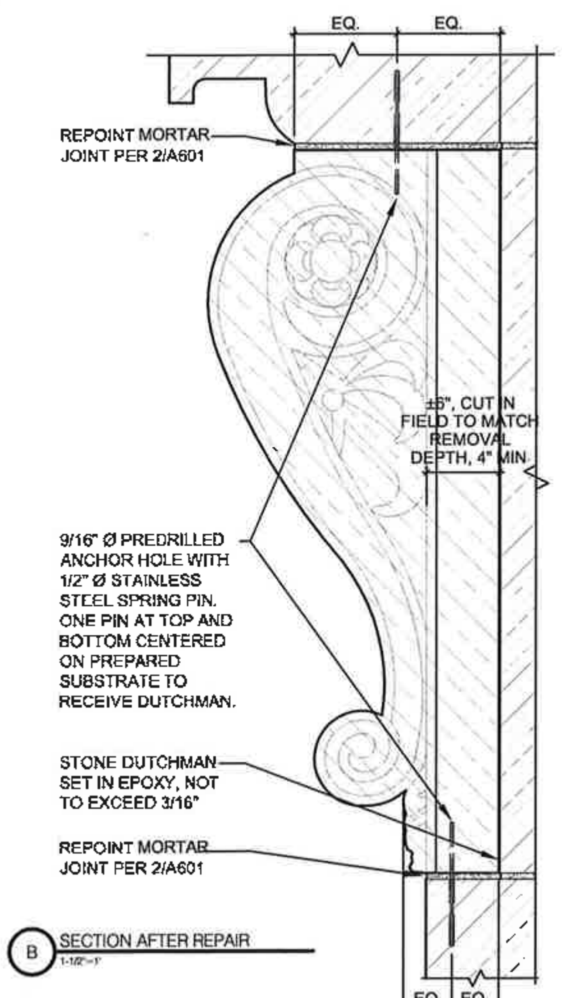


B SECTION AFTER REPAIR
1-1/2"=1'

A20 PARTIAL SCROLL DUTCHMAN REPAIR
NTS



A SECTION PRIOR TO REPAIR
1-1/2"=1'



B SECTION AFTER REPAIR
1-1/2"=1'

A21 FULL FACE SCROLL DUTCHMAN REPAIR
NTS

REPAIRS AT SCROLL UNITS
NTS

Exhibit A: Assessment protocol for scroll repairs.

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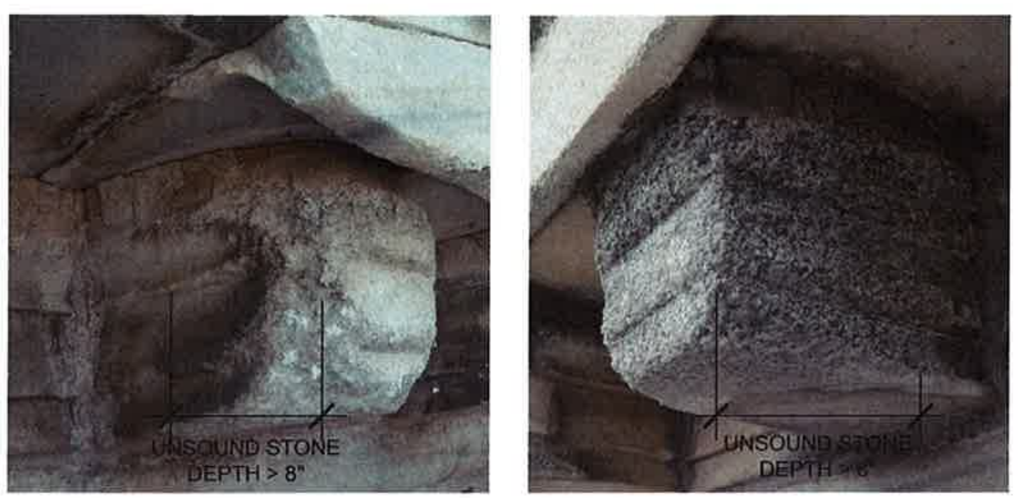
REPAIR ASSESSMENT PROTOCOL:

1. Designate "carve and smooth" or "dutchman" (general) repair strategy from grade and in the context of surrounding modillion blocks.

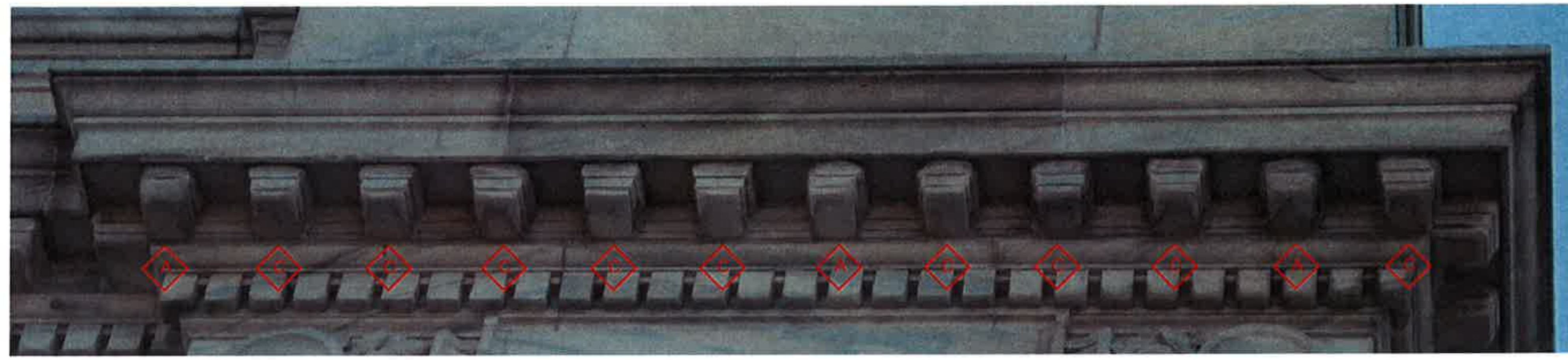
2. Confirm initial repair assignments by attempting to determine depth of unsound material through close-up visual inspection, including sounding with hammer.

3. For dutchman repairs, designate partial or full dutchman during close-up inspection. If deterioration exceeds 8", specify full dutchman repair.

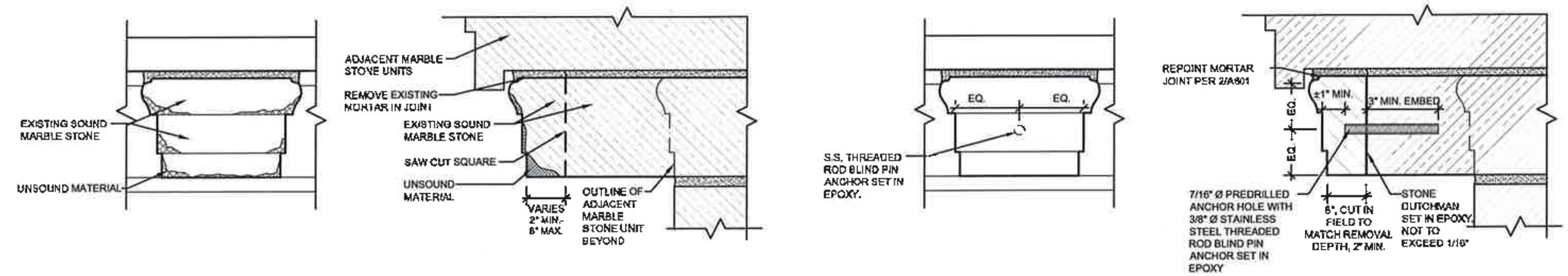
PARTIAL DUTCHMAN A23



FULL FACE DUTCHMAN A24



MODILLION BLOCKS FROM GRADE
NTS



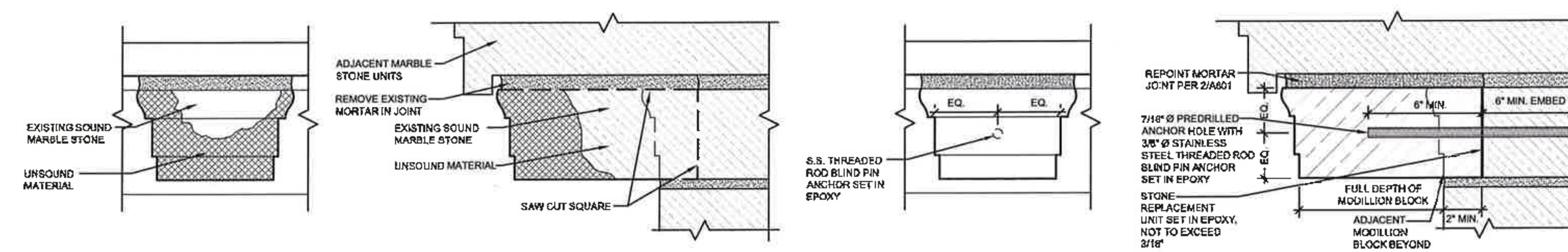
A ELEVATION PRIOR TO REPAIR 1-1/2"=1'

B SECTION PRIOR TO REPAIR 1-1/2"=1'

C ELEVATION AFTER REPAIR 1-1/2"=1'

D SECTION AFTER REPAIR 1-1/2"=1'

A23 PARTIAL DUTCHMAN REPAIR AT MODILLION BLOCKS
NTS



A ELEVATION PRIOR TO REPAIR 1-1/2"=1'

B SECTION PRIOR TO REPAIR 1-1/2"=1'

C ELEVATION AFTER REPAIR 1-1/2"=1'

D SECTION AFTER REPAIR 1-1/2"=1'

A24 FULL FACE DUTCHMAN REPAIR AT MODILLION BLOCKS
NTS

REPAIRS AT MODILLION BLOCKS
NTS

Exhibit B: Assessment protocol for modillion blocks.

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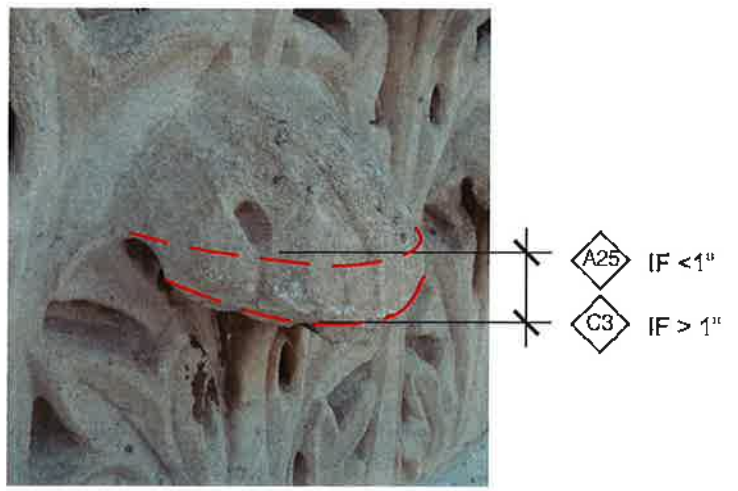
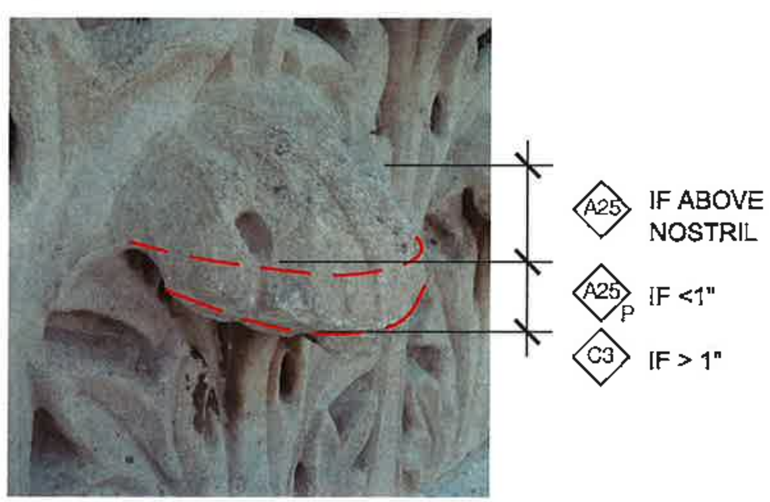
REPAIR ASSESSMENT PROTOCOL:

1. Remove unsound material before assessing for repair. Entire body of acanthus must be of sound stone.

2. Upper row of acanthus:
   Carve and smooth- sound material > 1" below "nostrils"
   Dutchman- sound material < 1" below "nostrils"



3. Lower row of acanthus:
   Carve and smooth- sound material > 1" below "nostrils"
   Pending dutchman- sound material > level of "nostrils" and < 1"
   Dutchman- sound material < level of "nostrils"

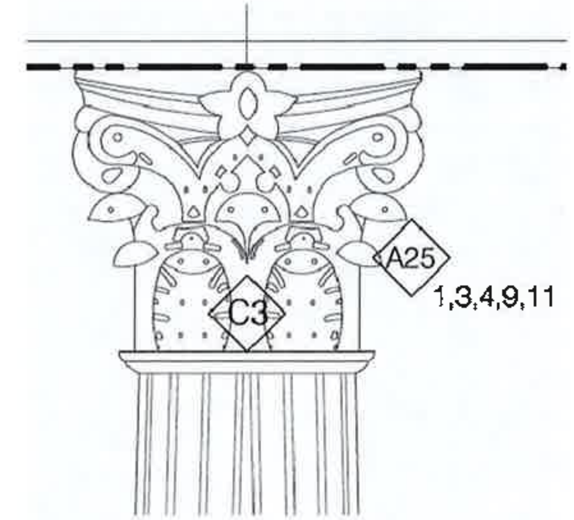


4. Repeat for each acanthus on capital

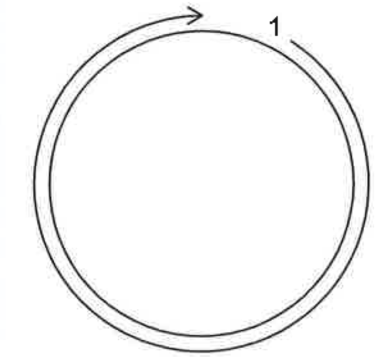
5. Review repair assignments in the context of the full capital.

6. Edit repair assignments as necessary after contextual review.

PILASTER CAPITAL
NTS



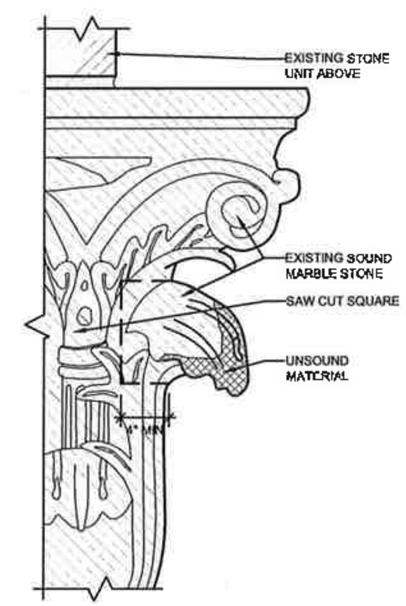
BACK OF COLUMN
(PORTICO)



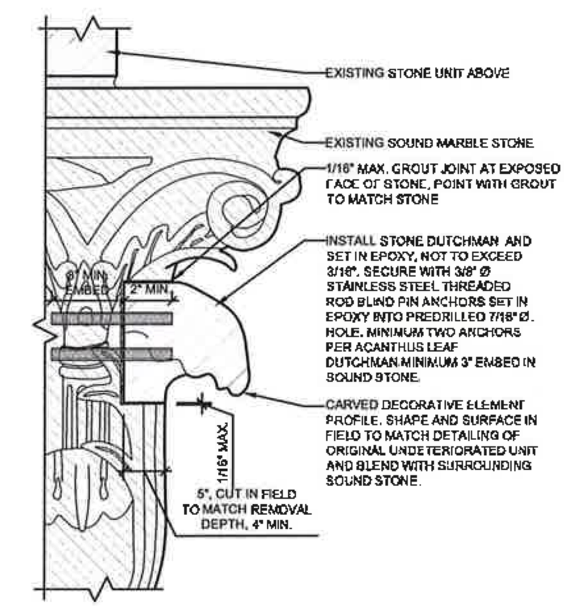
FRONT OF COLUMN
(SWING STAGE)

Number acanthus repairs on column capitals starting at the back of the column in plan, moving clockwise around the column.

COLUMN CAPITAL
NTS



A SECTION PRIOR TO REPAIR
1-1/2"=1'



B SECTION AFTER REPAIR
1-1/2"=1'

A25 REPAIRS AT COLUMN OR PILASTER CAPITAL ACANTHUS LEAF
NTS

Exhibit C: Assessment protocol for capital acanthus leaves.

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REPAIR ASSESSMENT PROTOCOL:

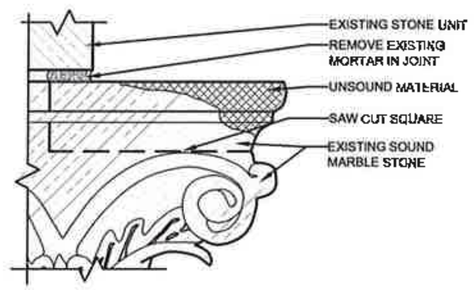
1. Attempt to determine depth of unsound material through close-up visual inspection, including sounding with hammer.

2. Water management consideration shall guide repair assessments.

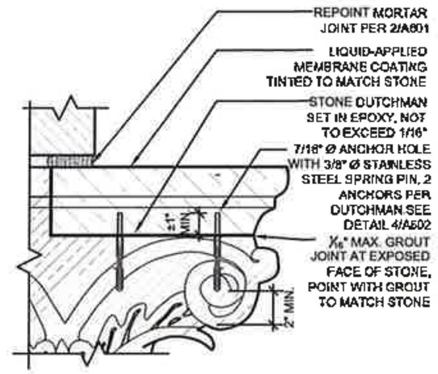
3. Repeat for each abacus on capital.

4. Review repair assignments in the context of the full capital.

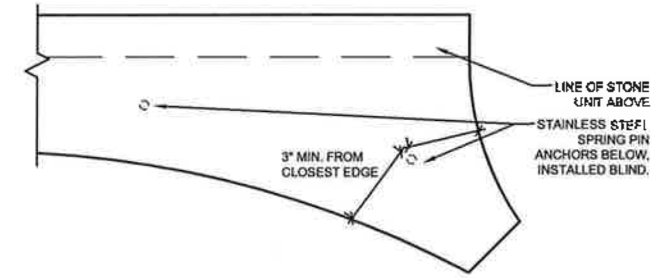
5. Edit repair assignments as necessary after contextual review. Consider possibility of combining elements (i.e.- abacus + fleuron; abacus + volute), however assign as single element dutchmen in field.



A SECTION PRIOR TO REPAIR
1-1/2"=1'



B SECTION AFTER REPAIR
1-1/2"=1'



C PLAN AFTER REPAIR
1-1/2"=1'

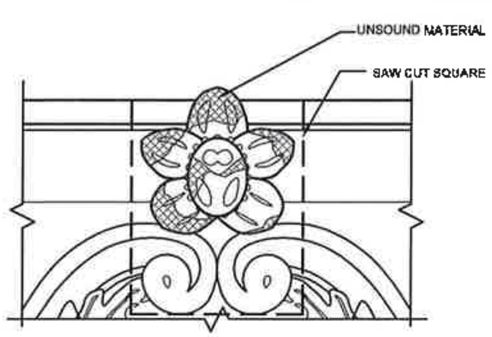
A28 REPAIRS AT COLUMN OR PILASTER CAPITAL ABACUS
NTS

REPAIR ASSESSMENT PROTOCOL:

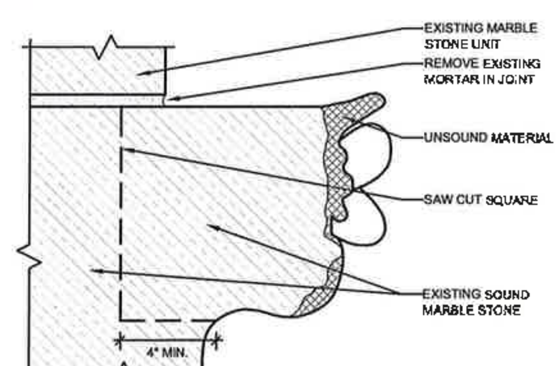
1. Remove unsound material before designating as "carve and smooth" or "dutchman" from grade. Consider surrounding context of full column capital and visual impact of fleuron element.

2. Aesthetic considerations shall guide repair assessments.

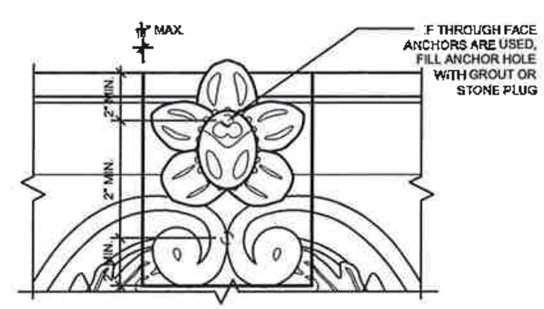
3. Confirm initial repair assignments through up-close visual inspection.



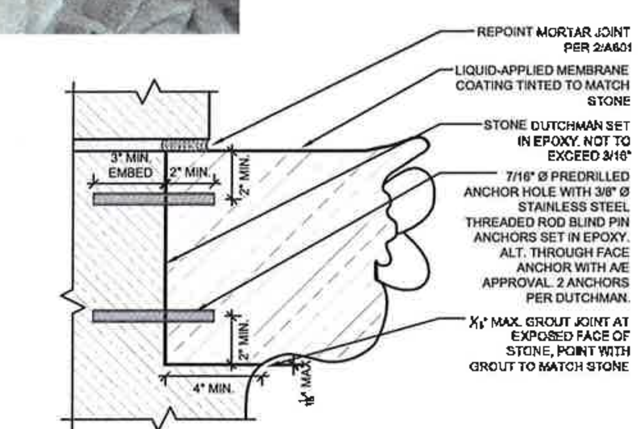
A ELEVATION PRIOR TO REPAIR
1-1/2"=1'



B SECTION PRIOR TO REPAIR
1-1/2"= 1'



C ELEVATION AFTER REPAIR
1-1/2"=1'



D SECTION AFTER REPAIR
1-1/2"=1'

A27 REPAIRS AT COLUMN OR PILASTER CAPITAL FLEURON
NTS

Exhibit D: Assessment protocol for capital abacus and fleuron ornament.

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Fig. 34. West wing, north facade following trial phase, viewed from the parking lot.

Fig. 35. West wing, north cornice following trial phase, viewed at close range.

Context Level

Life safety and water management issues have always been the highest priority, and to meet the construction budget, project objectives have focused on these categories almost exclusively. However, the trial phase demonstrated the effect a strictly functional approach would have on perceived building character. The ensuing dialogue raised questions and concerns that exposed certain patterns of expectation for desired outcome that challenged many of the initial assumptions about the value placed on building character and the visual impact architectural features have on perceived integrity and building stewardship.

To summarize conclusions at the context level, questions raised during the trials are revisited:

At what point does the loss of historic detail begin to detract from the dignified character of the State Capitol? Is there an acceptable level of detail that must be retained for a character-defining feature to remain convincing?

- In certain situations eroded detail does not necessarily detract from the overall impression one has of the building, and some might argue that the "patina" is part of the character of a monument that has stood the test of time. Context can also help disguise irregularities. Detail loss at objects with organic forms (i.e. capital elements) is difficult to detect even at reasonably close range. Because of the inherent irregularity, discontinuity is more readily masked.
- On the other hand, gaps, degraded edge boundaries and loss of significant detail can be perceived, even at substantial distances, if contrasting conditions are juxtaposed in a contextual setting. With sufficient loss of material, detail interpretation becomes more difficult and the perception of "wholeness" is challenged. Continuity, profile outline and context are key components for interpreting completeness or integrity of form. The quality and amount of direct light, or shade and shadow, accentuates outlined forms. This is particularly true for elements that are viewed against a dark background (modillions) or backlit against the sky (outside corners, balustrades).
- Smaller, closely spaced, repetitive elements (dentils) that are typically viewed from a distance are more likely to be interpreted collectively as a band rather than as individual elements. Minor imperfections of single units tend to be less obvious. However, loss of detail is visibly intrusive when deterioration occurs at outside corners or across a series of features.

To what extent is modification or reshaping of historic material appropriate?

- Perceived character may actually drive the level of repair in some cases. Although a given condition may not have crossed the threshold for repair, weathered material stands out as compromised when sandwiched between new stone replacements.

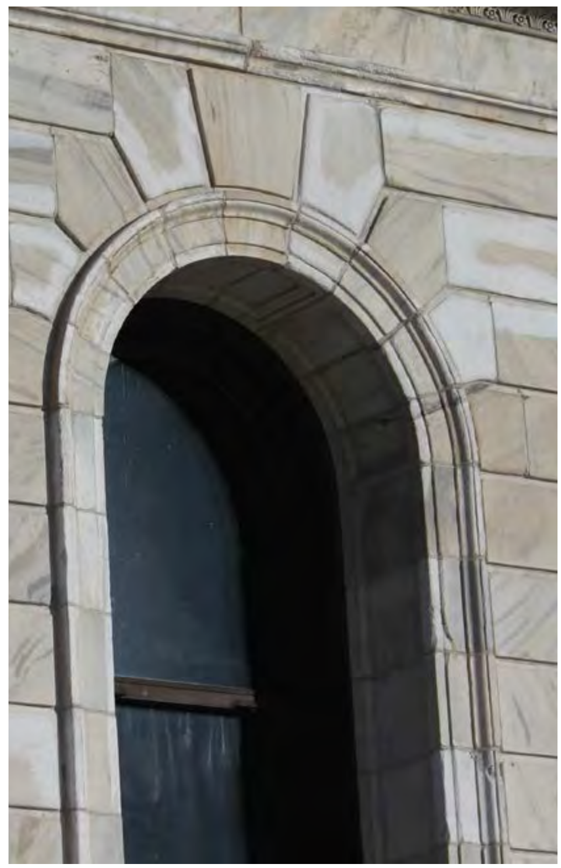
When is replacement of character-defining features required?

- Character driven repairs, particularly those where replacement is recommended, are the most difficult to prescribe because their valuation is completely subjective to the viewer.
- There are occasions where leaving deteriorated historic material in place would compromise functionality and/or detract from the perceived character of the building. Leaving severely weathered material in place directly above a new repair could potentially put new work at risk for accelerated decay. Depending on location and adjacencies to new stone repair, replacement may be recommended to avoid compromising performance of a newly installed work even though weathered stone may not meet the threshold for replacement.

Fig. 36 (top left). Dutchman repair at window surround. New white Georgia marble (between arrows) blends seamlessly with historic material. The existing condition prior to repair is shown below (Fig. 37)

Fig. 37. (bottom left). West wing, south facade window surround prior to removal of unsound material and dutchman repair.

Fig. 38 (below). East elevator tower window surround. Jambs were ground and trued. Severely deteriorated units at the right jamb are visible even at a distance.



- Where general repair is not practical due to the level of decay, or for situations where significant loss of historic detail has occurred, limited replacement using new stone to match the original was explored. Replacement is a more viable option now that compatible stone resources have been made available. Furthermore, the team of master stone carvers and masons that has been assembled will execute replacement repairs using tools and techniques that are much the same as those employed a hundred years ago.

How much historic material needs to be removed?

- The answer to this depends on a number of factors; whether the potential exists to become a life safety concern, the level of decay or extent of unsound material, and in some cases, the impact detail loss has on perceived character. As a rule, original material is only removed as required to mitigate life safety concerns or to reach sound stone that can then be prepared to receive new work. However, maintaining a consistent appearance may require more aggressive repairs than are required based on condition alone. Removal of deteriorated original material may also improve long- term durability. Although counter to preservation goals that place high value on retaining historic material, removal and replacement in kind may actually preserve the character of the building.

How will new work fit in with historic material?

- Freshly quarried stone sparkles like diamonds in the sun, much as Cass Gilbert had originally envisioned. Although weathered marble has lost that dazzling effect, light grinding and smoothing can restore the former visual qualities of the historic stone. Blending new work in with existing can be accomplished by lightly grinding and smoothing adjacent material to create gradual transitions. Cleaning protocols will also help moderate differences in color.

- A consistent appearance improves perception of overall building character. Repairs were determined to be more successful when adjacencies and groupings of architectural features were considered.

Will new work be distinguished from original work?

- Certain decorative features, such as S-shaped window hood brackets at the second floor, have markings that serve as the signature of the mason. Some of these pieces are scheduled for replacement which brings up several questions:

  – Should the signature marks be reproduced?

  – Should new replacement brackets be uniquely “signed” by today’s masons?

  – Should historic signatures and locations be documented? If so, how?

Fig. 39 (top). Dutchman repair at cornice drip edge and modillion blocks.

Fig. 40. Close up of fascia drip edge dutchman repair showing overlapping material. Construction sequencing can complicate future repairs.

Comprehensive Building Level

[Fifth Filter - Project Impact] The aesthetic impact that the proposed comprehensive strategy has on building character, along with an assessment of the impact these design decisions have on the overall Project, are the fifth filter for evaluating effectiveness of the repair.

Aside from the technical, preservation and aesthetic aspects of repair, a number of additional contributing factors and combinations thereof must also be considered when evaluating the effectiveness of a repair strategy.

The following long list of contributing factors, taken in their entirety, acts as a fifth filter:

- Location – primary, secondary, tertiary façade, entry, public access
- Proximity – 10 feet, 25 feet, 50 feet, 100 feet, 200 feet
- Visibility – eye level, perspective from grade, from adjacent buildings, from Quadriga level promenade, as photographed with zoom lenses to isolate points of interest
- Focal point – non-contributing, character-defining, point of interest
- Exposure – horizontal, vertical, sloped
- Context – adjacencies, hierarchical groupings, architectural features
- Preservation issues
- Character – field of wall, running pattern, unique detail, low relief, ornately carved detail

Weighting the effectiveness of different repair protocols for various architectural features, a comprehensive repair strategy is ultimately derived by combining the most successful approaches and applying them to the building as a whole. The aesthetic impact this proposed comprehensive strategy has on building character is reviewed relative to the overall impact these design decisions have on the Project. As an example, if a decision is made to tackle severely deteriorated column capital features in order to improve overall character, the sheer number of elements affected by this decision (there are 240 pilaster capitals and 50 full column capitals) has significant impact on Project cost.

Planning Considerations

What improvements can be made now to extend the longevity of in-place marble?

- Distressed material that does not meet the current threshold for repair or replacement will continue to weather. Thorough routine inspection and documentation is recommended to track advancing conditions and recurring areas of water penetration.

What is the right balance between retaining historic material and restoring character detail?

- If historic material is sound – then retention should be of primary consideration. If historic material could contribute to deterioration of other historic material – then some intervention should be considered.

If not required technically, when is replacement to improve character acceptable?

- A consistent appearance improves perception of overall building character. To maintain a unified, balanced effect, replacement repairs tend to be more comprehensive. This could potentially result in recommendations for removal even though criteria for replacement have not been met.

Fig. 41. East elevator tower gabled window hood and cartouche. The hood return on the right was repaired with new stone. Removal of unsound material on the left gable return results in irregular profiles and eroded corners. The cartouche and surrounding detail was lightly ground and smoothed. Unsound material was removed from both scrolled brackets.

Fig. 42. West wing, north facade window hood. Severely deteriorated scrolled brackets were replaced with new stone. The ledge corner on the right (removed to mitigate a potential safety hazard) was repaired with a new stone dutchman. The front drip edge is also a dutchman repair. The left corner and wash ledge show the existing condition prior to repair.

Visual Appearance

Considerable thought has gone into ways in which various protocols can be utilized to emphasize consistency of character when integrated into a preferred repair strategy. Consistent treatment of repetitive and/or linear units creates a sense of continuity. Blending new work with old suggests harmonized treatment even where a range of repairs is called for. Another approach is to group repairs into prioritized treatment zones. Focusing work on architectural groupings emphasizes the classical language of Beaux Arts architecture and creates a strong balanced appearance.

Overlay zones were established based on visual impact:

1. Critical Impact Zone: primary drip edges (cornice, second floor wash ledge), horizontal cornice elements (fascia, modillion blocks), carved detail with horizontal exposure (capital abacus), edge boundaries (roof balustrades and piers), focal points (statuary, gabled pediments at elevator and stair towers)

2. High Impact Zone: column capital elements (acanthus leaves, volutes, fleuron, astragal), S-curve bracket scrolls and window hoods (second floor), balustrade rail caps (second floor loggias and pavilion balconies), secondary wash ledges, second floor window sills, decorative keystones at main entry arches

3. Significant Impact Zone: roof balustrade rail caps with drip edges, pilaster capital elements (acanthus leaves, volutes, fleuron, astragal), column/pilaster pedestal and base features (drip edge, torus, carved base profiles), high relief ornamental detail (third floor), low relief detail at primary entries (swags, medallions), sill bands and sills (first floor window openings), stringcourse

4. Moderate Impact Zone: dome character-defining features (eagle statuary), dome character-defining features (high relief carved panel details), window surrounds (second and third floor), sills (third floor), high relief ornamental detail (upper story), low relief carving (entry area-first floor)

5. Low Impact Zone: dentils, capital column flutes, portal surrounds (primary entries)

Overlay zones were then used to prioritize the scope of work for the upcoming Stone Repair Project.

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PROCESS DEVELOPMENT: INFORMATION SHARING, DATA MANAGEMENT AND REPAIR TRACKING

A huge part of the effort that goes into designing large-scale restoration projects involves first gathering, then processing and finally managing vast amounts of information. Knowledge gained throughout the process has to be documented, evaluated and then transformed into Construction Documents that convey Project intent. Once construction starts, the process has to be monitored and tracked for completion. Following construction, the actual work completed has to be documented as part of the permanent building record.

The Minnesota State Capitol is not a typical restoration project. The building is massive - over 50,000 individual pieces of stone were used in its construction and each piece has upward of 60 identifying traits that can be assigned and evaluated when prescribing repairs. Due to the magnitude of

Information management at this scale requires a systematized approach to:

- **Documentation**
- **Data Management**
- **Repair Tracking**

Documentation

Documentation of existing conditions occurs at several levels:

1. Laser Scanning (Clark Engineering 2011)

   The exterior of the Capitol was laser scanned. Data collected as 3D point clouds was then translated into 2D CAD drawings. The intent was to provide accurate backgrounds for field assessment and Construction Drawings. Although advantages were definitely gained, accuracy fell somewhat short of the early expectations.

   - Precision is equipment dependent and camera resolution makes a huge difference. Clark began with the assumption that accuracy of (6" +/-) was sufficient. Adjustments were made later in the process once attention was drawn to inaccuracies. Subsequent output was more exact.
   - Accuracy is affected by distance, viewing angle, and selection of work points. Information pertaining to areas surveyed at considerable distance (i.e. dome and drum) is much more inconsistent. Sharp viewing angles exaggerate perspective. The resulting distortion is not always corrected.
   - End results are still only interpretations and incorrect assumptions are occasionally made. Field verification is required to confirm profiles and architectural detailing.

2. Field Condition Assessment (HGA-2010, WJE-2011, HGA/WJE – 2012-2013)

   The physical condition of stone was first reviewed during the investigative phases. Field assessments, based on visual observation and "sounding" techniques, were made for every stone on the building. Observations and were recorded on field assessment sheets.

3. Digital libraries (2006-2013)

   Digital photography makes extensive recordation of field conditions feasible. High resolution cameras equipped with powerful zoom lenses make it possible. Digital libraries have been established to help manage the large volume of images collected over the years. Naming, filing and tagging conventions have been custom created to facilitate sorting and searching.

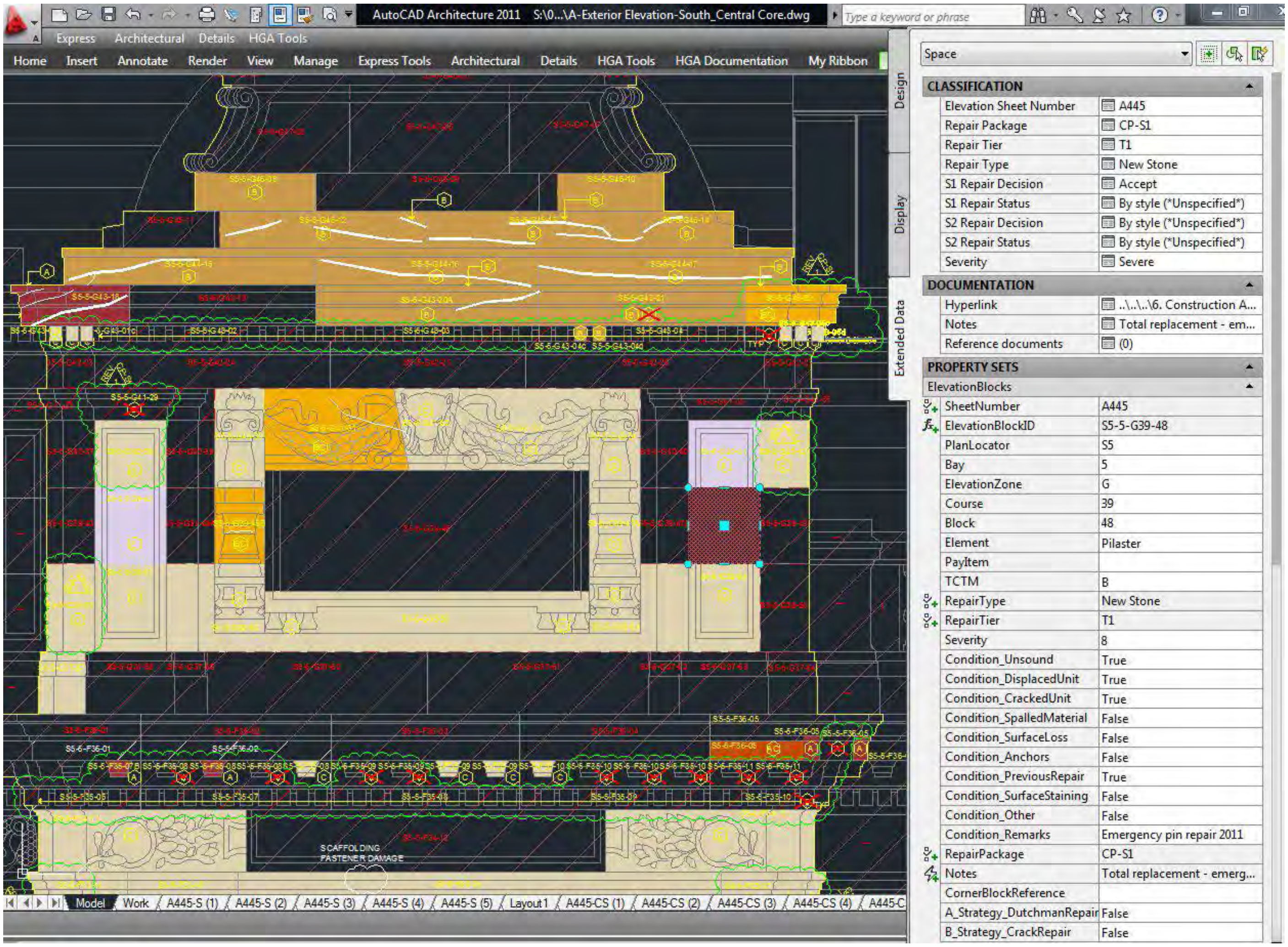

Fig. 44. Screen capture of customized CAAD database used to generate the Construction Documents.

Data Management

Managing the volume of information collected for over 50,000 individual pieces of stone is a formidable task. To put this in perspective, HGA has accrued nearly 37,000 digital images of the Capitol since 2006. The building assessment performed by WJE in 2011 generated over a thousand field assessment sheets. These numbers continue to grow as architects and engineers from both firms reexamine conditions for Phase 2 construction in 2013.

In a typical construction project, contractors provide the owner with an "as-built" drawing set that provides a record of the actual work accomplished. This method of delivery does not lend itself to the intense accounting required to track the quantities of repair, the type of repair performed, the status of repair work, nor does it leave the State with a way to track deferred work.

In order to effectively manage the information generated by a project of this magnitude, HGA developed a highly customized AutoCAD database (Fig. 44) capable of tracking over 50 specific information items for each piece of stone on the building. Data pertaining to condition, recommended repair type, and repair status is logged in and updated on a regular basis. Digital images can be hyperlinked to specific units for easy reference. These image references can be updated throughout the process from condition assessment to final repair. By the time Construction Documents are finalized, traditional CAD background drawings are replaced with "smart" versions populated with information received directly from the database.

Data entered into the database is translated directly into two different but supporting formats:

1. <u>Schedule format</u> – The stone schedule provides a way to quickly sort information and generate accurate quantities. (See Exhibit E)

2. <u>2D drawing format</u> – Graphic representation of the database is used as a key plan to locate repairs and communicate design intent with the contractors. Display themes are created to show specific results by selecting relevant database categories. To date, colored display themes have been created to show the overall scope of work (all recommended repairs) as well as select repairs (new stone replacement). Additional variations could be set up to show condition, recommended future work or any other topic of interest. (See Exhibit F)

Although an extremely powerful tool, this level information management is very time consuming in terms of both program development and day to day maintenance. Based on Phase 1 trials, it is likely that over 600 schedule sheets will be generated to track repairs.

Master Stone Work Schedule

Sheet Number	BLOCK ID	Element	TCTM Profile	Repair Status					Stone Condition Survey Condition Code											Require Repairs												CP-S1										Repair Status			
				Repair Type: Deferred	General Repairs	New Stone	No Work	Tier	Condition Severity	Unsound or Missing	Displaced Unit	Cracked Unit	Spalled Material	Surface Loss	Anchors	Previous Repair	Surface Staining	Other	Condition Related Remarks	Stone Dutchman	Replacement Unit	Removal and Reinstallation	Backup Reconstruction	Carve and Smooth	Crack Repair	Pin Anchor Repair	Cementitious Patch	Anchor Removal	Ledge Flashing	Biocide	Notes	Reference Detail	Repair Decision: Accept	NA	Pending	Field Review	Investigator	Revision #	Revise Scope: Add	NA	Remove	Demo Approval	Install Approval	Final Approval	Field Approval Date
A445	SC-1-G43-25	Dentil	(-)		●			T3	1					●																	REMOVE C @ (5) DENTILS TYP (UNO)		●								✓				
A445	SC-1-G43-26	Cornice Ledge	(-)		●			T2	5			●		●					cracked ledge- visible from below						●						CP-S2 possible dutchman	SK-46	●							✓					
A445	SC-1-G44-18	Gutter (copper clad)	(-)		●			T2	5			●		●					water infiltration						●							SK-18	●							✓					
A445	SC-1-G44-19	Gutter (copper clad)	(-)		●			T2	5			●		●					water infiltration						●							SK-18	●							✓					
A445	SC-1-G45-15	Block (tiered)	(-)		●			T2	5			●		●											●							SK-18	●							✓					
A445	SC-1-G45-16	Block (tiered)	(-)		●			T2	5			●		●											●							SK-18	●							✓					
A445	SC-1-G45-17	Block (tiered)	(-)		●			T2	5			●		●											●							SK-18	●							✓					
A446	SC-1-G46-12	Block (tiered)	(-)		●			T2	6			●		●											●							SK-18	●							✓					
A445	SC-1-G46-13	Block (tiered)	(-)		●			T2	5			●		●											●							SK-18	●							✓					
A445	S5-5-E29-22	Ashlar Unit	A		●			T2	1															●							ADD C		●			10.27.12	WJE	REV 1	✓						
A445	S5-5-E29-23	Ashlar Unit	A		●			T2	1															●									●							✓					
A445	S5-5-G43-21	Cornice Ledge	A		●			T2	5			●													●						REMOVE D	SK-18	●			10.27.12	WJE	REV 1			✓				
A445	SC-1-G39-50	Ashlar Unit	(-)		●			T2	4			●													●							SK-18			●					✓					
A445	SC-1-G43-22	Cornice Ledge	(-)			●		T2	5			●		●											●							SK-18	●							✓					
A445	S5-5-G43-18	Cornice Ledge	A			●		T2	5	●		●		●					SL-EV, CR-DV-4	●											FILL CORE, ADD HELICAL CP-S2	SK-46	●							✓					
A445	S5-5-G39-48	Pilaster	B			●		T1	8	●	●	●				●			Emergency pin repair 2011		●										Total replacement - emergency repair 2011		●							✓					
A445	SC-1-F36-25	Cornice Ledge	C			●		T2	6			●		●											●							SK-18	●							✓					
A445	SC-1-F36-25	Cornice Ledge	C			●		T2	6					●						●												SK-46	●							✓					
A445	S5-5-E32-02	Carved Detail - High Relief	CC			●		T3	4				●	●						●				●								SK-22	●							✓					
A445	S5-5-E32-02	Carved Detail - High Relief	CC			●		T3	4				●	●						●				●								SK-22	●							✓					
A445	S5-5-E32-02	Carved Detail - High Relief	CC			●		T3	5				●	●	●				FE anchor									●					●							✓					
A445	S5-5-E32-02	Carved Detail - High Relief	CC			●		T3	4				●	●						●				●								SK-22	●							✓					
A445	S5-5-E32-02	Carved Detail - High Relief	CC			●		T3	4				●	●						●				●								SK-22	●							✓					
A445	S5-5-F35-07	Modillion Block	D			●		T1	7	●							●	●	Mineral vein	●											Full replacement	SK-45	●			10.27.12	WJE	REV 1		✓					
A445	S5-5-F35-08	Modillion Block	E			●		T3	7					●			●	●		●											Partial replacement	SK-44	●			10.27.12	WJE	REV 1		✓					
A445	SC-1-G43-26	Dentil	F			●		T2	3					●						●											ADD A	SK-43	●						✓						
A445	SC-1-G43-26	Dentil	F			●		T2	3					●						●											ADD A	SK-43	●						✓						
A445	S5-5-F36-05	Cornice Corner (fascia)	G			●		T2	5				●	●					drip edge eroded 2"	●												SK-29	●							✓					
A445	S5-5-F36-05	Cornice Corner (fascia)	G			●		T2	5				●	●					drip edge eroded 2"	●												SK-29	●							✓					
A445	SC-1-F36-25	Cornice Ledge	G			●		T2	6					●						●												SK-46	●							✓					
A445	S5-5-E32-05	Capitol-Abacus	H			●		T2	6	●		●	●	●					(L) Left	●				●								SK-42	●							✓					
A445	S5-1-E32-05	Capitol-Fleuron	K			●		T3	3					●						●				●								SK-41	●							✓					
A445	S5-5-E32-06	Capitol-Acanthus Leaf	L			●		T1	3					●					(L) Upper	●				●								SK-39	●							✓					
A445	S5-5-D26-03	Window Hood - Gabled Return	N			●		T3	4					●						●												SK-38	●							✓					
A445	S5-5-D24-08	S Scroll - Partial	P			●		T1	7	●			●	●						●				●								SK-34	●							✓					
A445	S5-5-F36-05	Cornice Fascia	C			●		T2	5				●						drip edge	●				●								SK-28			●					✓					
A445	S5-5-C20-12	Ashlar Unit	(-)				●	T3	2					●																	REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-C20-13	Pilaster	(-)				●	T2	3					●																	REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-C21-02	Ashlar Unit	(-)				●	T3	2					●																	REMOVE C		●								✓				
A445	S5-5-C21-03	Pilaster	(-)				●	T2	3					●																	REMOVE C		●			10.27.12	WJE	REV 1			✓				
A446	S5-5-D25-20	Pilaster	(-)				●	T2	3			●																			REMOVE B		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-06	Dentil	(-)				●	T3	1					●																	REMOVE C - 6 DENTILS		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-07	Dentil	(-)				●	T3	1					●																	REMOVE C - 10 DENTILS		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-08	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-08	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-08	Dentil	(-)				●	T3	1					●																	REMOVE C - 10 DENTILS		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-09	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-09	Dentil	(-)				●	T3	1					●																	REMOVE C - 10 DENTILS		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-09	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-10	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-10	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-10	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-10	Dentil	(-)				●	T3	1					●																	REMOVE C - 6 DENTILS		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-11	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-F35-11	Modillion Block	(-)				●	T3	3					●			●	●	Mineral vein												REMOVE C		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-G43-02	Dentil	(-)				●	T3	3					●																	REMOVE C @ (10) DENTILS TYP (UNO)		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-G43-03	Dentil	(-)				●	T3	3					●																	REMOVE C @ (11) DENTILS TYP (UNO)		●			10.27.12	WJE	REV 1			✓				
A445	S5-5-G43-04	Dentil	(-)				●	T3	3					●																	REMOVE C @ (10) DENTILS TYP (UNO)		●			10.27.12	WJE	REV 1			✓				
A445	SC-1-D24-22	Pilaster	(-)				●	T2	2			●																			REMOVE B		●								✓				
A445	SC-1-F35-09	Dentil	(-)				●	T3	3					●																	REMOVE C @ (4) DENTILS TYP (UNO)		●								✓				
A445	SC-1-F35-10	Dentil	(-)				●	T3	3					●																	REMOVE C @ (4) DENTILS TYP (UNO)		●								✓				
A445	SC-1-F35-11	Dentil	(-)				●	T3	3					●																	REMOVE C @ (10) DENTILS TYP (UNO)		●								✓				
A445	SC-1-F35-12	Dentil	(-)				●	T3	1					●																	REMOVE C @ (4) DENTILS, REMOVE A @ (2) DENTILS		●							✓					
A445	SC-1-F36-13	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-14	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-15	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-16	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-18	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-19	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				
A445	SC-1-F36-22	Modillion Block	(-)				●	T3	3					●																	REMOVE C		●								✓				

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MINNESOTA STATE CAPITOL
EXTERIOR STONE REPAIR
CP-S1 - STONE REPAIR TRIALS & TESTING
ST. PAUL, MINNESOTA
RECS PROJECT #02CB0022

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED ARCHITECT UNDER THE LAWS OF THE STATE OF MINNESOTA

SIGNATURE
NAME: MICHAEL J. BJORNBERG
DATE: AUGUST 13, 2012
LICENSE NUMBER: MN ARCH 16901

11/12/2012

REVISION HISTORY

TRIAL REPAIRS (CP-S1)
COMM NO: 0476-057-00
SCALE
DATE: AUGUST 13, 2012
DRAWN

A445
EAST ELEVATOR
S5 BAY-5, SC ELEVATION
REPAIR SCHEDULE 3

Exhibit E: Sample stone repair schedule

Exhibit F: Sample stone repair construction drawing

The following outline summary describes the general extent of work encompassed by each repair approach:

Tier 1 Priorities (T1) – Life Safety

Public safety is paramount. In order to maintain a safe environment for building occupants and the visiting public, work required to mitigate all identified life safety concerns is used to define the base level of required repair for the Project.

T1 Work Scope. The following T1 conditions are always addressed:

1. **Structure Stabilization - Remove stone and rebuild compromised brick masonry backup**
   - **Roof Balustrades and Piers**
   - **Elevator Towers**
2. **Unit Stabilization - Remove and reset all displaced stone units, install new stone anchors**
   - **Pilasters– elevator tower**
   - **Balustrade piers**
3. **Material Stabilization - Remove or mechanically secure loose or broken stone fragments**
   - **Cornices: wash ledges, modillion blocks, dentils**
   - **Bracket Scrolls**
   - **Pilaster and column capital elements (acanthus leaves, fleurons, volutes)**

Tier 1 (T1): removal only, no further repair beyond stabilization to restore character

Tier 2 Priorities (T2) – Water Management/ Building Integrity

Recommendations for improved water management meet the objective for restored integrity of essential building façade components. Proposed general repairs are designed with long-term durability in mind to prevent excessive water infiltration. Reducing the potential for further damage to stone and the masonry exterior of the State Capitol is a critical component of building stewardship and a first step toward long term preservation goals.

T2 Work Scope. The following T2 conditions are addressed in addition to T1 work scope:

1. **Joint System Restoration**
2. **Crack Repair**
3. **Masonry Cleaning**

Tier 2 (T1 +T2): life safety mitigation, general repair and protection against water intrusion

Tier 3 Priorities (T3) – Historic Character

T3 Work Scope: The type and extent of repair work that is executed following the completion of baseline mitigation expands to include significant character defining features (see Table 3).

Tier 3 (T1 +T2+ T3): restore function and/or character of select architectural features

Tier 4 Priorities (T4) – Extensive Restoration/ Reconstruction

T4 Work Scope: The extent of repair work that is executed in addition to T3 work scope expands to include all remaining architectural and character defining features showing signs of distress.

Tier 4 (T1 +T2+ T3 + T4): extensive replacement of deteriorated material

PROJECT DESCRIPTION

The Minnesota State Capitol is one of the most magnificent capitols in the country and one of Cass Gilbert's most acclaimed masterworks. Balanced integration of Architecture and Art in both its exterior and interior design contribute to its beauty and renown. However, the exterior façade of the 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. The 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. While the granite has survived well, the distressed condition of the white Georgia marble is serious and concerns for public safety, building integrity and historic character are at a critical juncture.

Stone repair trials and testing, concluded at the end of 2012, were undertaken to explore the most pressing safety, stabilization and preservation issues. Comprehensive, full scale mock-ups enabled the design team, stone masons, carvers, and suppliers to test, experiment and respond directly to actual existing conditions. The evaluative process that followed measured the effectiveness of various repair tactics relative to an extensive and complex array of factors. Constructability, durability, visual appearance and preservation concerns were each considered. Technical viability, contextual perspective, historic character, cost and schedule impacts on the Project as a whole were also evaluated.

At the start of this Project, two primary objectives were identified and used to guide repair development for the trial phase:

- Resolve conditions that are, or may become, safety hazards.
- Minimize further deterioration of the building materials due to water infiltration.

The stated objectives are clear. However, the type and level of repair executed to mitigate serious conditions can range dramatically depending on the level of deterioration and the character of the architectural feature. The impact that different levels of repair have on both overall visual appearance and Project cost is significant.

The conclusion, reached at the end of the repair trial evaluation, is that mitigation work alone will not likely produce an end result capable of maintaining the historic character of the Capitol. The type and extent of repair work executed to repair and protect significant historic features of the Capitol following the completion of baseline mitigation will have a major impact on the overall appearance, perceived building integrity and the public's impression of stewardship.

Information gained from the trial phase is being used to develop guidelines and details for a whole-building repair approach that first and foremost addresses life-safety and water management issues and secondly considers long-term building stewardship. The whole-building repair approach provides a systematic procedure and method of assessment for identifying, prioritizing and assigning repairs today and for planning repairs in the future.

This report outlines four general levels of repair that could be implemented to maintain, repair or preserve the State Capitol. Repair approaches are additive, each building on the prior level, and each with a specific goal in mind. Together, they cover the full range of possibilities from mitigation through reconstruction:

- **Tier 1 (T1) - Life Safety.** Upholds a safe environment for occupants and the visiting public.
- **Tier 2 (T2) - Water Management.** Restores functionality of essential façade components.
- **Tier 3 (T3) - Historic Character.** Preserves overall visual character of the Capitol.
- **Tier 4 (T4) - Extensive Restoration/ Reconstruction.** Extends durability and provides more extensive reconstruction.

Fig. 45. Window hood bracket (west wing, south pavilion) outside of Governor's reception area. The cracked lower scroll, a Tier 1 priority repair, was removed by hand in 2010. Removed material was too unstable to reinstall.

Fig. 46 (above). Window hood bracket (west wing, south pavilion) outside of Governor's reception area. Condition following removal of cracked lower scroll is prioritized as a Tier 3 level repair. Tier 1 and Tier 2 level work scope does not include additional repair. This condition would remain as is unless Tier 3 level repairs are implemented.

Fig. 47. (right). Tier 3 level repair would restore the missing lower scroll and blend repairs in with remaining historic material. The repaired scroll was installed at a south facade window hood bracket during the trial phase.

REPAIR STRATEGY COMPARISON

Four basic approaches to stone repair at the State Capitol were explored as part of the ongoing evaluative process:

Tier 1 (T1) - Life Safety. Potential life safety concerns have been identified throughout the building. Loose and unsound material was removed during a preliminary investigation in 2010 and again in 2011 when a full building assessment was performed. Although immediate life safety concerns were mitigated, distressed and weathered marble will continue to deteriorate when exposed to environmental extremes. The extent of decay varies considerably and conditions can change without warning. Elements that were determined to be sound in 2011, including several modillion blocks and window hood lower scrolls, were removed in 2013. Material that is stable today may not be stable years from now, for that reason, regular inspection of weathered material is recommended. (See Table 2)

Projecting elements and highly carved decorative ornament routinely demonstrate the most severe damage and loss of detail. Certain architectural features (capital elements, window hood bracket scrolls) are consistently unsound. Compromised material is often associated with important character defining features and these are typically located immediately above areas accessible to the public.

Public safety is paramount and the Tier 1 strategy begins with a concerted effort to mitigate all identified life safety concerns. Concentrating exclusively on life safety issues, this approach establishes the baseline that defines the absolute minimum amount of work that is required to maintain a safe environment for staff and the visiting public. It includes removal and stabilization of unsound material only. Additional restoration to replace removed material, missing or eroded detail, or diminished character is NOT included at this level.

Removal and stabilization of unsound material is an appropriate immediate response to hazard mitigation but the process of removal has had, and will continue to have, a profound negative impact on the historic character and overall appearance of the building. Without further repair, the Capitol may actually appear to be in worse condition at the end of the project than it was to start. (See Fig. 45-47)

The following is a more detailed summary of recommended Tier 1 repairs:

- Reconstruct deteriorated brick backup masonry. Significant damage consistent with prolonged exposure to water saturation and subsequent freeze-thaw cycles occurs at the following locations: roof parapet balustrades and piers; second floor loggia and pavilion balustrade systems; and attic stories at elevator towers. Stone units must be removed in order to accomplish repairs. The condition of brick backup masonry and stone anchorage is then assessed. New brick masonry is selected based on compatible physical properties, such as water absorption and compressive strength, and the backup assembly is then reconstructed.

- Mechanically secure loose/broken stone fragments. In place stabilization of stone utilizing mechanical anchors (i.e. helical anchors, stainless steel pins or dowels) is an effective way to mitigate potential life-safety issues where replacement is impractical or in situations where high value is placed on retaining historic material.

- Reset displaced stone units. Displaced stone panels are significant in that anchorage or setting conditions no longer providing adequate support could develop into potential life safety concerns. Following disassembly, new stone anchorage systems are designed and the original stone unit is reinstalled. Stone repair may be required (i.e. where lighting protection fasteners have caused extensive damage or instability).

- Replace severely damaged units. Although relatively rare, full unit replacement is sometimes required to resolve life-safety issues. One pilaster unit pinned in place as an emergency repair in 2010 was replaced at the east elevator tower during the trial phase. Although the helical pin repair was performing well, new stone was the preferred solution to provide long term durability. Several pieces on the north wing have sustained irreparable damage from miscellaneous steel anchors and have been identified for full replacement. These repairs are required to protect the building against additional water infiltration.

Fig. 48. Second floor window hood (west wing, south). Existing condition showing previous repair with patching material at the corner and fascia drip edge. Patching material was found to be consistently unsound and has since been removed.

Fig. 49. Second floor window hood (west wing, south). Condition following removal of unstable patching material at the corner and fascia drip edge. Water shedding capabilities of severely degraded drip edges are significantly reduced. Diminished function puts adjacent material, in this case the bracket scroll, at higher risk for accelerated damage due to water runoff.

Fig. 50. Second floor window hood (west wing, north). Unstable material at the corner wash ledge and severely deteriorated material at the fascia drip edge were removed and replaced with new stone as part of the trial phase. Function is fully restored.

Not shown in this image is the metal flashing recommended to protect the upward facing ledge surface. (See Figs. 23 and 25)

Tier 2 (T2) - Water Management. Tier 2 level repairs include the scope of work outlined for Tier 1. After potential life safety hazards have been mitigated, Tier 2 (T2) repairs are implemented to reduce the potential for further water-related damage to stone and the masonry exterior of the State Capitol. Water related issues accelerate the natural weathering process of white Georgia marble. Extensive decay is consistently observed at building elements that facilitate water movement away from the building and at areas where water, snow and ice accumulate. Certain components (i.e. drip edges and wash ledges) are often sufficiently degraded so that function is compromised and severe deficiencies have begun to affect adjacent historic material.

Water-shedding elements exhibit some of the most severe deterioration observed on the building. As the building's first line of defense, these critical features are typically not good candidates for general repair, especially when considering durability over the long term. Previous attempts to repair these features with patching material appear to have accelerated damage to remaining stone. Unstable patch repairs have become life safety concerns in their own right and are being removed to mitigate potential hazards. Removal of unsound material is an appropriate response to hazard mitigation but the process of removal has a profound negative impact on the historic character and overall appearance of the building. Without further repair, features may actually appear to be in worse condition at the end of the project than they do to start. (See Fig. 48-50)

Following removal of unsound material, repairs are designed to protect both the building and remaining historic material. Architectural features that help direct water away from the building are given the highest priority (i.e. wash ledges, drip edges, sills, and joint systems). Protective coverings (i.e. metal flashing) are being considered where constructability issues and/or preservation concerns preclude extensive repair. In other cases, where deterioration is severe and function is compromised, a higher level of repair involving limited replacement can be implemented to restore the integrity of essential building façade components.

The quantity of stone needed to effectively implement repairs, and also the extent of repair undertaken on the building, have a significant impact on cost. Cost estimates are based on a specific level of repair. Quantities can be adjusted to some extent to control cost, however, more extensive repairs will obviously effect cost. At the current level of repair, only severely distressed material is repaired or replaced. Sound but deteriorated material not repaired at this time would remain in place, unsound material would be removed but not replaced. Distressed material and advanced levels of decay at secondary and tertiary water-shedding elements are not repaired at the Tier 2 level. At these locations, loose and unsound material is removed and surfaces are ground smooth to facilitate water shedding.

Tier 2 repairs focus on function, diminished character of significant architectural features is not restored. The following is a more detailed summary of Tier 2 repairs:

- Clean masonry surfaces: The purpose of the cleaning process is to remove biological growth, atmospheric deposits, soil, staining, grease, oil, and other contaminants without damaging the stone surface. Although the result of the cleaning is not expected to return the facade to a 100 percent clean or new appearance, cleaning and chemical treatment is important to mitigate conditions that put stone at higher risk of damage from prolonged exposure to moisture. Biological growth absorbs and traps water near the surface of the stone and moisture retention accelerates stone distress. Areas exposed to water runoff, the focus of prioritized Tier 2 repairs, are at increased risk for delamination and material spalling which can quickly develop into life safety concerns.
- Chemical treatment, including biocide application and detergent cleaning at heavily soiled areas, is currently included in the cost at Tier 2. Biocide treatment requires cyclical application to maintain effectiveness and deferring the first application would not preclude future application. For these reasons, deferring treatment may be an option to consider if short-term alternatives to conserve cost become necessary.

Fig. 51. Cornice (east wing, south). Unstable material at the fascia drip edge was removed during the investigative phases to mitigate life safety concerns. Water shedding capabilities of the drip edge are compromised.

This condition would remain as is if a Tier 1 level of repair is implemented.

Fig. 52. Cornice (west wing, south). Unstable material at the fascia drip edge, removed during the investigative phases to mitigate life safety concerns, has been ground smooth to improve water-shedding capabilities. Decayed and weathered material remains in place and will continue to deteriorate over time.

Primary drip edges would be replaced to restore function at the high end of Tier 2 (See Fig. 15) but the irregular drip edge profile at left would remain as shown should the low end of Tier 2 repairs be implemented. Although marginally improved, function is still compromised putting adjacent historic material (modillion blocks) at higher risk for water damage.

Modillion blocks and dentils are not repaired at the Tier 2 level. A stone dutchman repair (arrow) installed during original construction has held up well over the years.

Fig. 53. Cornice (east elevator, southeast corner). Unstable material at the fascia drip edge was replaced during the repair trials to demonstrate restored water-shedding functionality.

Lead caps were also installed at skyward facing joints and at the base of wall as a mock-up demonstration. Due to the severity of stone deterioration observed at wash ledges, metal flashing is currently recommended to provide more substantial protection at these locations.

Modillion blocks and dentils are not repaired at the Tier 2 level.

- Repairs at the drum and dome are not included in Tier 2 level repairs. Repair work on the dome was completed in 2009. The scope of work included masonry repairs related to water infiltration only.
- Repair an/or repoint compromised joint systems with compatible mortar or sealant: Joint systems bond the masonry units together and prevent water from penetrating deeper into the wall assembly. The different types of mortar observed on the building indicate that the joints have been repointed throughout the building's history. Deteriorated mortar joints are concentrated at the cornice, roof parapets and horizontal wash bands,however, localized joint deterioration occurs throughout the remaining facade. Recommended repointing ranges from 5% at the lower level to 100% at the upper stories and select areas prone to mortar deterioration caused by excessive movement. Horizontal joint systems with high exposure to moisture would receive additional protection from lead weather caps installed at all skyward facing joints (See Fig. 53).
- Repair cracks and fissures: Cracks are defined as a partial separation of stone material. Typically linear, these openings can occur singly, as a network of map cracking, or as erosion of mineral veins. Conditions vary widely, ranging from minor to significant, depending on the width, depth, length, and orientation of material discontinuity. Most prevalent at projecting features and highly carved stone units, cracks in the stone that could potentially contribute to advanced stone deterioration are repaired at the Tier 2 level. Small cracks and surface imperfections not meeting the threshold for required repair today are identified as "watch items" in the database. These should be routinely inspected, documented and tracked as potential future repair items.
- Preserve and protect sound historic material in place. Retention of historic material is a high priority. Where general repair or in kind replacement is not an option, due to preservation considerations and/or constructability, reversible mitigation strategies (i.e. lead weather caps and metal flashing) are considered a reasonable and cost effective alternative until more viable alternatives become available in the future. Metal flashing is recommended as a protective measure at: cornice ledges, second story window hoods (not including gabled hoods at pavilions), and stone gutters.
- Smooth rough, eroded, weathered stone surfaces. Irregular surfaces trap moisture and particulates. Under these conditions, the potential for freeze/thaw damage increases and a substrate favorable for biological growth is provided. Grinding and smoothing irregular surfaces helps facilitate water shedding capabilities of the stone. Although some deteriorated material will remain, the improved performance of smoothed surfaces could significantly extend the installed "life" of the stone or architectural feature. (See Fig. 52) The current scope of work for Tier 2 includes a modest percentage of the surfaces that would benefit from resurfacing.
- Replace primary water shedding features showing visible deterioration. Where removal occurs, new stone is provided to restore the feature. Replacement does not typically require full removal of an entire unit. The preferred strategy is partial replacement, where material is only removed as required to prepare sound stone to receive new work. The scope of work defined for Tier 2 includes repair and protection of approximately 70% of the primary water shedding features (cornice fascia, second floor water table, and projecting window hoods), and no replacement at secondary or tertiary wash ledges or sill bands. (See case studies for examples.)

Reducing the potential for further damage to stone and the masonry exterior of the State Capitol is a critical component of long-term building stewardship. Tier 2 level repairs address building integrity, defined in terms of the effectiveness of the exterior envelope to stop water and/or air infiltration in addition to those issues identified as potential life safety concerns that were carried over from Tier 1.

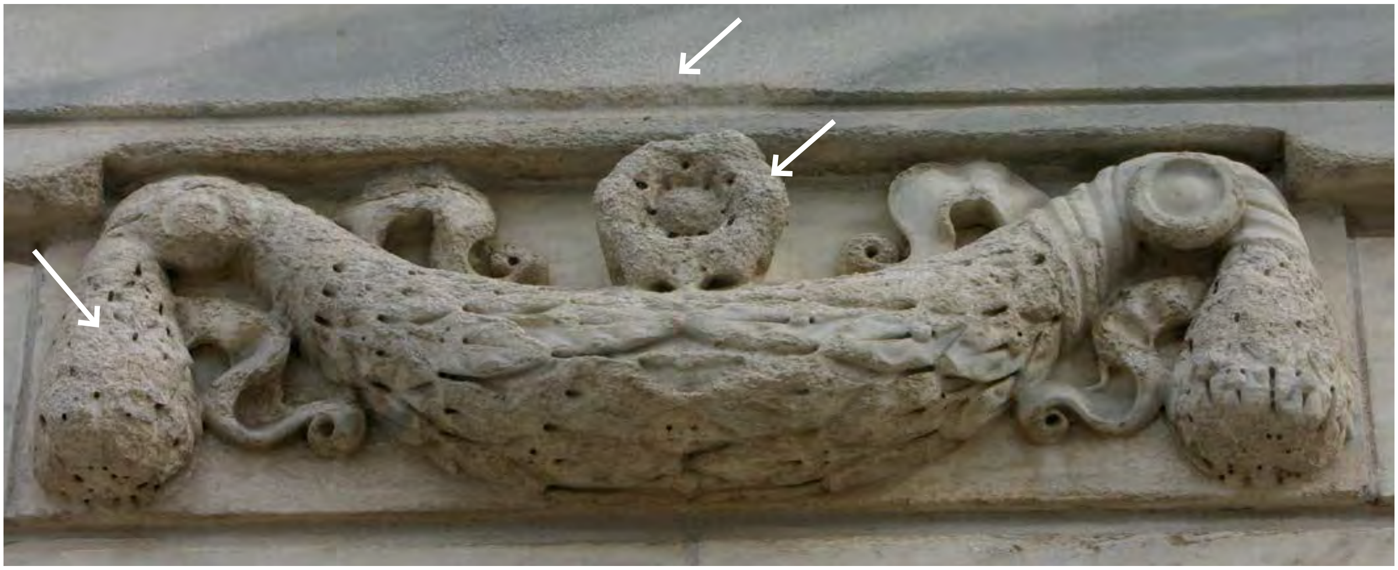


Fig. 54. Eroded detail at main (south) entry.


Fig. 55. Missing material at west entry loggia column.


Fig. 56. Cracked east elevator cartouche


Fig. 57. Eroded detail at north entry arch keystone.

Tier 3 (T3) Historic Character. Carved details typically exhibit the most severe damage. Mechanisms of decay and tabulations of distress conditions were described in previous reports detailing the results of earlier investigations.[1], [2] Relatively thin, delicately carved profiles are particularly vulnerable to the effects of thermal hysteresis, the main cause of distress. Projecting units, with larger surface areas exposed to extreme climate conditions, experience more frequent thermal cycling and are more susceptible to continued deterioration. Original carving practices, including pneumatic tooling, exacerbated naturally occurring micro-fractures which has left stone more vulnerable to water infiltration and increased rates of decay. As a result, original hand-carved detail is losing definition and, in some cases, is absent completely. (See Fig. 54-57)

Distress is most prevalent on the more ornate carved stone features including bracket scrolls, column capitals, cartouche, keystones, oxeye window surrounds, balustrades, as well as cornice elements such as modillion blocks and dentils. These features account for approximately 50% of severely spalled stone and 80% of the severe surface loss observed on the building. In most cases, these are character defining features, essential physical components or contributing elements that give the Capitol a unique identity. Character-defining aspects of a historic building include its massing, materials, features, craftsmanship, decorative details, as well its site and environment. As missing or deteriorated material loses its ability to convey this significance, conditions begin to detract from the overall impression of the building. Whether repair takes place now, or at some point in the future, repair and protection of significant historic features of the Capitol will become necessary if the dignified character of this monumental building is to remain intact.

Although most character defining features rarely affect building performance, and life safety concerns can be mitigated without further restoration, details were developed and tested during the trial phase to evaluate possibilities to repair, protect and preserve historic ornament and character. Tier 3 level repairs are included in this report for reference but are not part of the current scope of work.

The approach to repair at the Tier 3 level strives to accomplish two objectives:

1. Optimize prospects for long-term durability and
2. Maintain the character and dignified appearance of the State Capitol.

At this level of repair, more extensive replacement of essential building façade components and vulnerable water shedding features is provided. Whereas Tier 2 level repairs respond to only the most critical distress conditions related to water management issues, Tier 3 level repair comprehensively restores water-shedding function, provides a higher level of protection for remaining historic material, and selects the most significant architectural character defining features to preserve and repair. Tables 1 and 2 outline the types of repair included at each level.

At Tier 3, the most effective repair protocols are applied holistically across the building, striking a balance between new work and remaining historic material. Newly quarried Georgia sparkles in the sun like diamonds, and freshly carved detail with crisp edges stands out against original stone. By comparison, weathered material will appear to be in worse condition. New work must be considered in the context of remaining historic material. Restoration and repair of select features and architectural groupings with high visual impact (See Table 3) can help counterbalance the visual impact of repairs made to water shedding features and more functional elements that were never intended to be focal points. A unified expression is maintained and the overall impression of the building remains intact.

1 Wiss, Janney, Elstner Associates., Inc. Minnesota State Capitol Facade Inspection and Stone Assessment Report. Prepared for the State of Minnesota in collaboration with J.E. Dunn Construction. May 4, 2012.

2 Hammel, Green and Abrahamson, Inc. Minnesota State Capitol Preliminary Stone Investigation. Prepared for the State of Minnesota. April 30, 2011.

Fig. 58 (right):Typical conditions at cornice. Drip edges and modillion blocks immediately below are severely eroded

Fig. 59 (below): An unstable modillion block has been removed to mitigate a potential life safety hazard. The existing condition would remain as shown at either Tier 1 or Tier 2 level of repair. Replacement of missing material to restore character occurs as a Tier 3 level repair.

Fig. 60 (above): This modillion block, although demonstrating extreme loss of detail, is structurally sound. Not currently considered a hazard, the existing condition would remain as shown at either Tier 1 or Tier 2 level of repair. Replacement of deteriorated material to restore character occurs as a Tier 3 level repair.

Fig. 61 (left): At repair Tier 3, significant character defining features and compromised water-shedding features are replaced. Sound historic material still capable of conveying historic character remains. Although not repaired in the trial phase, deterioration along the drip edge (arrow), would likely trigger replacement as a Tier 3 repair.

A prioritized and tiered approach to repair is not unprecedented. The New York Public Library is similar to the Minnesota State Capitol in age, design, marble material, and public profile. Exposure to atmospheric conditions had resulted in extensive deterioration to carved marble architectural elements. WJE worked on the restoration and describes the approach as follows:

> In 2011, work was completed on a comprehensive building cleaning and repair program which primarily included installing marble dutchman units at the locations of removed unsound material and addressing water management concerns. Repairs included select architectural elements such as column capitals, keystones, and scrolled modillions that significantly contributed to the historic character and appearance of the building. In an effort to preserve and retain historic material, only the portion of architectural element that was observed to be unsound or severely deteriorated, such as a single acanthus leaf on a column capital, was removed and replaced. Similar adjacent elements, such as an acanthus leaf on the same column capital, were not necessarily replaced if the extent of deterioration was not as severe. Similar repair approaches were followed at other buildings comparable to the Minnesota State Capitol including the New York Metropolitan Museum of Art (limestone), Wisconsin State Capitol (granite), Nebraska State Capitol (limestone), and North Dakota State Capitol (limestone), and others.

Prioritized groupings created for Tier 3 level repair takes a similar approach. Work performed during the phase 1 trials helped to demonstrate the visual impact that certain features or architectural groupings had on perceived building character. Certain key aspects, outline and linear continuity for example, influenced overall perception of repair effectiveness to a much higher degree than did crisp, defined edges at more ornate features. Smaller areas of eroded detail had less impact than did missing material.

The appearance of finished repairs has been carefully considered, both at close range for impact on immediate context, as well as for the effect repairs have on overall impressions of the Capitol. When developing an approach to repair that includes character defining features, the following key aspects were considered:

- **Perimeter Boundaries**
  - Roof Parapet: balustrade caps, piers, and balusters
  - Outside Corners: main façade transitions (primary), projecting bays (secondary)
  - Defining Edges and Outlines: linear features (horizontal bands, drip edges, pilaster and column shafts)
- **Architectural Assemblies**
  - Cornice Assembly: wash ledge, fascia, drip edges, modillions, dentils (See Figs. 58-61)
  - Column and Pilaster Features: pedestal, base with torus, capital elements (abacus, fleuron, volutes, acanthus leaves, astragal)
  - Window Hoods (horizontal and gabled): wash ledge, fascia, drip edges, scrolled S-brackets
- **Organizing Features**
  - Bay Types: entry facade, projecting pavilion, typical wing
  - Horizontal Transitions: sill bands, wash ledges, water tables, stringcourses, bullnose
- **Focal Points (carved detail)**
  - High Relief: arch keystones, swags, cartouche, medallions, dome panel details, statuary
  - Low Relief: frieze panels, pavilion panel details

Fig. 62 (top right): Typical portal jamb (east entry). Previous patch repairs, some of which are failing, have been installed at nearly all raised panels and outside corners. Replacement required to restore deteriorated material at this level would be extensive.

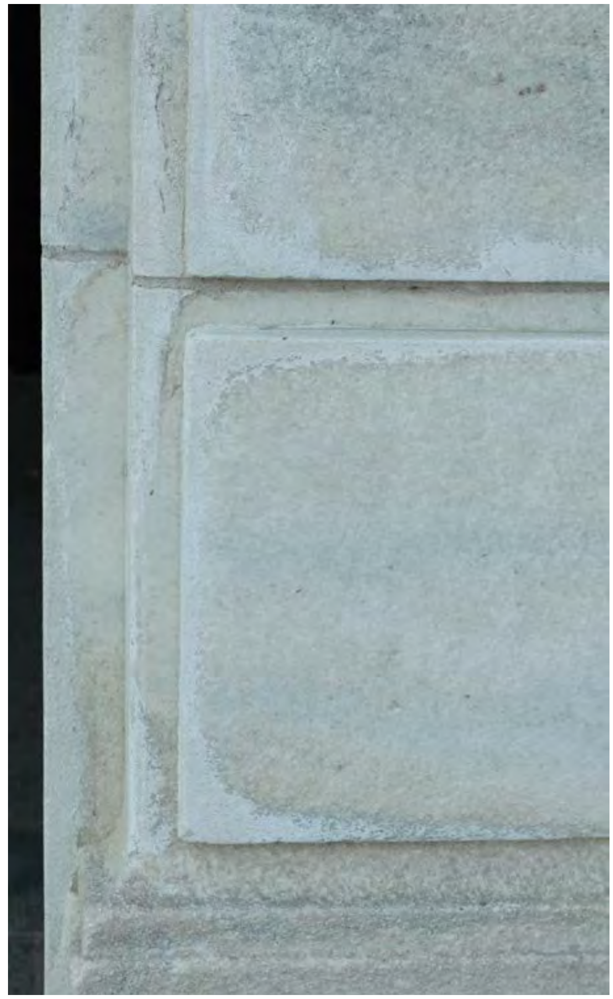


Fig. 63 (above): Typical portal jamb (south entry). Erosion of detail is extensive at the south entry. Replacement required to restore deteriorated material at this level would be extensive.

Fig. 64 (bottom right): Typical corner (east facade stair tower). Unsound material at outside corners and minor wash bands is commonplace. Replacement required to restore deteriorated material at this level would be extensive.

Tier 4 (T4) Restoration / Reconstruction. The strategy for repair at this level is to remove all deteriorated material. To maximize long-term durability, replacement is favored over repair. Considerably more original material would be disrupted in the process and this contradicts sound preservation practice. Not all deteriorated material can, or should be removed. Although repairs will theoretically last longer, maintenance and inspection will still be required. Tier 4 repairs, involving more extensive restoration, are beyond the scope of work anticipated for this Project but are included for reference. (Figs. 62-64)

The following case studies are provided to demonstrate the full range of repairs and the potential impact each level of repair could have on the overall visual character of the building.

Cornice - Tier 1- Life Safety (T1)

Fig. 65: Typical cornice ledge. Several unstable modillion blocks and dentils have been removed.

All unsound material is removed or stabilized:

- Unstable material at modillion blocks and dentils is removed back to sound stone. Clean, saw-cut removal, depicted in the adjacent image, is not included in the current cost. Material remaining after hazard mitigation would be more irregular. (See Fig. 28)
- Missing character defining features are not replaced.
- Sound weathered material remains as is.

Cornice - Tier 2- Water Management (T2)

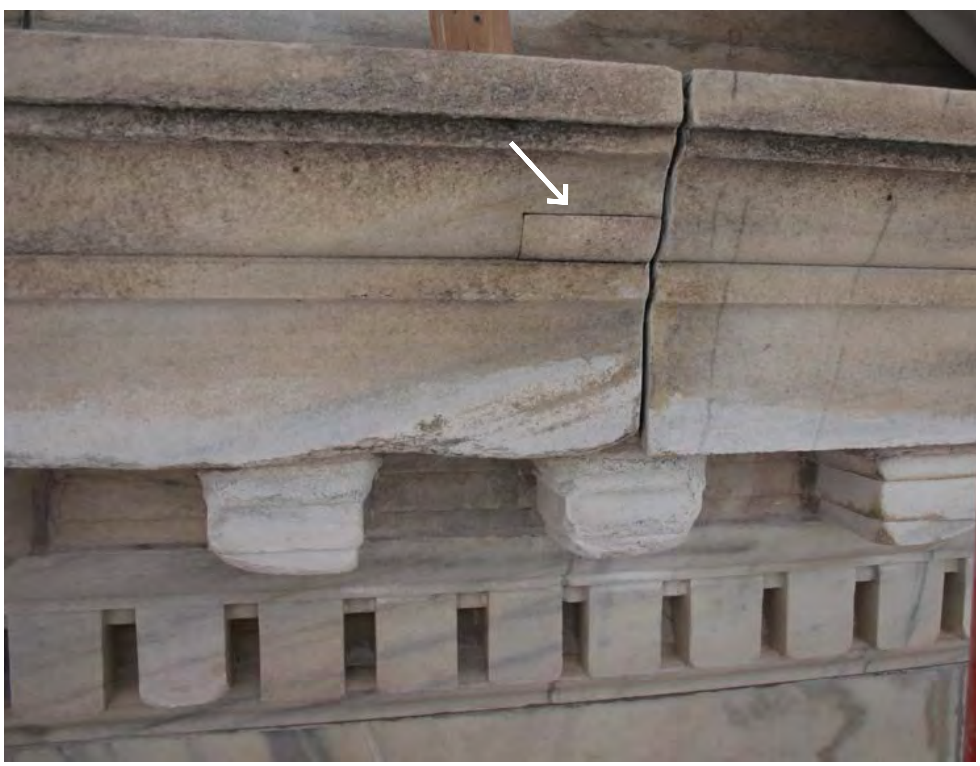
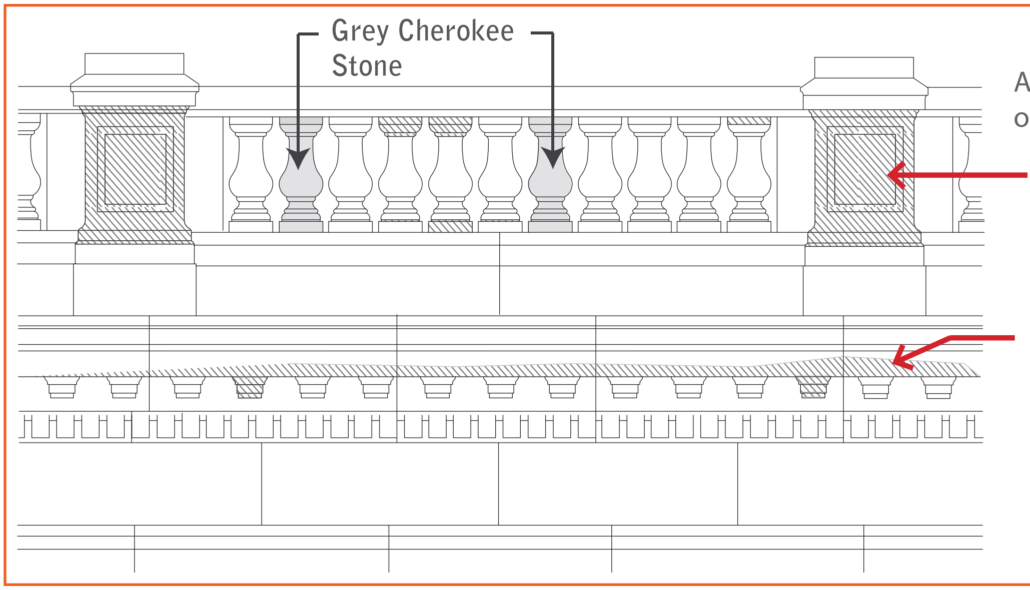


Fig. 66: Typical cornice ledge. Eroded surface material has been ground smooth to facilitate water shedding capabilities at the drip edge. Note original dutchman (arrow) which has held up extremely well for over 100 years.

Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Rough/uneven surfaces are smoothed to facilitate water shedding capabilities.
- Sound weathered material remains as is.
- Drip edge fascia and character defining features (modillions) that have irregular profiles remain as is.

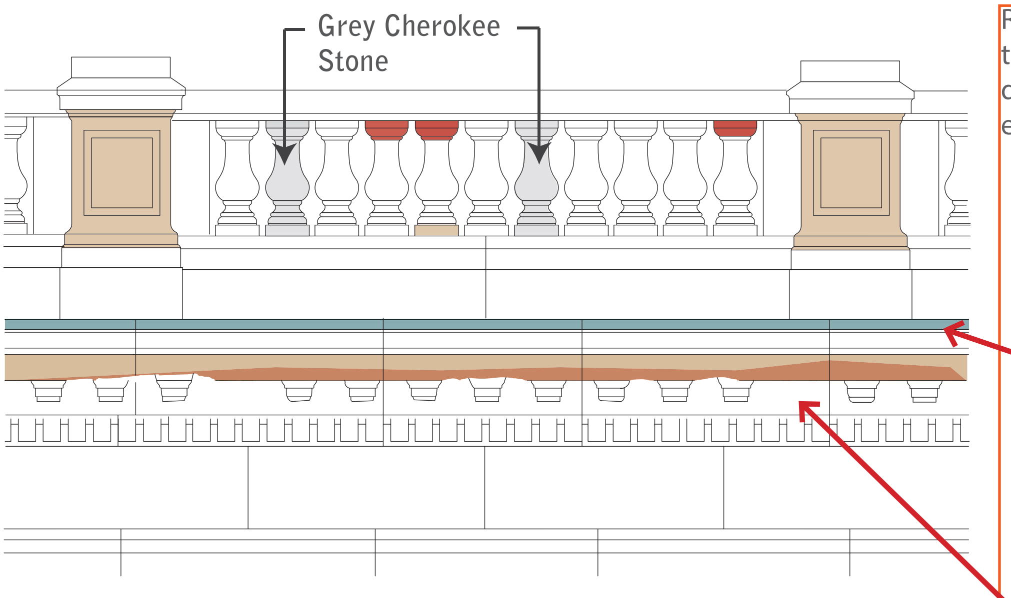
Cornice - Tier 1- Life Safety (T1)



All unsound material is removed or stabilized

- Unstable backup brick masonry at baluster piers is removed and piers are rebuilt.
- Unstable material at drip edges is removed.
- Mismatched material at balusters remains (earlier replacement units were carved from white or grey Cherokee marble).

Cornice - Tier 2- Water Management (T2)



Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Unstable baluster caps, removed to mitigate life safety hazards, are replaced to stabilize the assembly.
- Cornice wash ledge is protected with metal flashing.
- Drip edge fascia is ground and smoothed to facilitate water shedding.
- Missing modillions are not replaced.
- Drip edges are highly irregular.

Cornice - Tier 3- Historic Character (T3)

Fig. 67: Typical cornice ledge. Deteriorated material is selectively replaced with new stone.

Select character-defining features are restored:

- Primary drip edges are replaced comprehensively to restore function.
- Deteriorated modillion blocks are repaired or, in some cases, replaced to maintain character.
- Original weathered material capable of conveying significance remains in place.

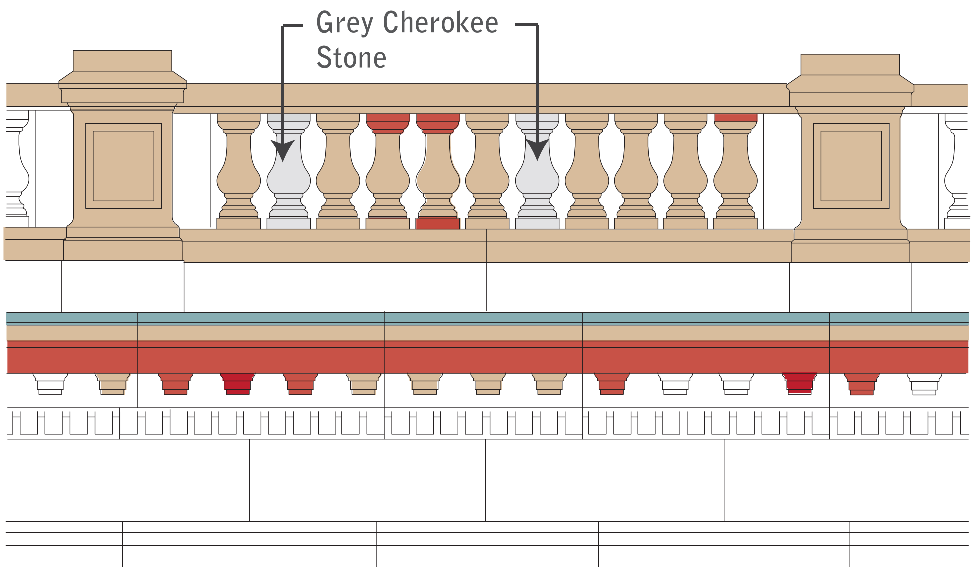
Cornice - Tier 4- Restoration (T4)

Fig. 68: Typical cornice ledge. All deteriorated material is replaced with new stone.

Deteriorated material is removed and replaced to improve long-term durability and preserve character:

- Primary drip edges are replaced to restore function.
- Character-defining features are restored.

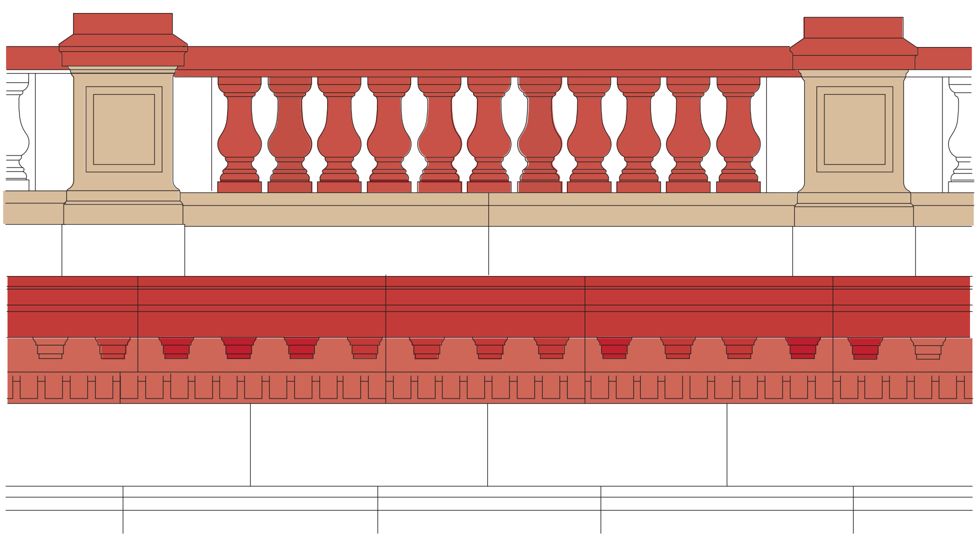
Cornice - Tier 3- Historic Character (T3)



Select character-defining features are restored:

- Deteriorated baluster caps are replaced
- Cornice wash ledge is protected with metal flashing
- Primary drip edges are replaced to restore function.
- Deteriorated modillion blocks are repaired/ replaced.
- Missing modillion blocks are replaced.

Cornice - Tier 4- Restoration (T4)



Deteriorated material is removed and replaced to improve long-term durability and preserve character:

- Deteriorated baluster components are replaced.
- Mismatched materials are replaced.
- Primary cornice drip edges and wash ledges are replaced to restore function.
- Character defining features, including dentils, are restored.

Pilaster Capital - Tier 1- Life Safety (T1)

Fig. 69: Typical fleuron. Unstable material is removed.

All unsound material is removed or stabilized:

- Unstable material is removed back to sound stone.
- Deteriorated character defining features are not replaced.
- Sound weathered material remains as is.

Pilaster Capital - Tier 2- Water Management (T2)

Fig. 70: New abacus. Unstable material is replaced and blended with original stone.

Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Abacus cap was replaced during the trial phase. Although this level of repair provides added protection to historic material below, abacus replacement is not included in the current scope of work for Tier 2.
- Rough and uneven surfaces are smoothed to facilitate water shedding capabilities.
- Sound weathered material remains as is.

Pilaster Capital - Tier 3- Historic Character (T3)

Fig. 71: New acanthus leaf.

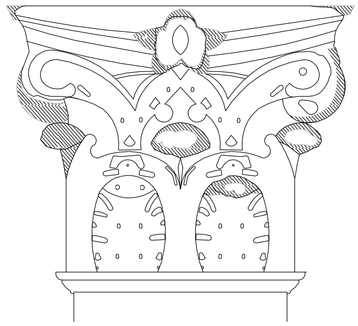
Fig. 72: New fleuron and acanthus leaf.

Select character-defining element are restored:

- Severely deteriorated volutes, acanthus leaves and fleurons are restored to maintain character.
- Original weathered material capable of conveying significance remains in place.

Pilaster Capital

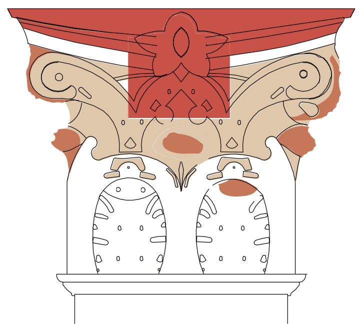
Tier 1-Life Safety (T1)



All unsound material is removed or stabilized:

- Significant loss of detail occurs following life safety hazard mitigation.
- Character defining features are not replaced.

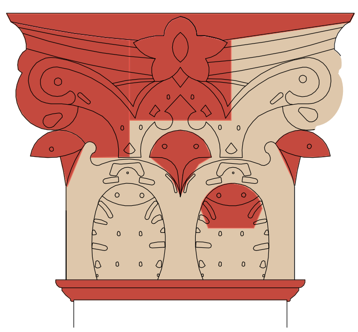
Tier 2-Water Management (T2)



Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Abacus caps provide added protection to historic material below. They are not included in the current scope of work at the Tier 2 level.

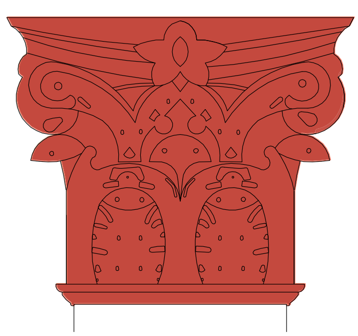
Tier 3-Building Stewardship (T3)



Select character-defining elements are restored:

- Abacus caps are replaced to provide added protection to historic material below.
- Severely deteriorated volutes, acanthus leaves and fleurons are restored as required to maintain character.

Tier 4 - Restoration (T4)



Complete character-defining feature is restored:

- Severely deteriorated capital elements are fully restored to maintain character.

Tier 1- Life Safety (T1)

Fig. 73: Degraded material at bracket and drip edge condition is typical. Missing corner at the ledge was removed during hazard mitigation

Tier 2- Water Management (T2)

Fig. 74: Original material at drip edge is deteriorated but did not meet the threshold for replacement. Metal flashing is installed to protect wash ledge.

Tier 3- Historic Character (T3)

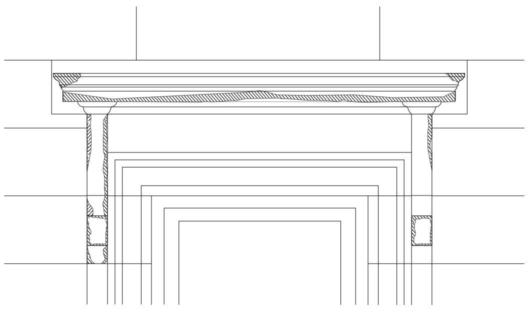
Fig. 75: New drip edge and partial lower scroll replacement

Tier 4- Restoration (T4)

Fig. 76: New full bracket replacement

Window Hoods & Bracket Scrolls

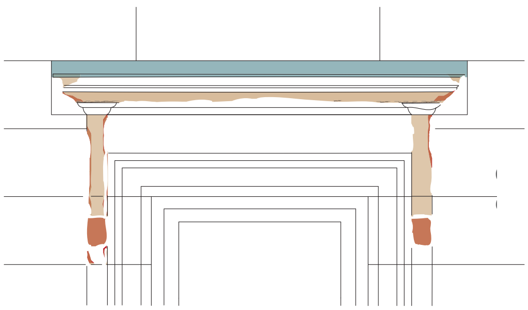
Tier 1- Life Safety (T1)



All unsound material is removed or stabilized:

- Significant loss of detail occurs following life safety hazard mitigation.
- Profiles and edges are irregular.
- Damaged character defining features (scrolls) are not replaced.

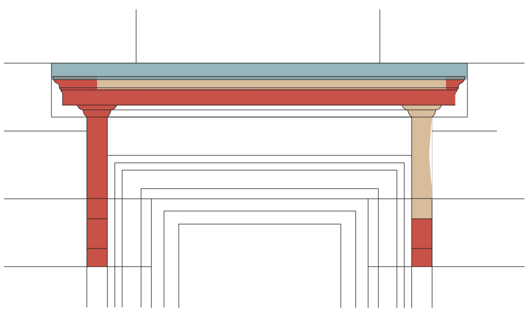
Tier 2- Water Management (T2)



Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Window hood wash ledge is protected with metal flashing.
- Drip edge fascia is ground and smoothed to facilitate water shedding.
- Drip edges are irregular.
- Damaged character defining features (scrolls) are not replaced.

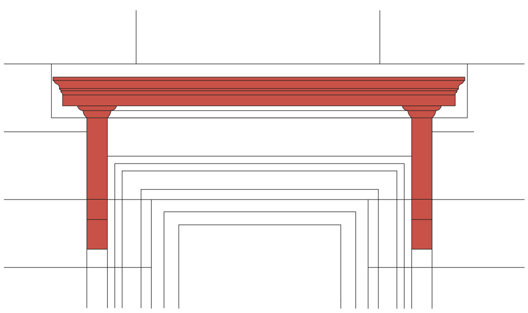
Tier 3- Historic Character (T3)



Select character-defining elements are restored:

- Deteriorated brackets and scrolls are replaced.
- Cornice wash ledge is protected with metal flashing.
- Primary drip edges are replaced to restore function.

Tier 4- Restoration (T4)



Complete character-defining feature is restored:

- Brackets, scrolls, and window hood wash ledges are restored to maintain character.

Pilaster Base & Wash Ledge

Tier 1- Life Safety (T1)

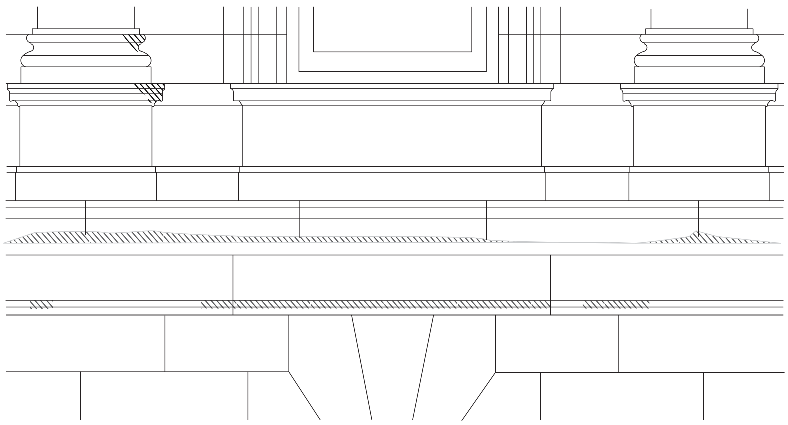
Fig. 77: Degraded material at pilaster pedestal wash band is typical. Conditions are typically most severe at outside corners

Tier 2- Water Management (T2)

Fig. 78: Degraded material at pilaster pedestal wash band after grinding and smoothing. Decay, visible as darker grained material along the bottom of the drip edge, is still present following repair.

Pilaster Base & Wash Ledge

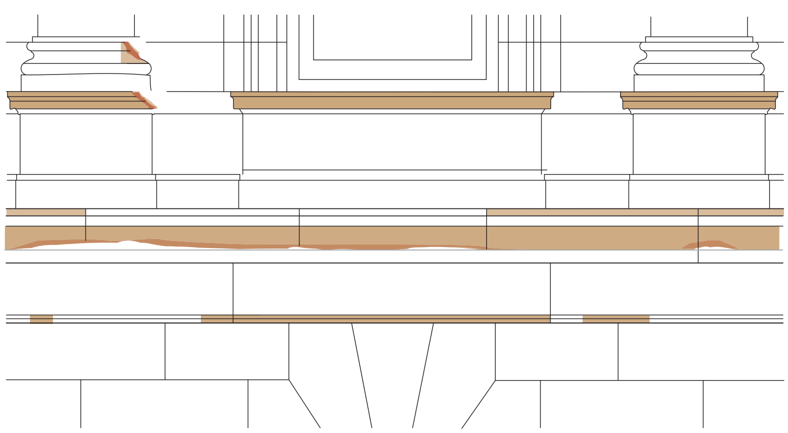
Tier 1- Life Safety (T1)



All unsound material is removed or stabilized:

- Unstable material at sills, pilaster bases and secondary horizontal ledges is removed.
- Unstable material at drip edges is removed.
- Profiles remain irregular and uneven.

Tier 2- Water Management (T2)



Repairs are made to reduce the potential for further water damage to stone and masonry exterior:

- Irregular surfaces at sills, pilaster bases and secondary horizontal ledges are ground smooth to facilitate water shedding.
- Water table wash ledge and drip edge fascia are smoothed to facilitate water shedding.
- Drip edges are irregular.
- Missing material at stringcourse and pilaster base are not replaced.

Pilaster Base & Wash Ledge

Tier 3- Historic Character (T3)

Fig. 79: Degraded corner after replacement with new stone Dutchman.

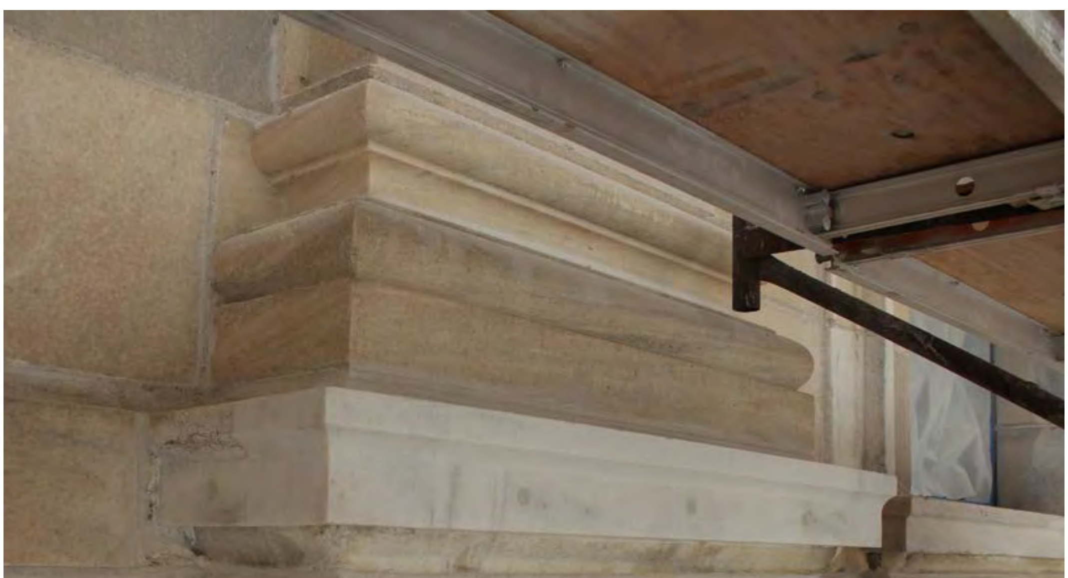
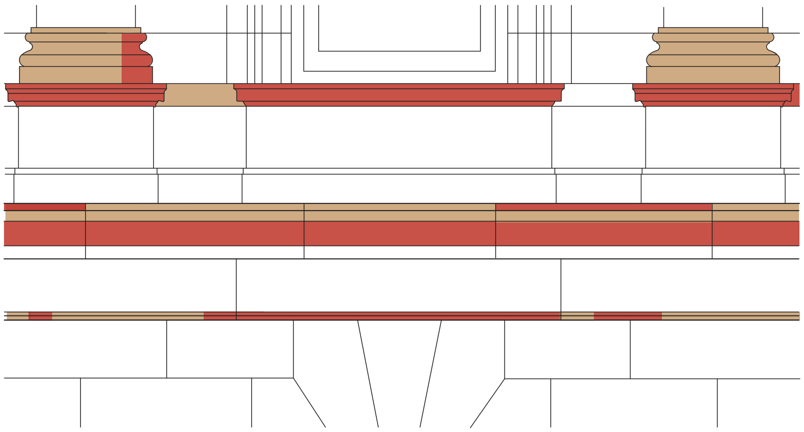


Fig. 80: Complete ledge replacement. The detail has been revised so that stone plugs visible in the trial repair are no longer necessary.

Pilaster Base & Wash Ledge

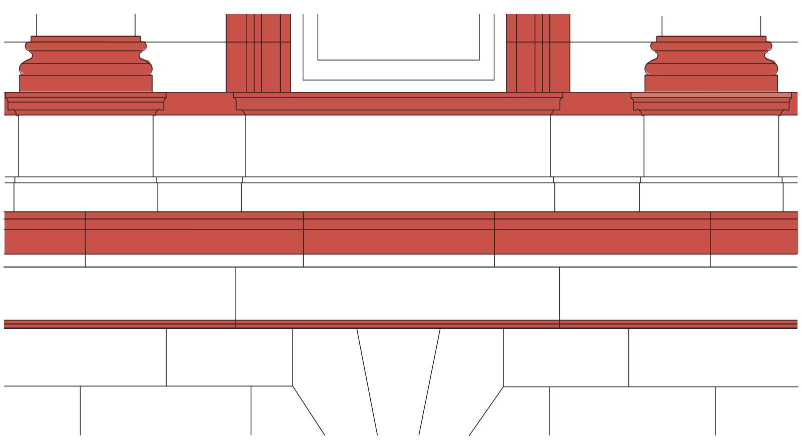
Tier 3- Historic Character (T3)



Select character-defining features are restored:

- Sills, and pedestal wash ledges are repaired/replaced to restore function.
- Water table wash ledges are repaired to restore function.
- Drip edges are replaced to restore function.
- Secondary horizontal ledges are ground smooth to facilitate water shedding.
- Missing material at stringcourse and pilaster base is repaired.

Tier 4- Restoration (T4)



Deteriorated material is removed and replaced to improve long-term durability and preserve character:

- Sills, pilaster base and pedestal wash ledge.
- Water table wash ledge, fascia, and drip edges.
- Secondary horizontal ledge and stringcourse.
- Window surrounds.

Restore the Georgia marble exterior

Tier 1 -Life Safety (T1)

Tier 2 -Water Management (T2)

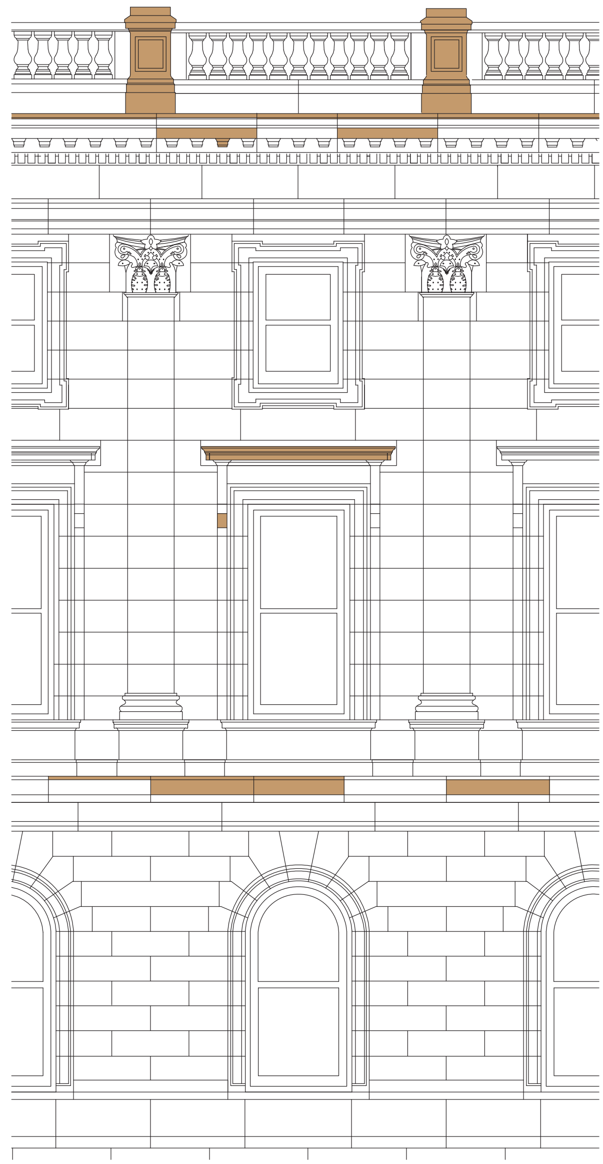
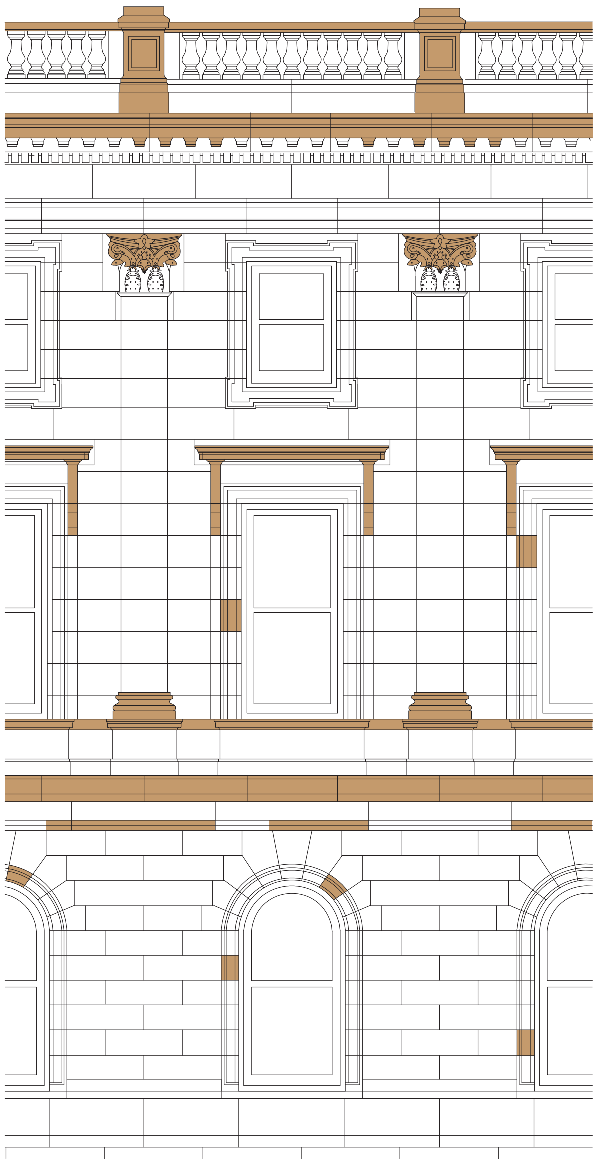


Fig. 80 -81: A typical building bay is used to show areas and elements that are focused on at each level of repair.

Tier 3- Historic Character (T3)



Tier 4 - Restoration/Reconstruction (T4)

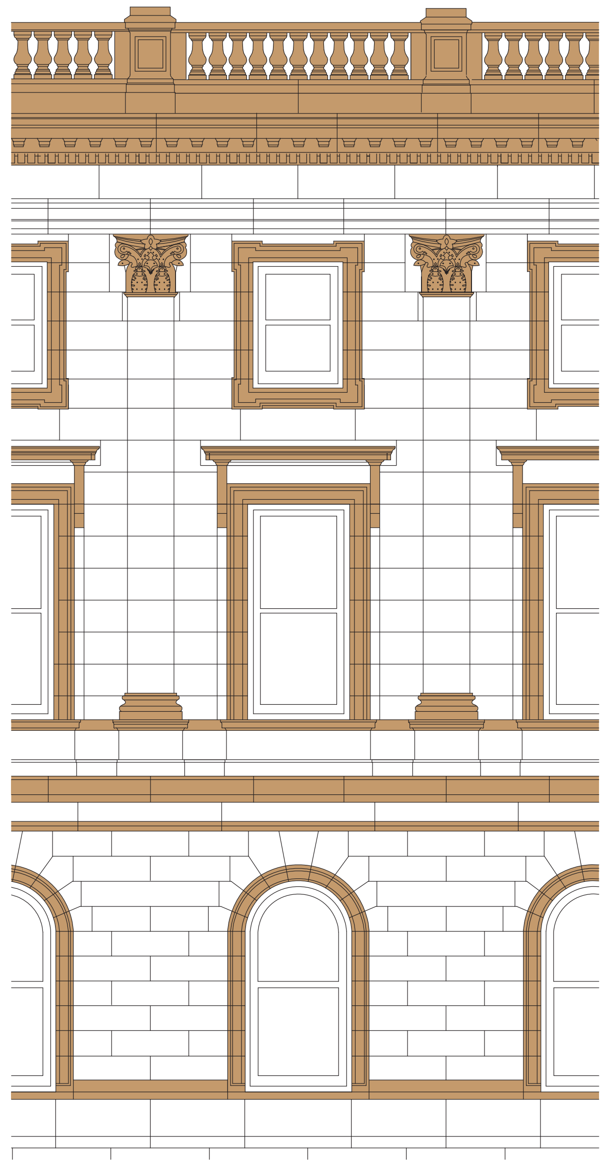


Fig. 82 -83: A typical building bay is used to show areas and elements that are focused on at each level of repair.

Table 1: Repair Strategy Comparison – Type of Repairs Included

Repair Priorities and Typical Locations	Repair Scope				images
	Tier 1 (T1)	Tier 2 (T1+T2)	Tier 3 (T1+T2+T3*)	Tier 4 (T1+T2+T3**)	
Life Safety (T1)	●	●	●	●	
Stabilize or remove all unsound material: • Reconstruct deteriorated brick backup masonry (roof balustrades and piers, second floor logia and pavilion balustrade systems, attic stories at elevator towers • Mechanically secure loose/broken stone fragments • Reset displaced stone units • Replace corroded anchors					
Water Management/Building Integrity (T2)		●	●	●	
Reduce the potential for further water damage to stone and masonry exterior: • Cleaning • Repair joint systems • Repair cracks and fissures • Protect and preserve sound historic material in place w/ metal flashing until more viable alternative become available in the future: - Cornice ledges - Second story window hoods - Stone gutters • Smooth rough, eroded, weathered surfaces to facilitate water shedding capabilities of the stone: - Highly granulated field of wall surfaces - High-relief decorative features and panels • Replace select primary water shedding features showing severe deterioration: - Drip edges at cornice fascia, second floor water table, projecting window hoods					
Water Management/Building Integrity (T2)		(a)	●	●	
Optimize water shedding capabilities: • Replace remaining primary water shedding features showing visible deterioration - Drip edges at the cornice fascia, second floor water table, projecting window hoods • Replace secondary water shedding features showing visible deterioration and selected areas where water management may potentially be an issue - Pilaster bases, major sill bands - Capital abacus					
Historic Character (T3)			●	●	
Preserve the historic character of the Minnesota State Capitol: • Smooth surfaces of character defining features - minor spalls or surface deterioration - edge boundaries • Replace significant character defining features with severe damage (see Table 3 for list of features) • Replace tertiary horizontal band features showing visible deterioration - Minor bands and stringcourse profiles - Bullnose features					
Extensive Restoration/Reconstruction (T4)				●	
Restore the Minnesota State Capitol: • Replace material showing visible deterioration - Entry Portals - Window surrounds - Remaining character defining details					

a. Water management repairs listed in this section are not included in the current scope of work.

Table 2: Repair Strategy Comparison – Overall Project Impact					
Repair Priorities and Typical Locations	Repair Scope				images
	Tier 1 (T1)	Tier 2 (T1+T2)	Tier 3 (T1+T2+T3*)	Tier 4 (T1+T2+T3**)	
Current Constructability Issues					
Relative Value [a]	48%	52%	67%	70%	
Project Duration [b]	3	3	4	7-8	
Long-term Building Stewardship					
Overall appearance	-	-	+	+	
Preservation (retention/protection of historic material)	-	+	+	-	
Long-term Durability	-	±	+	+	
Inspection Cycle [c]	2 years [e]	3–5 years [f]	10–15 years [g]	15–20 years [h]	
Maintenance [d] (See Table 4)	2 years $$$$ [e]	6–10 years/ $$$ [f]	20 years $$ [g]	20 years $ [h]	

* Select character defining features. Includes features that negatively impact overall visual appearance and those with diminished capacity to convey significance

** All character defining features with visible deterioration.

a. Total construction cost includes provisions for general conditions, access, special conditions, and sound mitigation in addition to work directly related to stone repair. Stone cost (based on amount allocated for stone repair contractor) is expressed as a % of total construction cost demonstrates the value of stone repair relative to the total cost to complete the work.
b. The construction schedule is predicated on a maximum number of pieces that can be reasonably repaired in a single construction season (1500 installed Dutchman/year).
c. *Inspections* are by an Architect/Engineer with the intent of evaluating the rate of deterioration and assessing life safety conditions for elements not replaced or repaired during previous comprehensive repair projects. The Inspections category is an estimate intended to provide a proportional understanding based on the differences in the extent and types of repairs between the options. During inspection intervals, the State should anticipate the erection of scaffolding or swing stages. The actual frequency of inspections is determined by the rate of deterioration of the stone, which is in turn affected by such variables as microclimate, building elevation, architectural feature, and characteristics of individual stone units. Additional monitoring and assessment of the stone is required to assist in understanding a rate of deterioration for the stone.
d. *Maintenance* is performed in combination with an inspection cycle and includes a contractor to address life safety and water management, remove unsound materials, and perform minor repairs on an ongoing basis. The Maintenance category is an estimate intended to provide a proportional understanding based on the differences in the extent and types of repairs between the options. During maintenance intervals, the State should anticipate the erection of scaffolding and swing stages and should have a stone mason contracted to conduct repairs. Regardless of the repair option implemented, building maintenance is anticipated to be required at 15 to 20 years to repoint mortar in joints and maintain water management at joints between stone units. The frequency of inspections and maintenance is determined by the rate of deterioration of the stone, which is in turn affected by such variables as microclimate, building elevation, architectural feature, and characteristics of individual stone units. Additional monitoring and assessment of the stone is required to assist in understanding a rate of deterioration for the stone.
e. Both inspections and maintenance are currently estimated to be needed every two years. Inspection and maintenance costs will be fairly high as the entire building will need to be comprehensively surveyed. Existing deteriorated stone will continue to deteriorate and require regularly scheduled removal. Every 15–20 years, it is anticipated that mortar joints will require repointing.
f. Inspections are currently anticipated to be performed routinely following completion of the first phase of the project. Maintenance cycles will be performed every other inspection cycle. The cost of inspections will be higher than other repair options because the scope of the initial repairs is not as extensive. Inspections and maintenance will be focused on those areas that did not receive previous repairs or replacements during the repair work. Existing deteriorated stone will continue to deteriorate and require regularly scheduled removal. Every 15–20 years, it is anticipated that mortar joints will require repointing.
g. Inspections are currently anticipated to be performed routinely following completion of the project. Maintenance will be performed every other inspection cycle and will include the repointing or mortar joints, which is typically recommended every 15–20 years. The cost of inspections will be moderate to low because the scope of initial repairs included a large percentage of areas with the most extensive deterioration. Inspections and maintenance will be focused on column capitals and at localized areas where more extensive repairs were not performed. At these locations, existing deteriorated stone will continue to deteriorate and may require regularly scheduled removal.
h. Inspections and maintenance are currently anticipated to be performed simultaneously and include the repointing of mortar joints, which is recommended every 15 –20 years. The cost of inspections and maintenance will be relatively low as many of the architectural elements were removed and replaced with new material during initial repairs. Inspections and maintenance will be focused on portions of the building that did not receive previous repairs. At these locations, existing deteriorated stone will continue to deteriorate and may require regularly scheduled removal.

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Table 3: Repair Strategy Comparison – Relative Impact of Dutchman Repair Quantities on Overall Project						
Overall Visual Impact	Repair Priorities and Typical Locations	Quantity impact†	Quantity expressed as a % of total building linear footage or number of features			Repair Priority Ranking
			Tier 2 (T1+T2)	Tier 3 (T1+T2+T3*)	Tier 4 (T1+T2+T3**)	
High	- **cornice elements**					
	o drip edges		90%	100%	100%	1
	o modillion blocks	1060	0%	100%	100%	4
	- **window hoods**	76	90%	100%	100%	2
	- **scrolled brackets**	**130**	-	-	-	-
	o full face bracket scroll		0%	75%	100%	5
	o partial bracket scroll		0%	25%	0%	-
	- secondary wash ledges	2565 LF	60%	90%	100%	3
	- sills		0%	50%	100%	6
	- column capitals	**58**	-	-	-	-
	o full cap (fleuron and abacus)	198	0%	100%	100%	9
	o volute	140	0%	50%	100%	11
	o acanthus leaf	758	0%	25%	100%	12
	o astragal	396 LF	0%	20%	100%	13
	- loggia and pavilion balcony rail systems	25 sections	0%	25%	50%	14
	- decorative keystones at entry arches	16	0%	100%	100%	15
Significant	- **column/pilaster bases and pedestals**	34/120	50%	100%	100%	7
	- tertiary sill bands and sills	4620 LF	0%	30%	100%	8
	- **pilaster capitals**	**164**	-	-	-	-
	o full cap (fleuron and abacus)	164	0%	100%	100%	10
	o volute	328	0%	50%	100%	16
	o acanthus leaf	772	0%	25%	100%	17
	o astragal	820 LF	0%	20%	100%	18
	- roof balustrade rail systems	54 sections	0%	25%	100%	19
	- high relief detail (elevator and stair towers)	20	0%	5%	30%	20
	- low relief detail (entries- swags, medallions)	40	0%	5%	30%	21
Moderate	- dome eagle statuary	12	0%	0%	0%	
	- dome carved panel details	12	0%	5%	50%	
	- window surrounds (floors 1-3)	175 openings	3%	5%	30%	
	o first story - 64 windows	2406 units				
	o second story- 48 windows	945 units				
	o third story- 71 windows	550 units				
	o drum- 12 windows	216 units				
	- high relief ornamental detail (upper story)	8	0%	5%		
	- low relief carving	238	0%	5%		
Low	- dentils	4000	0%	5%	50%	
	- capital column flutes	58	0%	1 column	50 columns	
	- portal surrounds (primary entries)	16	0%	0%	100%	

* Select character defining features. Includes features that negatively impact overall visual appearance and those with diminished capacity to convey significance

** All character defining features with visible deterioration

† Approximate linear footage or number of existing building features

HGA + WJE

REPAIR COST IMPLICATIONS

The exterior of the Minnesota State Capitol, with over 50,000 individual pieces of stone, is enormous both in size and complexity. This is a highly decorative stone exterior. Character-defining features are often ornately carved and can be quite large. Some elements are focal points and are highly significant in their own right; other elements are more repetitive but contribute in a contextual way. Context and priority groupings tend to favor comprehensive treatment which impacts quantity. Therefore, material and labor costs associated with character defining features are much higher. Even relatively minor scope changes can have a major impact on Project cost.

Tables 1, 2, and 3 describe various types of repair the impact the four different repair strategies have on the project. The manner in which character-defining features are treated, and the extent to which repairs are implemented, is the point where the various repair approaches diverge from one another, both in terms of overall appearance and cost. Unit costs developed in the trial phase are currently being used to assign value and track costs based on projected repair quantities.

Quantities for select architectural features are included in Table 3 along with proportional work scope for the optional levels of repair. Order of magnitude cost implications can be illustrated by comparing two very different architectural features types. Project cost is impacted primarily by quantity (Case 1) or complexity (Case 2):

- **Case 1: Highly repetitive architectural element relatively simple profile and modest cost (cornice modillion block - total repair unit cost $2600) :**

  Tier 1- 0 %
  Tier 2- 50 % $1,387,500
  Tier 3- 100 % $2,775,000

- **Case 2: Significant element in an architectural grouping- ornately carved, high cost (window hood brackets-full replacement):**

  Tier 1- 20 % $494,000
  Tier 2- 75 % $1,862,500
  Tier 3- 100 % $2,470,000

In both cases, quantity is expressed as a percentage of the total number of building features. For example, Case 1 (Tier 2) recommends repair of 50% of the modillions on the building. Table 3 shows an approximate quantity of 1060 modillions for the building.

Conditions at the State Capitol vary as widely as the repairs that could be implemented to correct the deficiencies. Even with an over arching strategy in place, each situation is unique and evaluation takes place on a case by case basis and a stone by stone analysis. The decision making process is inherently complex and cost implications can be significant depending on the extent and type of repair selected. On one hand, the level of repair required to restore building integrity and improve capabilities of water-shedding features is fairly straightforward. On the other hand, determining the appropriate level of repair to follow hazard mitigation or to restore eroded character-defining detail requires more disciplined planning. Consistency is critical and rigorous assessment protocols with well-defined threshold criteria have been developed to guide the effort.

Test repairs executed during the trial phase demonstrated that most technical issues related to acquisition, fabrication, removal and installation can be resolved. The process has been vetted and a team of professionals with extensive preservation experience and specialized restoration skills is assembled and ready to begin work on the Project. At this point, the final extent of the Project as reflected in Construction Documents will likely be influenced more by material, fabrication and construction costs than technical hurdles or limitations.

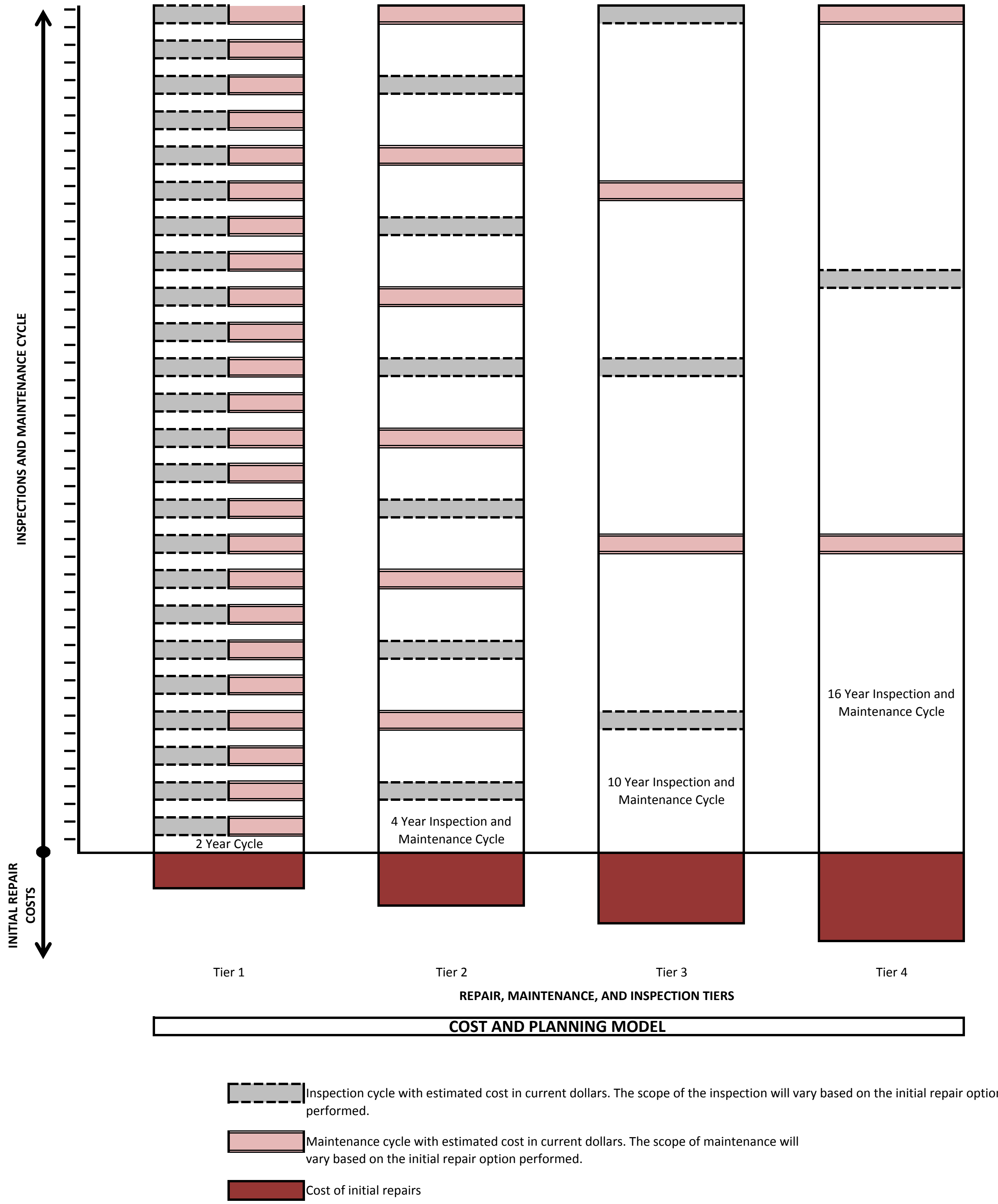

Table 4: Long-Term Building Stewardship Cost and Planning Model; refer to Note 'd' on Table 2 for additional information.

Many cost estimates have been generated throughout this process. Preliminary estimates were based on industry standards and general construction practices. These have since been refined to reflect the unique, highly specialized, project specific requirements for stone repair. Repair protocols developed for the trial phase helped provide a sound basis for more accurate unit pricing. Detailed estimates that evolved as strategies for repair were refined and updated cost models are included at the end of this section. (See Exhibit G.)

As the various options for repair are being weighed, long-term building stewardship costs must also be taken into consideration. Deteriorated material left in place requires frequent inspection and regular maintenance. The type of distress and extent of deteriorated material left in place determines the timing for the next round of future inspection and maintenance repairs, the interval between repair projects, and the access requirements to complete the repairs. All of these impact long-term building stewardship costs. (For recommendations and assumptions pertaining to inspection and maintenance, see Table 4.)

The deliberate and thorough approach being taken to address the need for marble stone repair and restoration at the Minnesota State Capitol building utilizes and applies the lessons learned during the investigative and trial phases to achieve the best possible outcome within a given budget. It is important to address this issue now, so that the opportunities for long-term preservation that exist today are not missed:

Long-term advantages to be gained by implementing an appropriate amount of work now include:

- Mobilization and Access: Deferring work misses an opportunity to take advantage of access already in place. General construction costs related to mobilization and access to the building are substantial, regardless of the level of repair. However, if stone repair is not optimized, a higher percentage of the total construction cost is allocated to general conditions, such as scaffolding, rather than to stone repair. This results in a lower repair value per construction dollar.

- Stone Availability: White Georgia marble matching the properties of the original stone installed at the Capitol is now available in sufficient quantity to execute repairs at the highest level. This has not always been the case. Material is exclusive to a single source and the quarry is opened only for large scale restoration projects. When not in use, the current practice is to allow the quarry to fill with water and there is significant cost associated with reopening it. Although the quarry is currently open, there is no guarantee that material will be available at a future date.

- Material Cost: The supplier has announced that there will be an annual markup on material cost for white Georgia marble.

- Fabrication Cost: The trial phase demonstrated that unit pricing is dependent on quantity as well as a standardized approach to production carving. As quantity goes up, price comes down. The design team has been working with fabricators and installers to develop effective details that minimize waste and maximize production efficiency. This is an evolving process and the team will continue to look for ways to improve both process and final outcome.

- Project Execution: A limited pool of skilled carvers and stone masons, who are qualified to execute the highly specialized work required for a project of this magnitude, are available today. The number of skilled masons trained in this art will continue to dwindle in the future.

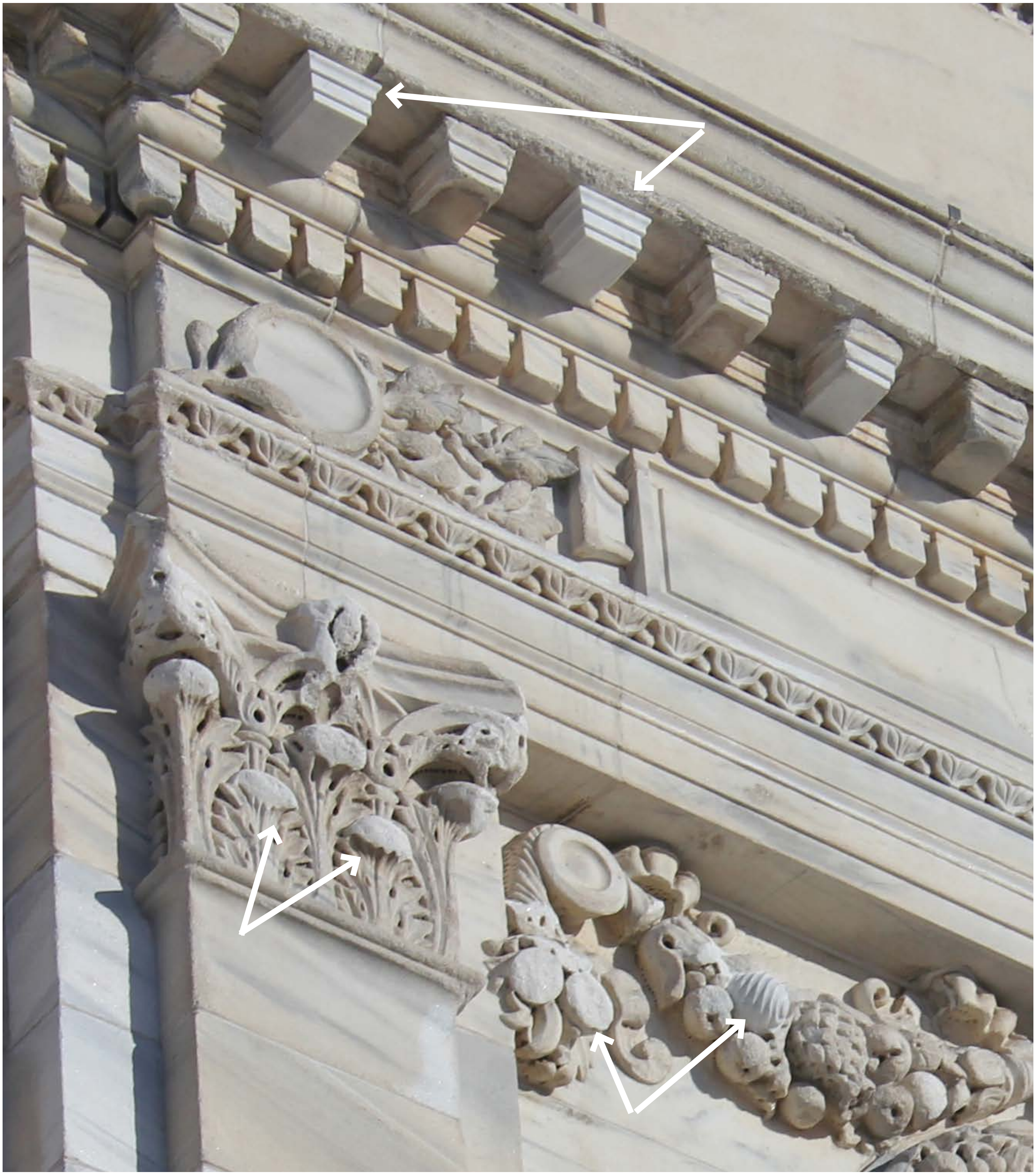

Fig. 86. Crisp new modillion blocks, a Tier 3 level repair priority, have strong visual impact. The effect can be compared and contrasted with the Tier 1 level approach taken at the pilaster capitol. In this case, unsound material has been removed but not restored. In lieu of replacement, surfaces are ground smooth to facilitate water runoff. Highly carved detail to the right of the pilaster also shows a range of repairs - two similar pieces have been removed, one other missing element of approximately the same size was replaced.

- Flexibility: Unique features and/or specific units are customized to fit exact locations. Smaller pieces and repetitive units are easier to mix and match in response to field conditions. This helps reduce material waste both in production and during installation which in effect adds value back to the Project. The added advantage is that these pieces are ready for installation early in the project which helps avoid costly delays.
- Efficiency: To optimize stone repair value, work should be scheduled to maximize efficiency. Repair quantities and construction scheduling should align with the projected maximum number of installed dutchman repairs that can be completed in a season (approximately 1500 per season).
- Construction Sequencing: Limited and narrowly focused repair work may hinder future repairs of adjacent material or may have to be removed to execute additional repair in the future.
- Longevity of Repairs: The continued or renewed durability of repaired stone is related to the level of repair selected. Weathered material left in place and not addressed will continue to deteriorate at an accelerated pace.
- Coordination of exterior stone repairs with potential interior restoration work, current french door restoration and window repair, and sash replacement minimizes negative impact on building tenants.

The success of the Stone Repair Project will be judged by the overall visual appearance of the building, the impression it leaves in coming years on occupants and the visiting public, and eventually the longevity of repaired surfaces. Some level of weathering is expected on a building of this age. Not all deterioration requires correction, and missing or eroded detail does not always detract from the perceived character of the building. However, severe and/or advanced distress and decay conditions will eventually require repair or replacement in order to maintain a cohesive appearance that will not detract from the stately image of this historic monument.

Exhibit G: Construction Cost Comparison

Minnesota State Capitol - Exterior Stone Repair Strategies
Budget Range
St. Paul, Minnesota
April 26, 2013

JE DUNN CONSTRUCTION

Construction Cost Summary

Option	Description	Projected Budget
T1 Approach	All unsound material is removed or stabilized to support life safety. Missing features are not replaced.	25,000,000
T2 Approach	This tier provides added focus on restoring function to water shedding components of the building in order to slow future deterioration of adjacent exterior building material and to protect interior finishes from water damage. Repair incudes Dutchman replacement of some water shedding features. The building is cleaned, joints are restored, and cracks are repaired.	29,500,000
T3 Approach	This tier provides added focus on the carved building elements which typically exhibit the most severe damage. Repair includes select Dutchman replacement of highly deteriorated character defining features of the building to aid in preserving the visual character of the original architecture.	56,000,000
T4 Approach	This tier adds more extensive replacement of deteriorated material, including full replacement of additional select character defining features in order to improve long term durability and preserve visual character.	105,000,000

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