Rehabilitate Eastern Approach

New York State Capitol
Albany, New York

OGS Project S6574

Governor Andrew M. Cuomo
Commissioner RoAnn Destito

PREPARED FOR
New York State Office of General Services
PREPARED BY
Simpson Gumpertz & Heger

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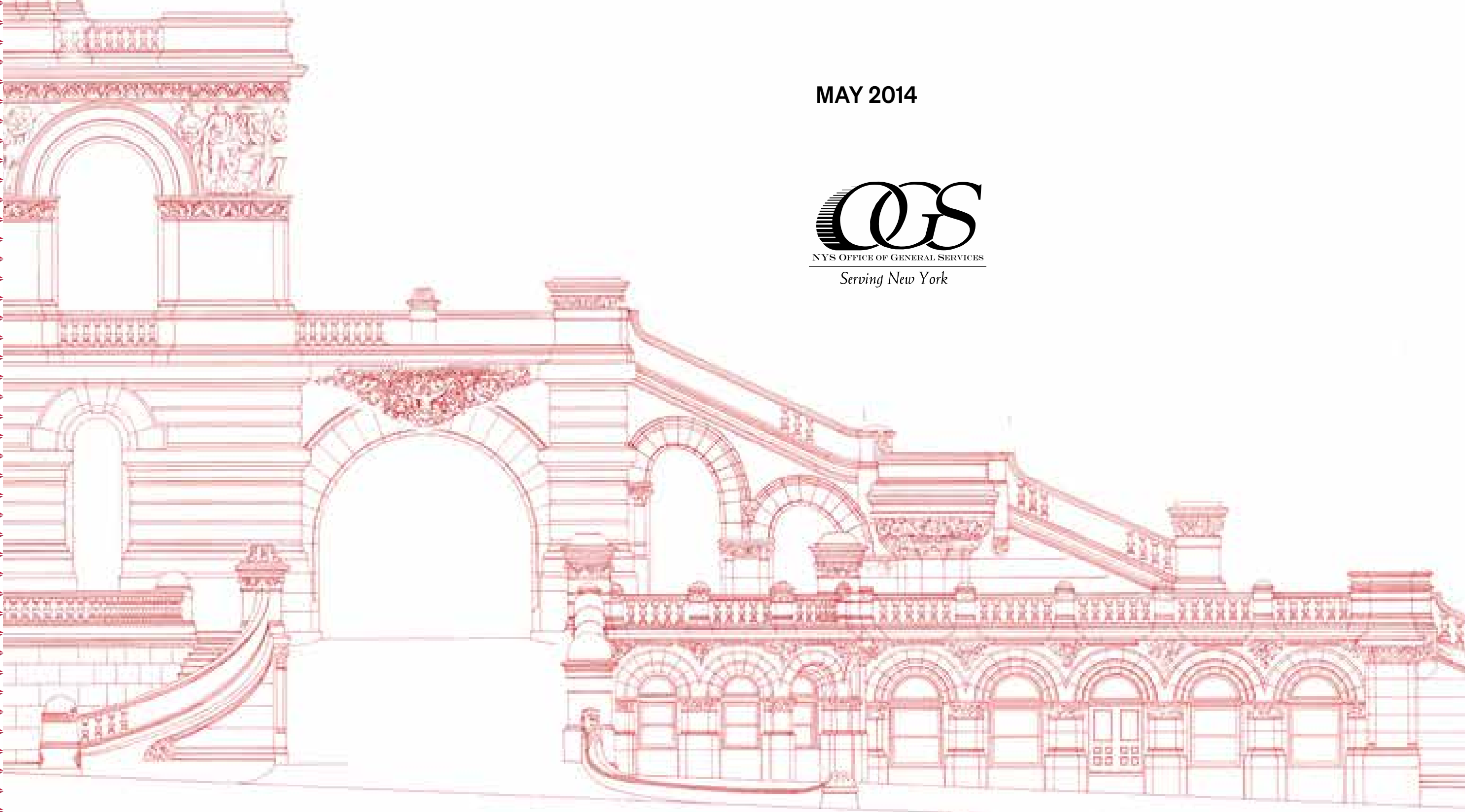

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Executive Summary

The New York State Office of General Services (OGS) engaged Simpson Gumpertz & Heger, Associates, Inc., P.C. (SGH) to perform an investigation of the Eastern Approach, Executive Ramp, and Eastern Promenade of the New York State Capitol and to provide comprehensive recommendations for their rehabilitation. The primary objective of this investigation was to determine the source of ongoing deterioration and large-scale stone displacement at the Eastern Approach and its periphery areas. SGH engaged a team of consultants to assist with the investigation. This report, along with the separately bound appendices, summarizes our investigation scope of work, findings, and recommendations.

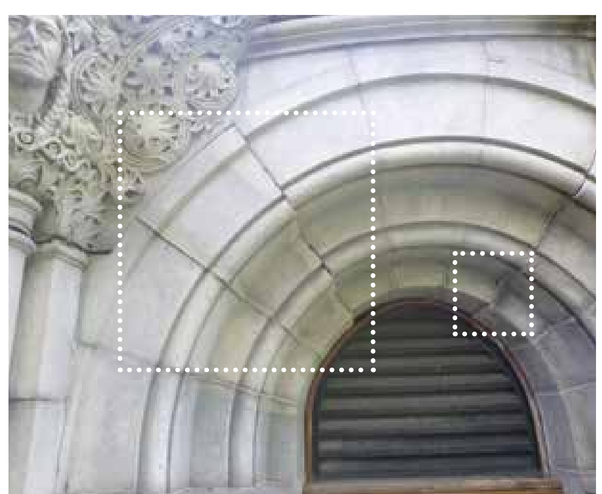
Eastern Approach The Eastern Approach is a terraced, unreinforced mass masonry staircase rising from the East Capitol Park to the second floor of the Capitol's East Portico. The Eastern Approach exhibits significant deterioration, including cracking, spalling, and masonry displacement. Despite the extensive exterior distress, the underlying brick masonry structure and mat foundation are generally intact and functioning, except at two locations below Flight 3 (Figure 6a). Here the brick masonry bearing walls are so heavily deteriorated and displaced that they are no longer stable and need to be addressed immediately by either shoring or rebuilding the wall areas.

The deterioration primarily stems from the long-standing, uncontrolled water entry into the structure. Water enters through defects in the drainage system, gaps resulting from masonry damage and displacement, and due to the lack of a functional waterproofing or flashing system. The water entry is causing significant corrosion to both the original structural floor systems and to the shims in the remedial pre-cast concrete shoring installed in the 1950s to address the original corrosion problems. The corrosion has jacked (i.e. lifted) portions of the structure (Figures 6b–c), causing masonry displacement and deterioration, most notably at the Landing 2 balustrades, which are rotated out-of-plane by approximately 4 degrees. Although currently stable, if damage is allowed to continue, the balustrades will no longer be able to carry code required railing loads or their own weight. Water entry is also causing freeze-thaw deterioration to the masonry, damaging the historic carved finishes, and causing significant localized deterioration to the brick walls.

There is also masonry displacement is at the Arcade level vaults and arches. This damage is likely due to differential movement between the Capitol and Eastern Approach structures, which do not have integrated foundations. Water infiltration, which deteriorates the surrounding mortar, exacerbates the displacement by creating gaps that allow the masonry to further slide out of position. The magnitude of the movement to date has not undermined the structural performance of the vaults, and further deterioration will likely be limited by managing water entry from above. We recommend monitoring to see if further displacement occurs.

Comprehensive repairs will require rebuilding large areas of the Eastern Approach to incorporate a water management system and to address the deterioration to the stone, brick bearing walls, and the floor structure. Further stone and brick masonry damage is expected until these repairs are implemented. In the interim, immediate repairs are required at the Flight 3 brick bearing walls and periodic monitoring is recommended to verify similar localized areas of structural instability do not develop.

Executive Ramp The Executive Ramp is aged and the drive surface, curbs, and retaining walls are deteriorated. Deterioration relates to water infiltration, freeze-thaw cycling, and general use. Water enters the masonry retaining walls through failed sealant joints and from ground water collected in the poorly drained soil below the drive surface. The water entry is causing stone damage, including rotation of the granite balustrade due to general mortar joint deterioration and freeze-thaw ratcheting. In addition, the saturated soil exerts a calculated soil pressure that exceeds the retaining wall's capacity, and accounts for displacement at the base of wall. Recommended repairs include rebuilding portions of the retaining wall; incorporating flashing, damp proofing, and a soil drainage system; replacing the drive surface; and incorporating a snow melt system to limit damage from plowing and de-icing salts.



Clockwise from left:

Figure 6a Deteriorated and unstable brick masonry below Flight 3.

Figure 6b Typical corroded steel baseplates and shims below shoring members.

Figure 6c Displaced stones at cornice and arched windows.

Eastern Promenades The Eastern Promenades are in serviceable condition with isolated damage to the concrete decks and walls as well as granite cladding and balustrades. However, significant efflorescence and rust staining on the interior and exterior of the walls and on the underside of the deck slab indicate substantial water entry. Sources of water entry include deck deterioration, poor drain integration, deteriorated mortar joints, and failed sealants in the balustrade, control joints, and perimeter conditions. This water entry is causing isolated damage related to freeze-thaw deterioration and corrosion of embedded reinforcement and encased beams. The use of deicing salts accelerates these deterioration mechanisms. Recommended actions include repairing the existing deck surface and providing a waterproof traffic coating over the deck slabs; rebuilding the balustrade with flashing at its base; and repairing isolated granite deterioration.

East Portico The East Portico was not part of the original study scope. Since the area will be disrupted by scaffolding and construction equipment required to complete the recommended Eastern Approach work, the East Portico work is included in these repair documents and cost estimate. Repair recommendations are based on our previous Capitol investigations and include stone repairs and replacement of the Portico's fourth-floor roof.

Exterior Lighting and Miscellaneous Items Decorative bronze light fixtures adorn the project area balustrades, and are historically significant as part of the early adoption of electricity at the Capitol. The recommended work includes the removal, refurbishment, and reinstallation of the fixtures to both preserve them and to complete adjacent masonry reconstruction work. Other lighting, security cameras, and utilities in the project area will also be addressed as part of this work.

Construction will impact the landscaping in the East Capitol Park. Project costs include the necessary tree relocation and repair of the lawn areas upon project completion. Also included in the project are related improvements to the security gates and site appurtenances.

Project Cost The total cost for the recommendations summarized above is $16,962,000.

Project Area and Study Scope

Project Area The New York State Capitol's Eastern Approach is an approximately 15,000 square foot terraced granite staircase rising roughly 40 feet from the East Capitol Park to its uppermost landing abutting the Capitol's East Portico (Figures 8a–9a). The lower portion of the Eastern Approach includes an enclosed, unfinished basement space, which until recently was used for storage of construction material. The upper portion of the Eastern Approach spans the paved Executive Ramp and is supported by an arcade of granite piers and groin vaults. The second and largest of the Eastern Approach's four terraced landings provides access to the driveway and the East Portico's first-floor entrance to the Capitol. The uppermost landing provides access to a second-floor Capitol entrance within the East Portico.

Figure 8a Aerial view of New York State Capitol's north and east facades, circa 1968..

The Executive Ramp beneath the Eastern Approach, serves as a secure passenger drop-off and parking area. The ramp rises roughly 12 feet above street level and the adjacent East Capitol Park; the eastern edge of the elevated ramp is supported by granite retaining walls with a balustrade, which connects to the lower portion of the Approach.

Raised promenades wrap around both the northeast and southeast corners of the building. These promenades connect the East Portico's first-floor entrance, which is several feet above grade due to the eastwardly slope of the site, to the North and South Portico first-floor entrances. The Eastern Promenades are bounded by a granite site wall and balustrade.

The three-story, terraced East Portico (Figure 9b) anchors the center of the facade, and provides building access at the first- and second-floor levels. The East Portico was not directly within this project's scope, but this project area will be impacted by adjacent Eastern Approach repairs and recommended repairs are included in the project cost estimate.

The entire project area is part of the New York State Capitol, which is a National Historic Landmark.

SGH Involvement and Current Scope Simpson Gumpertz & Heger (SGH) first became involved with the Capitol in 1997, when we were engaged by the New York Office of General Services (OGS) to provide a complete investigation of the Capitol's roofs and facade. The aged roofs were the focus of our first investigation, though we did perform a cursory review of the Eastern Approach, and some limited discussion is included in our 10 April 1998 study report. At that time we noted several cracked or displaced granite stones, failed sealant joints, severe efflorescence, and dampness in the basement space below the stair.

In 2013, OGS engaged SGH to perform a structural survey and investigation of the Eastern Approach, Executive Ramp, and Eastern Promenades and to provide comprehensive recommendations for their rehabilitation. The primary objective of our investigation was to determine the source of ongoing deterioration and large-scale stone displacement at the Eastern Approach and its periphery areas.

To complete this work, SGH assembled a consultant team consisting of Robert Silman Associates (RSA, structural review), MH Professional Engineers (MHPE, mechanical, electrical, and plumbing review), Clark Engineering and Surveying (CES, surveying), Page

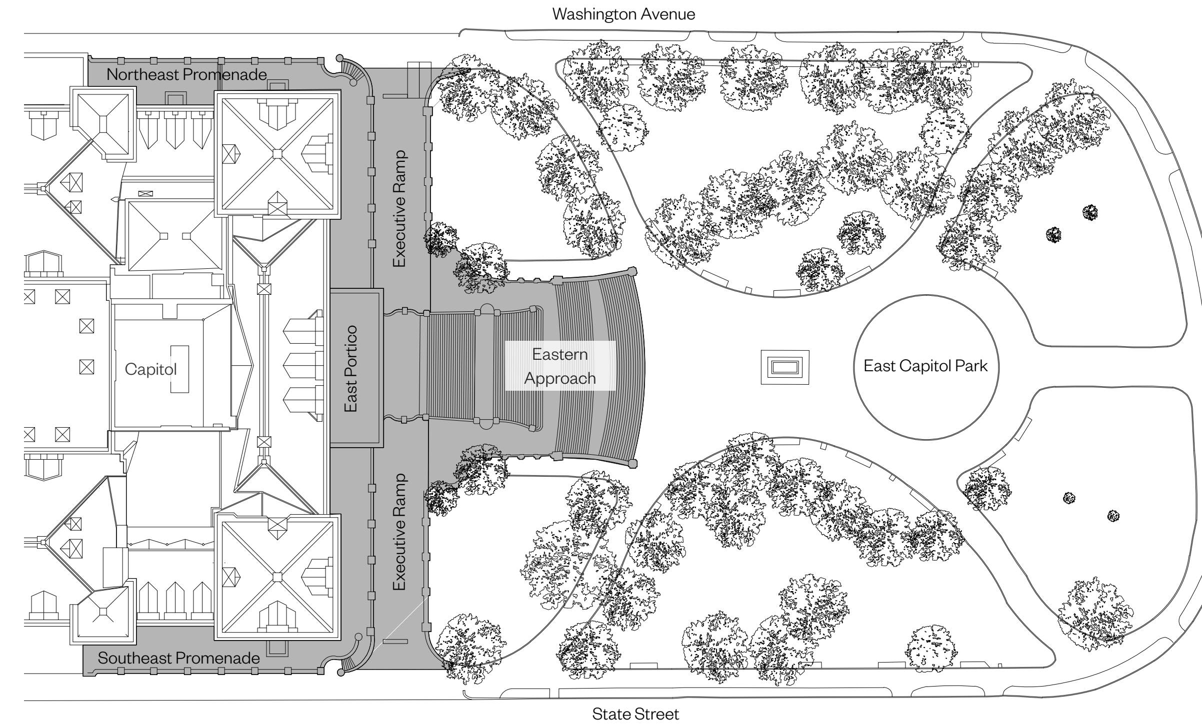


Figure 9a Site plan of project areas.
Figure 9b East Portico and the Capitol's east facade.

Ayers Cowley Architects, LLC (PACA, historic preservation review), and Fisher Associates (Fisher, inspection for hazardous materials and testing). We also engaged Titan Roofing (Titan) to make and repair exploratory openings and VJ Associates (VJA) to provide a construction cost estimate for our recommended repairs. OGS and the commission on the restoration of the Capitol also assisted by providing historic drawings, photos, and reports, while assisting our access into the New York State Archives.

Our findings and recommendations are based on the following work completed by SGH and our team of consultants:

- Detailed survey of all exterior masonry components, including using an aerial lift to closely inspect portions of the Eastern Approach above the Executive Ramp.
- Detailed survey of all accessible interior spaces below the Eastern Approach and Eastern Promenades, including access to confined-space sub-basement areas.
- Review of available documents, including the following: original construction drawings available in the New York State Archives; 1950s Praeger-Maguire staircase stabilization drawings; 1960s promenade reconstruction drawings; 1954 photo negatives of the Eastern Approach available in the New York State Archives.
- Level survey of all exterior surface areas.
- Exploratory openings at the staircase and driveway to assess hidden components of the construction.
- Water testing on the staircase and promenades to understand existing leakage paths.
- Structural analysis, including three-dimensional (3D) modeling and finite element analysis (FEA), of the complex staircase vault structures to evaluate load capacity and to identify any deficiencies in the original design.
- Environmental review and hazardous material testing of exposed materials in the project area and at exploratory openings.
- Review of existing electrical and plumbing systems in the project area, and review of existing building mechanical systems with regard to potential addition of a snow-melt system within the project area.
- Review of available soil data in the project area and structural evaluation of the Executive Ramp retaining walls.

We completed the drawing review and all field investigation work in October and November 2013; subsequent analysis and the development of this report were completed in early 2014.

The following report summarizes our findings and recommendations. The separately bound appendices provide relevant original and repair drawings, a full summary of our test and survey results, and individual consultant reports. We also provide electronic copies of relevant materials bound with the appendices.

Figure 10a Eastern Approach shortly after construction.

History of Construction and Repairs

Various Eastern Approach designs were generated by Thomas Fuller and the successor firm of Eidlitz, Richardson, and Olmsted. These designs never came to fruition, leaving the prominent east facade incomplete well into the Capitol's construction (Figure 11a). In 1889, under the direction of Isaac Perry, the current iteration of the Eastern Approach was approved by the Capitol's Supervising Commissioners. Construction of the Eastern Approach began in 1891 and was completed in 1897 (Figure 11b).[1] Construction of the Eastern Promenades and enlargement of the East Portico to its current appearance are not specifically mentioned in these plans, but this work appears to have occurred during this same construction period.

Perry stated his Approach design was intended to provide a "spacious and imposing" entrance to both the first- and second-floor levels of the principal elevation of the Capitol.[2] The design is a monumental terraced staircase similar to Fuller's original proposals; however, it was modified by Perry to incorporate rich Romanesque detail similar to Eidlitz and Richardson's work elsewhere in the Capitol's construction.

Clockwise from top left:

Figure 11a New York Capitol's east facade, circa 1891.

Figure 11b New York Capitol's east facade, circa 1905.

Figure 11c Original Eastern Approach light fixture.

Figure 11d Current Eastern Approach light fixture with original posts, circa 1930s lanterns, and contemporary lamps.

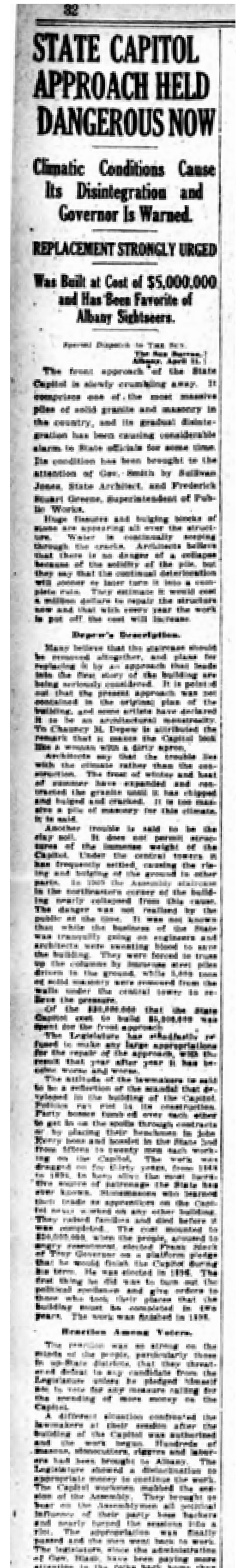
1 Criticism of original Fuller & Eidlitz et al approach designs and construction dates; Capitol Historic Structure Report (HSR), 308, 309, 310.

2 Perry plan for stair; HSR, 310–11.

Figure 12a *Knickerbocker News* circa 1952.
Figure 12b *New York Sun* circa 1924.
Figure 12c *Geneva Daily Times* circa 1924.

'Catacomb Exploration' Begun

Workmen Digging Under Capitol Steps



STATE CAPITOL APPROACH HELD DANGEROUS NOW

Climatic Conditions Cause Its Disintegration and Governor Is Warned.

REPLACEMENT STRONGLY URGED

Was Built at Cost of $5,000,000 and Has Been Favorite of Albany Sightseers.

Plan Removal of Eastern Stairway to State Capitol

Albany, May 2.—Tentative plans for the removal of the great eastern stairway approach to the State Capitol are being made by Sullivan W. Jones, state architect.

The state architect is making a series of drawings which will show how the Capitol would look if the massive stairway was removed. Removal of the stairway, Mr. Jones says, will prove very artistic and will be of great benefit to the Capitol in the utilization of waste space and beautifying the present approach.

"The proper main entrance to the Capitol," he said, "is through Capitol park on the eastern side of the building. The present stairway is virtually useless and if not removed is doomed to ruin. One of the things which should be done is to terrace the park up to the first floor of the Capitol and make the main entrance at that point."

During the last year or two the great stairway has started to crack to a great extent. At the present cost of granite and marble it is estimated it would cost at least $5,000000 to reproduce it.

Governor Smith is said to look with favor upon the removal of the present entrance. Architect Jones admitted today he had discussed the matter with the Governor but he said their talk was purely informal and that there was nothing for publication.

The state architect said that another improvement for which he was having drawings made was to move the offices of the Governor so that the Executive's private room would be in the stairway.

"This would afford the Governor an excellent office and would be a material improvement," Jones said. "The new offices could be annexed to the present suite."

Prediction was made by the state architect that next year's Legislature would make an appropriation for the removal of the main stairway.

Much sentiment is attached to the present massive stairway, but Mr. Jones said he thought this might be due to a large extent to the fact that many honeymoon couples have their pictures taken on the steps.

The fact that many fat men use the stairs as a means to reduce is not a good argument in the opinion of Architect Jones why the present entrance should not be removed.

The Eastern Approach, Executive Ramp, and Eastern Promenades also prominently featured a grand exterior lighting system with large cast bronze fixtures mounted to piers on the staircase, ramp, and promenade railings (Figure 11c). This electric lighting system, designed by Mitchell-Vance, was declared "the finest ever installed to light the exterior of a building" at the time of construction.[3] It was powered via concealed wiring and conduit bored through the railing's granite piers. In 1931 the lanterns atop the original fixtures were replaced, to match fixtures in the West Capitol Park. The original cast bronze posts remain (Figure 11d).

Ongoing Issues and Previous Repair—Eastern Approach Within a few decades of completion, leakage and masonry deterioration in the Eastern Approach were already cause for alarm. A 1924 news report called the staircase "dangerous," stating "water is continuously seeping through the cracks"[4] (Figures 12b–c). Over the next twenty-five years, various reconstruction or removal plans were brought before the State Legislature.[5] No appropriation passed until 1951 when the Eastern Approach was closed to the public and Praeger-Maguire, a consulting engineering firm from New York City, was engaged to investigate the ongoing deterioration of the staircase.[6]

No record of a Praeger-Maguire's study report was found, but extensive State correspondence and news reports between 1939 and 1951 indicate the Eastern Approach problems consisted of rusting and displaced metal framing below landings, outwardly displaced balustrades and walls, cracked treads and landings, and prominent leakage through the vaults above the driveway.[7–9] While there are some anecdotal references to previous Capitol foundation settlement-related issues or perceived "forward movement of the steps down the hill," the Eastern Approach problems are most commonly attributed to water infiltration and freeze-thaw cycles deteriorating the metal framing and masonry support structure.[10,11]

Praeger-Maguire provided drawings, dated September 1952, detailing a system of pre-cast concrete sills, columns, and cap beams to fully support all existing steel framing members below the Eastern Approach landings and the basement's interior floor. These drawings include several elevation points and note significant settlement at each landing level since the Eastern Approach's original construction; however, it is not clear if this was localized settlement (i.e., individual landing stones were displaced) or global settlement (i.e., the entire stair structure settled). The highly variable settlement measurements between each landing indicate individual stone displacement rather than structural settlement. These drawings also include waterproofing installation at the Eastern Approach's uppermost landing (Landing 4), addition of drains to lower landings, and excavation of roughly 6 feet of soil from within the staircase's sub-basement chambers in order to install the pre-cast shoring at this level. The excavation and shoring work began in 1952 (Figure 12a).[12] In 1953, reconstruction of the displaced lower staircase balustrade railings was included in the ongoing repair project.[13] The upper landing work was not completed until 1956.[14]

3 Lighting commentary from Cuyler Reynolds for 1899 *Architectural Record*; HSR, 315.

4 "State Capitol Approach held dangerous," *NY Sun*, New York, New York, Monday, 21 April 1924.

5 "Plan Removal of Eastern Stairway to State Capitol," *Geneva Daily Times*, Geneva, New York, 2 May 1924, 2.

6 "Superintendent Public Bldgs. Bertram D. Tallamy hires Emil Praeger to conduct a structural analysis," *Knickerbocker News*, Albany, New York, Thursday 12 December 1951.

7 "Repairs needed on Capitol steps: Study Underway," *The Times Record* (Troy, NY) 13 December 1951, 34.

8 "Loose balusters, water penetration through stone joints," 30 July 1951 letter to DPW Assistant Superintendent Charles E. Walsh, Jr.

9 White, C.J., "Movement in north/south stair walls," 28 September 1951, Memo from Cornelius J. White, State Architect.

10 Camp, E.D., Letter to W.E. Haugaerd regarding the Capitol Steps, "Definite forward movement of the steps down the hill," 4 March 1939.

11 "Sliding of the stair structure to the east," January 3, 1941 summary report.

12 "'Catacomb Exploration' Begun", *The Knickerbocker News*, Albany, New York, Tuesday, 18 November 1952.

13 State Architect (specific name not noted), "Memorandum to Mr. J. B. McMorran," Recommendation to replace balustrades/railings from grade up to second landing; 12 May 1953.

14 Larson, C.W., "Rehab Top platform steps E side Stairway," 55/135, FR0816, 1955 and Larson, C.W. "Rehab Top platform of steps E side staircase," 56/163, FR0852 1956 (OGS projects).

The 1950s repairs appear to have addressed the immediate concerns with the Eastern Approach's structural stability; however, they did little to minimize water infiltration. This fact is acknowledged in a 1952 memorandum summarizing the State's review of Praeger-Maguire's repair plan, which stated "while the repairs which are recommended…are quite substantial to provide the necessary structural stability, they cannot be classed as other than temporary."[15] By 1964, the State reports the steel shims and base plates below many pre-cast shoring members are corroding and there are ongoing leakage issues below the stair.[16] Additional inspection reports from 1986 and 1987 indicate ongoing corrosion of these steel shims and baseplates, as well as deterioration of twenty-eight of the pre-cast columns.[17] We found no further reports of inspection or remedial work after these late 1980s reports.

In addition to the leakage issues and structural stabilization work, we also understand the Eastern Approach was sandblasted to remove soot and soiling sometime after the 1911 Capitol fire. The Eastern Portico was sandblasted several decades later. We found no reports or documents detailing the exact extent or procedure for this work.

Ongoing Issues and Previous Repair—Eastern Promenades and Executive Ramp The Eastern Promenade decks were originally constructed with a brick jack arch floor system with a concrete topping. A 1965 inspection report states that "the steel is so rusted that it crumbles when touched" and "no supporting strength can be attributed to such a condition, which exists under most of the traffic way."[18] Drawings prepared by the State Department of Public Works dated August 1966 show completely removing the Eastern Promenade structure, replacing decks with new reinforced concrete and concrete-encased steel beams and rebuilding the Promenade perimeter walls reusing the existing stone. This reconstruction work was presumably completed shortly thereafter, and we found no further mention of work or issues with the Promenades.

At the Executive Ramp, a 1940 inspection report mentions horizontal displacement along the length of the driveway retaining walls and some cracking in pier stones.[19] There are no reports of repairs or subsequent inspections. Sometime since 1997, electrically operated barrier gates and related concrete curbs were installed at either end of the driveway. At the north end of the driveway (adjacent to Washington Avenue) an enclosed guard booth was installed in 2012, as part of the recent Capitol east quadrant roof and skylight restoration project.

15 State Architect (specific name not noted; eastern approach.doc), Memorandum to Mr. J. B. McMorran, Review of P-M repair plan and "temporary fix" comment; 12 June 1952 and Keays, R.J., Letter to Mr. Cornelius J. White, "Repairs to Capitol Steps," 11 June 1952.
16 Halsey, E.L., Report on Inspection of Area Under Steps to Capitiol (Eagle St. Side), Memo to Mr. Charles S. Kswecki, Rust on precast shims and ongoing moisture issues; 9 June 1964 .
17 Moakler, M.W., "Deteriorated Steel Bearing Plates Udner Columns That Support The East Stairs State Capitol Albany, New York, Project No. 35480-C," Memo to Raymond Webster, Rust on precast shims; 24 January 1986 (Capitol-Rehab East Stairs-35480.pdf).
18 Smith, G. W., "State Capitol—Proposed Benches for Promenade South-east Corner Location," Memo to General C.V.R. Schuyler, Corroded prom decks; 22 April 1965.
19 Markham, W.C. and R.H. Salisbury, "Report on Inspection of Staircase Along East Side of Capitol Building," Drive wall movement; 25 December 1940, 13.

Eastern Approach

The New York State Capitol's Eastern Approach is a terraced, unreinforced mass masonry staircase rising from the East Capitol Park to the second floor of the Capitol's East Portico. The Eastern Approach has significant deterioration, including cracking, spalling, and masonry displacement. Despite the extensive exterior distress, the underlying brick masonry structure and mat foundation, with the exception of the brick masonry jack arch floor systems and two support walls, are generally intact and appear to be functioning as intended.

The deterioration primarily stems from the long-standing, uncontrolled water entry into the construction due to the lack of a functional waterproofing or flashing system and the defects in the drainage system. The water entry is causing significant corrosion to both the original structural systems (thus requiring shoring in the 1950s), and to the shims in the remedial pre-cast concrete shoring.

The resulting corrosion has jacked the structure, causing masonry displacement and further deterioration. Water entry is also causing freeze-thaw deterioration to the masonry, damaging the historic carved finishes, and causing significant localized deterioration to the brick support walls such that the masonry is no longer stable. Repairs will require rebuilding large areas of the Eastern Approach to incorporate a comprehensive water management system and to address the deterioration to the stone, brick bearing walls, and the floor structure.

Construction and Layout In total there are four landings interconnected by four flights of steps, each numbered as Flight 1 through 4 from the bottom of the staircase to the top (Figure 16a). Below each landing and flight of steps are unoccupied spaces currently utilized for material storage (limited terra cotta roofing attic stock). These areas are described on pages 18–19.

The Eastern Approach's exterior is constructed with the same Hallowell grey granite as the rest of the Capitol's facades, and is used for all staircase cladding, original landing slabs, stair treads, balustrades, and the

KEY FINDINGS: EASTERN APPROACH

- Masonry damage, distress, and displacement are due to combination of water leakage throughout the staircase and rust jacking of landings due to corrosion. Continued unmanaged water entry will cause further damage and may result in future structural instability. Remediation requires reconstruction of the walking surface and railings with dedicated waterproofing and flashing system.
- Pre-cast concrete shoring is intact and still supports landing and floor structures as intended; however, corroded shims and extensive rust scale have lifted these floor/landing structures by 1 inch or more (Figures 26a–d). The greatest concern for future stability is the Landing 2 balustrade, which is rotated out-of-plane (Figures 29a–b). Remediation requires removal of the shoring and deteriorated decks they support.
- **Most of the brick masonry super structure is intact and functioning; however, supporting walls at Flight 3 are severely deteriorated and bulge, such that the bearing support of Flight 3 tread stones is compromised. Brick masonry must be rebuilt or shored (Figure 6a).**
- Exterior granite exhibits isolated cracks, spalls, and staining, which mar the decorative carvings. Typically the material is sound. Several stones in the arches over the Executive Ramp are spalled and loose. This falling hazard is currently mitigated by the installation of netting, which needs to remain in place until the stone is repaired.
- Several stones are displaced in the arches and vaults above the driveway. Displacement at vaults and arches below Landing 4 are due to differential settlement between the Capitol and Eastern Approach structures; at least a portion of this movement occurred prior to the 1950s stabilization work. Further study is required to determine if this movement is ongoing.

exposed vaults over the driveway. The Landing 1, 2, and 3 walkway surfaces are constructed with deep granite landing slabs (measured at 11 inches thick at Landing 2) (Figure 17a). At Landing 1, the slabs span between two load bearing masonry walls and the undersides are visible from the Lower Basement, where we noted that the underside is unfinished, but relatively planar (Figure 17b). At Landings 2 and 3, the granite rests on a concrete topping and/or mortar setting bed (measured to be 6 inches thick at Landing 2), which is installed over the shored brick jack arch floor system. Flights 1, 2, and 3 are constructed with deep granite treads that bear directly on multiple brick bearing walls (Figure 17c). As with Landing 1, the underside of the flight treads are visible from below, though these stones are rough cut and variable (unlike the landing slabs).

Flight 4 and Landing 4 are constructed over the exposed granite vaults, so the complete structural system is not visible. Based on our limited openings, Landing 4 is constructed, top to bottom, with a 5–3/4 inch reinforced concrete wearing surface, a bituminous built-up waterproofing membrane, a 5–3/4 inch concrete slab with wire reinforcement, intermittent bituminous damp proofing (not found at every opening), a brick jack arch floor system with 12 inch deep beams spanning east-west at 4 feet on center, and a masonry and/or cementitious fill over the granite vaults (Figure 17d). Landing 4 is the only area without a granite surface, as the original stone slabs were removed in the 1950s. No opening was made in Flight 4 to confirm the construction, but based on drawings it is constructed similar to Landing 4.

The Eastern Approach sits on a mat foundation. The original drawings indicate a concrete mat, while the 1950s drawings indicate a granite block mat. We did not confirm the foundation's construction. We did not observe any visible cracks or displacement in the floor or foundation walls that would indicate ongoing settlement or foundation issues. The Sub-Basement floor (and assumed top of foundation) level varies between 6 feet, 9 inches to 9 feet, 9 inches below the relatively level basement floor, indicating the foundation may be stepped rather than the consistent mat shown in the 1950s sections.

There is limited lighting in the enclosed spaces below the staircase. No permanent lighting is available in the Sub-Basement, Lower Basement, or Upper Stair Attic. The lighting in the Upper Basement is intermittent utility lighting that provides marginal light levels. There is a large electrical pull box at the west wall of the basement that connects to electrical service within the Capitol basement; this pull box feeds all lighting on the staircase interior and exterior, as well as exterior flood lighting and irrigation systems in the East Park (Figure 17e).

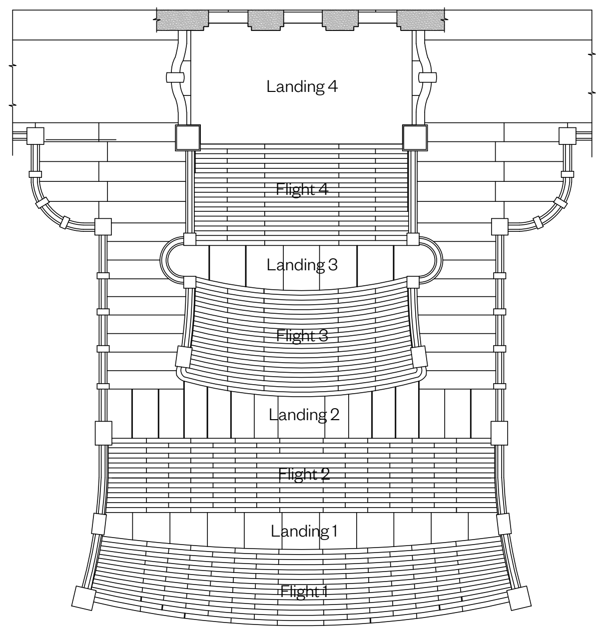
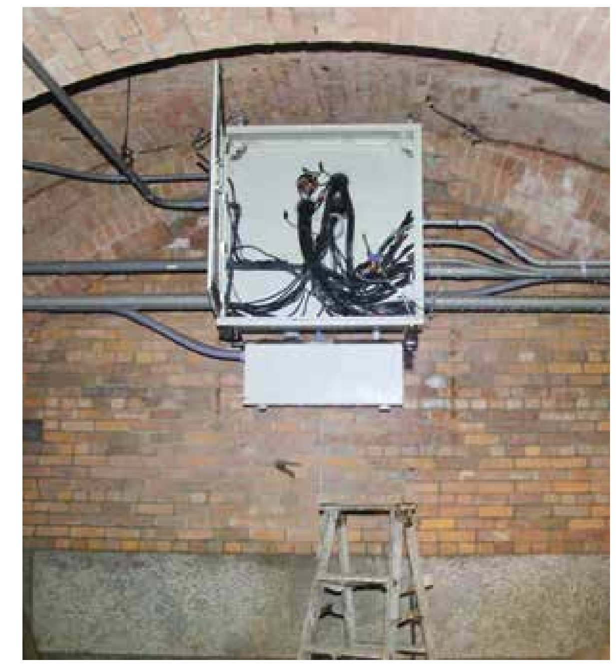
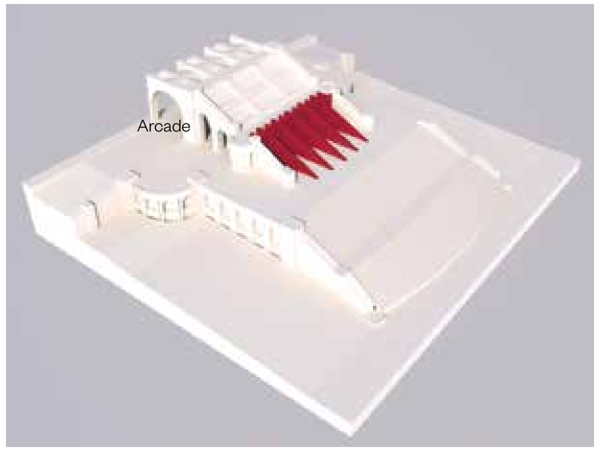


Figure 16a Plan of Eastern Approach (note: north is to the right).

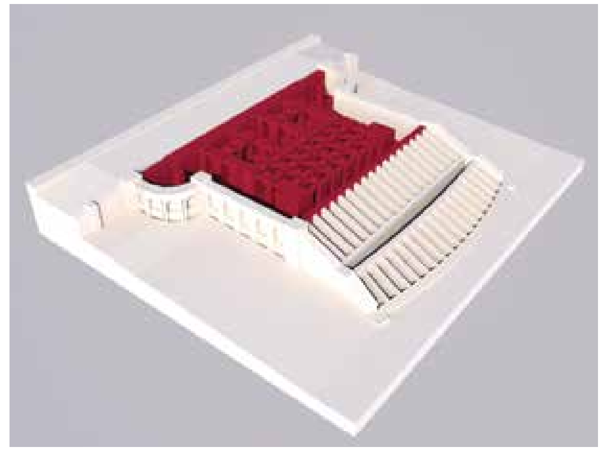


Clockwise from top left:
Figure 17a Balustrade stones removed at Landing 2 to expose edge of massive eleven-inch deep landing stone.
Figure 17b Water stains and rebuilt masonry below Landing 1.
Figure 17c Stone treads supported by brick masonry.
Figure 17d Opening work underway at Landing 4 concrete wearing surface.
Figure 17e Pull box in Upper Basement.

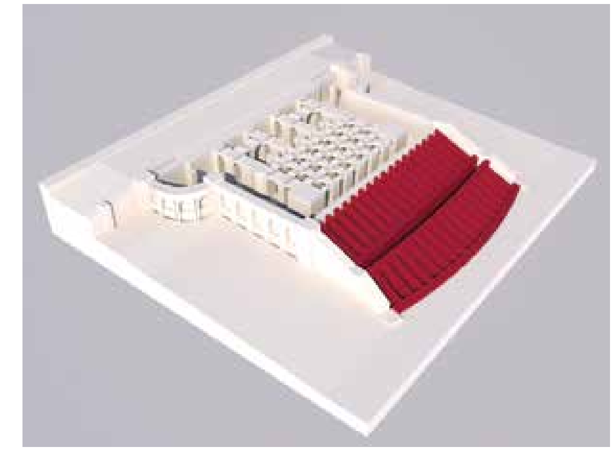


Upper Stair Attic The Upper Stair Attic (approximately 1,500 square feet) is the space below Landing 3 and Flight 3, accessed by a rusted steel door that opens onto the Arcade to the west of this attic. The attic is subdivided by intermittent brick bearing walls and by the precast concrete shoring supporting the brick jack arch floor system (including transfer beams) below Landing 3.

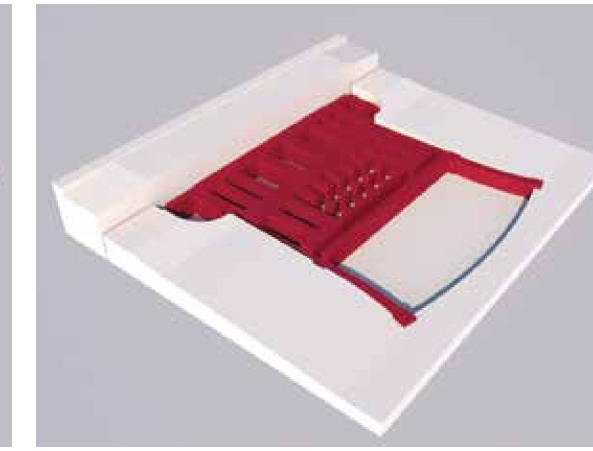
Arcade The open air arcade and drive below Landing 4 and Flight 4 is divided into three bays with granite groin vaults spanning each bay. The largest and western-most set of vaults extends over the Executive Ramp, and connects with the lower floor of the East Portico.



Upper Basement The Upper Basement floor (approximately 6,000 square feet) nearly aligns with the East Capitol Park grade, and its footprint corresponds with the area below Landings 2 and 3 and Flights 3 and 4. The Upper Basement is accessed through infill wood doors on the north and south elevation (not original material). At its center is an array of brick masonry piers, which supports the upper stair structure. The floor is a brick jack arch floor system with a partial concrete topping, shored by precast concrete framing in the Sub-Basement. Precast concrete shoring is also installed at the perimeter of this level to support Landing 2 above. The center core has a brick vault ceiling, with intermittent sandstone accents, suggesting perhaps a more grand original purpose than simple storage. The Upper Basement's north and south exterior walls each have eight arched window openings with wood framed double hung windows with a metal louver in the transom; the current windows are not original and we understand were installed in the mid-1980s. No flashing is visible at these windows and there is some water staining suggesting water leakage.



Lower Basement The Lower Basement (approximately 3,000 square feet) is the area below Landing 1 and Flights 1 and 2. This area is accessed from the Upper Basement level, and consists of two long passageways below Landing 1 and Flight 2, and eighteen discrete chambers below Flight 1 (which are only partially accessible). The Flight 2 corridor has intermittent walls with arched openings. The drawings indicate the lower basement walls extend to the foundation, but this space is partially soil-filled so the foundation is not visible.



Sub-Basement The Sub-Basement (approximately 6,000 square feet) is directly below the Upper Basement, and is subdivided into fifteen discrete below-grade chambers by the main structure's massive load bearing masonry walls. These chambers were originally filled with soil and covered by the basement floor, and thus never intended for access or use, but the soil was removed during the 1950s repairs. All but six chambers are now accessible via concrete capped access holes in the Upper Basement floor; two of the inaccessible chambers can be viewed from interconnecting crawlways (four could not be inspected). The Sub-Basement chambers are riddled with precast concrete shoring that supports the floor above.

Clockwise from top left:

Figure 20a Water stained brick masonry in Upper Basement.

Figure 20b Standing water in sub-basement chamber.

Figure 20c Typical failed sealant joints below Flight 4 balustrade.

Figure 20d Sealant at treads and landings is typically intact.

Figure 20e Exposed waterproofing felt at Landing 4.

Deterioration Due to Leakage Most deterioration relates to the uncontrolled water entry due to the lack of functional waterproofing or flashing system; cracks and open joints in the masonry stair surface and railings; and failures in the storm drainage system. Left unchecked, this water entry will continue to deteriorate and destabilize portions of the staircase structure, leading to further distress and damage to the masonry.

Heavy efflorescence, water staining, and damp masonry is visible throughout the Eastern Approach, and provides evidence as to the extent of leakage into the masonry (Figure 20a). In the Sub-Basement, up to 12 inches of standing water is collected in the perimeter chambers (Figure 20b), likely related to leakage from above and the failed storm water piping. Incidental below-grade leakage may also contribute. Throughout the staircase there are open masonry joints, cracks, and other stone deterioration that allow water entry into the system. Most masonry joints are filled with sealant, which at the balustrade and exterior walls is typically split, crazed, or failed and falling out of the joints (Figure 20c). Sealant at treads and landings (Figure 20d) appears to be a more recent application and is typically intact. In our exploratory openings, we only observed a waterproofing system at Landing 4.

The waterproofing and damp proofing at the Landing 4 openings was typically worn and thin (Figure 22e). At thicker areas of the membrane, typically found at inside corners at the landing perimeter, the membrane was soft and tacky indicating material failure from long-term saturation. There is no drainage path in the system, so water is allowed to pond and saturate the membrane. At the landing perimeter, the waterproofing turns up on the adjacent balustrade, treads, or rising wall and is secured with a copper termination bar; this termination is several inches below the landing surface and is buried by the concrete wearing surface. After more than sixty years in service, the waterproofing system is no longer effective.

All four landings have insufficient slope to drain (due to either initial construction or subsequent settlement); water ponds at the back of the landings and against the upper stair rising walls (Figures 22a–b). Remedial drains installed as part of the 1950s work limit some ponding, but these drains are frequently not at the lowest points of the landing. As a remediation measure at Landing 4, two holes were cored through the north portion of the landing and connected to PVC piping that drains onto the Executive Ramp below (Figure 22c). OGS indicated these "drains" were installed by facility personnel sometime in the last ten to fifteen years, but because of the retrofit construction they do not connect to the sub-surface waterproofing at this landing. As such, they provide some limited relief of surface ponding, but do not drain the waterproofing layer. Water also leaks around the core holes, causing extensive efflorescence staining here.

Failures in the storm drainage system also contribute to the leakage. The flat promenade style drains at the landings are easily covered with leaves and debris, and when clogged they cause substantial water to pond on the landings (Figure 23a). Failed storm piping, most notably below two internal drains at Landing 1, allows water to simply drain onto the basement floor below (Figure 23b). In the Upper Basement, the storm piping is covered with fiberglass insulation and wrapped with heat trace tape; however, the insulation is stained and we observed leakage through a failed cleanout. All storm piping is run to exterior outlets that drain onto the sidewalks directly adjacent to the staircase.

Our water testing results and observations during a rain storm (Figures 23c–d) confirmed the widespread leakage indicated by the extensive water stains and moisture in the basement spaces. We produced leakage through the masonry system at all water tests, observed water pour into the basement from the failed storm drain piping and cleanouts during the storm, and observed seepage through the masonry shortly after the rain.

Water-related masonry deterioration, including freeze-thaw deterioration, is visible throughout the staircase, including missing mortar, isolated displacement or bulges, spalling, and missing brick masonry. In the enclosed

Clockwise from top left:

Figure 22a Water ponding at uneven stones on Landing 2.

Figure 22b Water ponding at Landing 2 rising wall.

Figure 22c Remedial PVC drain piping at underside of Landing 4.

Clockwise from top left:

Figure 23a Water ponding around clogged drain at Landing 1.

Figure 23b Failed storm drainage pipe below Landing 1.

Figure 23c Water test at Landing 2 railing.

Figure 23d Leakage in basement space below water test.

spaces below the stairs and landings, we observed significant deterioration to the top of brick walls supporting the flight and landing stones. Brick below these stones is typically water stained, missing mortar, and often displaced. At our exploratory openings below the Landing 2 floor system, brick could be removed by hand or with hand tools for several courses below, and for multiple wythes into the wall (Figure 24a). **The most significant deterioration is at the north and south side walls below Flight 3, where the innermost wythe is completely failed and bulged away from the wall system. This portion of the wall is in danger of collapse; our opening at this location essentially involved unstacking loose brick by hand** (Figures 24b–24d). At several locations in the Lower Basement, the brickwork below the landing or tread stones has a different brick and mortar color, indicating it was rebuilt (though we found no record of this work), likely due to similar deterioration (Figure 17b).

Freeze-Thaw Deterioration

Ongoing water infiltration will erode mortar joints, causing settlement, loose or bulged bricks, or other distress in this material as setting beds deteriorate or disappear. This deterioration can be compounded when the masonry, concrete, and cementitious fill and setting beds are saturated and regularly subjected to freezing conditions (as is the case in this unheated structure). When these porous and partially saturated materials freeze, the contained water increases in volume as it transitions from water to ice, creating potentially large bursting forces within the pores of the material. Repeated cycles of alternating freezing and thawing can compromise the material's integrity by softening and scaling the affected area. Damage resulting from freezing and thawing typically starts at the surface of the material and progresses inwards as the outermost layers become deteriorated and allow water infiltration deeper into the material.




The Landing 2 balustrade opening exposed the cementitious fill below one edge of the landing stone, and we observed evidence of water saturation and freeze-thaw deterioration within the system (Figure 25a). This fill had deteriorated to a sandy consistency and could be removed with a brush for several inches below the stone; even when relatively solid material was encountered, the fill had striated cracks and a flakey consistency (Figure 25b).

The decorative carved stone is also damaged due to water entry and freeze-thaw deterioration, including spalling and exfoliation (Figure 25c). Previous sandblasting campaigns also likely damaged the stone surface. Most prominently, **the decorative carving on the face of the drive arches below Landing 4 is deteriorated with extensive exfoliation of the granite surface and several loose or missing pieces of spalled stone (we removed one roughly 10 pound piece of loose stone by hand over the north arch)** (Figures 25d–e). These areas are covered with water stains and efflorescence; we observed water seeping from the stone despite no recent rain events. These carved areas are covered with black netting, which we understand was installed roughly fifteen years ago after a piece of stone fell onto the driveway below.

Opposite page, clockwise from top left:
Figure 24a Exploratory opening below Landing 2.
Figure 24b Bulged and unstable brick masonry wall below Flight 3.
Figure 24c Bulged masonry removed by hand.
Figure 24d Bulged interior wythe is several inches out of plane.

Clockwise from top right:
Figure 25a Deteriorated mortar below Landing 2 balustrade.
Figure 25b Cementitious fill below landing stone is friable.
Figure 25c Exfoliated granite at East Portico pier requires resurfacing.





Figure 25d Water staining and spalls on north elevation arch.
Figure 25e Loose spall removed from the location that is noted on Figure 25d.

Clockwise from top left:

Figure 26a Pre-cast shoring below Landing 2.

Figure 26b Corrosion on shoring baseplate and shims.

Figure 26c Damaged pre-cast shoring member.

Figure 26d Open crack below lifted Landing 2 structure.

Deterioration Due To Corrosion The significant water entry is causing widespread corrosion, most significantly at the landing and basement floor systems, but also at incidental anchors and embedded lintels, such as at the straps and through-wall anchors at each Upper Basement window pier. Left unchecked, corrosion will continue and may destabilize portions of the stair structure, though we see no immediate hazards at this time. Eliminating leakage from above will greatly reduce the rate of corrosion; however, some corrosion could continue given the damp environment.

The framing members in the brick jack arch floor systems are corroded at the beam ends (rust scale is visible at exposed portions of these members). The installation of the extensive grillage of 1950s pre-cast concrete shoring was prompted by concerns with the structural stability of these corroded beams. Much of the reported 1950s landing settlement and displacement at adjacent walls could be attributed to the corrosion and resultant section loss and weakening of these members.

Corrosion

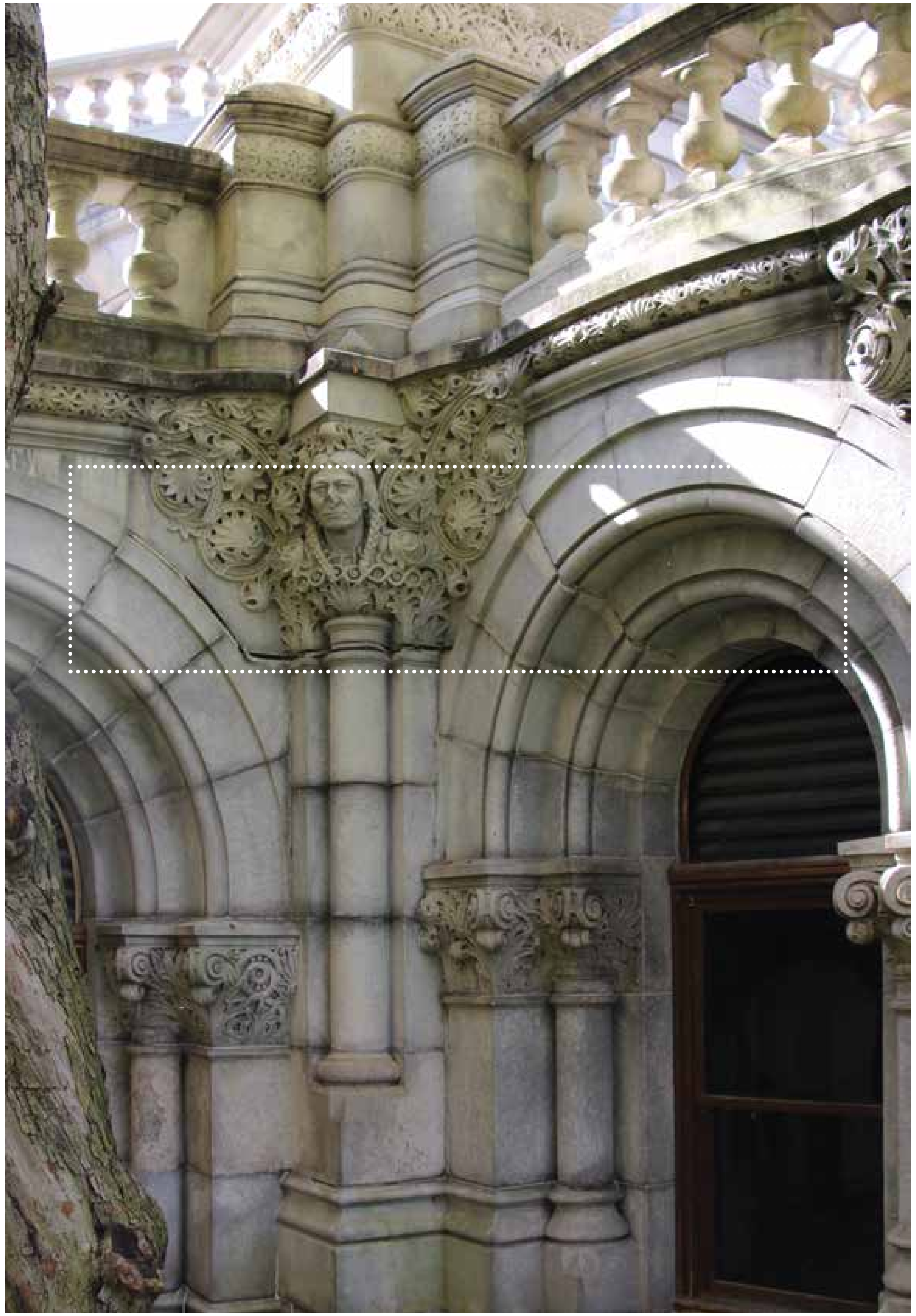
Ferrous metals, such as the original beams and the 1950s steel shims, will corrode when exposed to water and oxygen. Corrosion is a chemical reaction creating iron oxide, or rust. This resultant rust product, or scale, is brittle and reduces member's strength. This rust scale is also destructive because it is several times larger than the original material it consumed, resulting in expansive forces on adjacent materials when constrained. Given a continuous source of water and oxygen, ferrous elements will continue to rust and expand until all original material is consumed. In fact the rate of corrosion accelerates with time because the corrosion creates a greater surface area, which is exposed to further corrosion. Corrosion is not possible without a water source, so strategies to slow corrosion typically focus on mechanisms to control water entry.

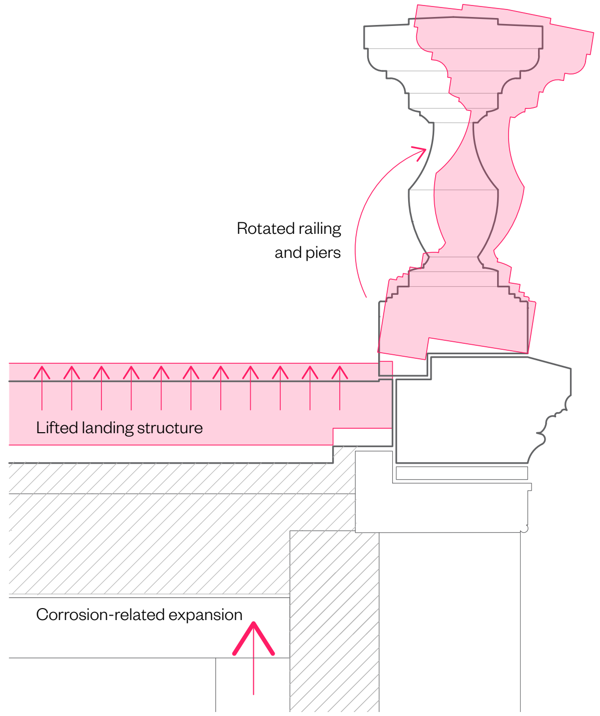
We could not verify the complete condition of the original beams. Based on the limited exposed conditions observed, the few interior openings, and the fact that comprehensive pre-cast shoring was installed in the 1950s, we would not expect the original landing and basement floor structures to function without the pre-cast or a similar shoring method in place.

Components of the pre-cast concrete shoring system are now corroding as well. The shoring consists of a pre-cast concrete cap beam located below each original floor beam, which is held in place by two pre-cast columns supported on a pre-cast sill beam. Steel baseplates and wedge shims were used between the column and sill beam to field fit the pre-cast tight to the underside of the brick jack arch floor system. These baseplates and shims typically have extensive rust scale (Figures 26a–b). The pre-cast units themselves are generally intact, though many are cracked (Figure 26c) or spalling due to corroding reinforcement (89 of 133 units at the basement level have some damage; we did not comprehensively survey each sub-basement unit's condition).

In the masonry walls below Landing 2, the bed joint aligned with the bottom flange of the jack arch floor beams is consistently cracked, open, and visibly larger (Figure 26d) than other joints (roughly 1 inch wide, though it varies somewhat along the length).

Figure 28a Displaced stones and large open exterior joint below lifted Landing 2 structure.





Clockwise from top left:

Figure 29a Landing 2 balustrade rotation mechanism.

Figure 29b Rotated Landing 2 balustrade.

Figure 29c Landing 2 balustrade piers and railing stones are keyed together.

On the exterior, there are large open joints along the top portion of the granite stair walls (Figure 28a) that roughly correspond with the location of the interior open joint. This damage is linked to the corrosion-related expansion of the embedded floor beams and precast concrete shims, which is lifting the floor upward. This is also causing rotation of the Landing 2 balustrade (Figures 29a–b), which partially rests on the Landing 2 slabs. **Portions of the balustrade are rotated up to 4.3 degrees out-of-plane. RSA calculated that at a 9 degrees displacement, the balustrade is no longer able to support the code-required railing loads and at a 10 degrees displacement, it becomes unstable and unable to support its own weight.**

While the balustrade is currently several degrees away from these benchmark rotations, we note that corrosion expansion is not linear and rates of corrosion accelerate with time, so that the continued rate of rotation will correspondingly accelerate. In addition to these safety concerns, the differential rotation along the length of the balustrade is causing cracks and spalls, typically where pier and balustrade components are keyed together (Figure 29c).

Structural Analysis—Eastern Approach

RSA completed a structural analysis of the staircase superstructure that focused on the masonry vaults in the Arcade and Upper Basement, and on the brick jack arch floor systems below other landings. The findings discovered that:

» The structure is stable and has sufficient capacity to support existing dead loads and contemporary code-required live loads.

» Structural damage observed is the result of long-term exposure to water, deterioration or materials from freeze-thaw cycling, rust jacking of the floor system and shoring, and other modes of moisture-related deterioration, not inadequate structural design.

» The upper stair vault structure is only moderately loaded in relation to its calculated capacity and the static structural analysis of this area does not provide any obvious mechanism for the isolated stone displacement observed in the arches and vaults stones below.

Deterioration Due To Settlement A previous hypothesis for the Eastern Approach deterioration was foundation movement; however, in the Sub-Basement we did not observe any apparent displacement or, unevenness in the top of the structure's mat foundation nor did we observe any cracks or distress in the basement walls that would indicate localized foundation movement. Relative movement between the Eastern Approach and the Capitol could not be observed at the foundation level, as the two structures are separated by the Executive Ramp (see further discussion on Arcade below). Consistent cracking was observed at the centerline of the arched openings in the supporting walls below Flight 2, but these are typically hairline and related to small differential thermal or moisture movement.

Previous soil borings and analysis performed in the East Capitol Park indicated the subsurface conditions consist of 5 to 8 feet of miscellaneous fill (clayey silt) over native soil consisting of varved clay and silt. Groundwater was not encountered in any test boring. The analysis recommended 3,200 pound per square foot soil capacity, but noted the clay may be soft with very limited capacity in isolated areas. The Eastern Approach's massive mat foundation is appropriate to distribute the structure's loads across this variable soil type, though there could be some localized distress if a large soft clay area is present. This is consistent with our findings; no localized distress was observed.

CES completed a level survey, providing elevations at every stair tread joint, at each corner of the rectangular landing slabs, and at a 10 foot on-center grid on the Landing 4 concrete surface, to determine if there was gross notable displacement compared to the 1950s drawings. No appreciable global settlement was noted. Landing 2 had a notable increase in elevation (1 to 2 inches), as does the east edge of Landing 3 (0.5 to 1 inch); these movements are consistent with the rust jacking of the floor system as discussed above. It was not possible to compare elevation points across Landing 4, as the original stone landing was replaced with the concrete surface. We did note that where the Landing 4 abuts the East Portico, the landing surface is approximately 1 inch below the portico floor; a cementitious fillet is installed to prevent the step from being a tripping hazard. The fillet is not integral with the landing concrete, and is perhaps installed to address either an original construction tolerance issue, or subsequent settlement or differential movement that has occurred between these two areas.

Stone Damage We catalogued all of the damage observed and compared it to the damage noted on the 1950s documents. Below is a summary of some of the catalogued damage:

- Treads Stones: 79 of approximately 390 stair tread stones are cracked (Figure 31a); the majority of these cracks (87 percent) were shown on the 1950s drawings and thus occurred prior to 1952. Other than cracks, the granite treads are typically intact and in good condition with limited wear.
- Landings Stones: 8 of 74 landing stones are cracked (Figure 31b). Seven of these cracks are large apparent through-cracks in Landing 2 stones adjacent to the upper stair structure; the eighth is a small corner crack where a Landing 2 stone abuts the south railing. These existing cracks are not shown on the 1950s drawings and all appear to be due to distress caused by the jacking of this landing level due to the corrosion issues discussed above. The 1950s drawings do show three other cracked landing stones, all of which were either partially replaced or repaired. Other than cracks, the granite landing stones are typically intact and in good condition with limited wear.
- Stair Walls and Balustrade: The granite cladding on these walls is generally intact, though we observed approximately 36 stones with spalls or failing patches, 33 cracked stones, and 42 displaced stones – most of this distress is located near the top of the wall or within the balustrade bases and piers (Figure 31c).

Code Compliance

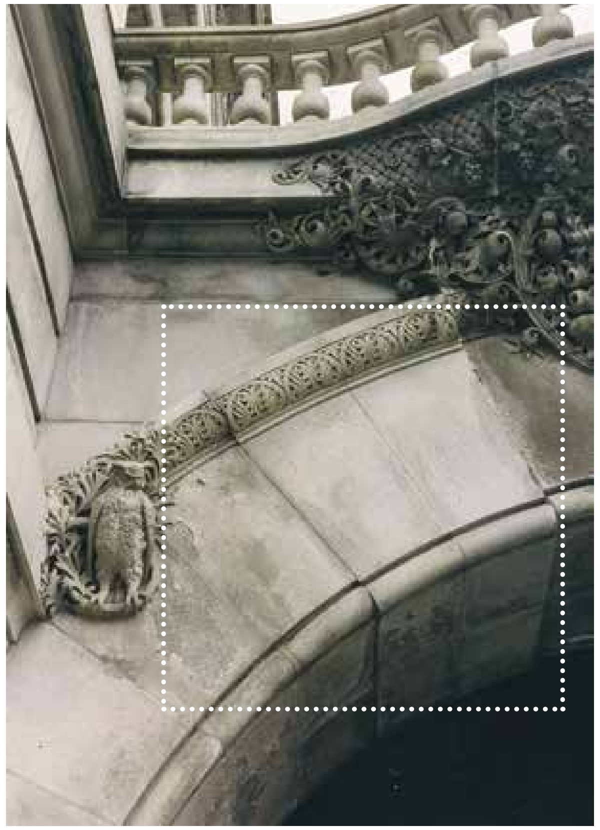
The existing stair tread rises and runs meet New York State Building Code requirements; however, the vertical rise between landings and extent of handrails do not meet contemporary code requirements. Because the Eastern Approach is part of the historic New York State Capitol structure, this staircase can be exempted from these code requirements and repair approaches do not include any consideration to upgrade stair to contemporary building code requirements.

Clockwise from top left:

Figure 31a Typical cracked tread stones at Flight 4.

Figure 31b Cracked Landing 2 stones at interface with Flight 3.

Figure 31c Typical balustrade crack at Flight 1.



Clockwise from top right:

Figure 32a Current displacement observed at south elevation.

Figure 32b Eastern Approach's south elevation circa 1954.

Figure 32c Displaced arch stones circa 1997.

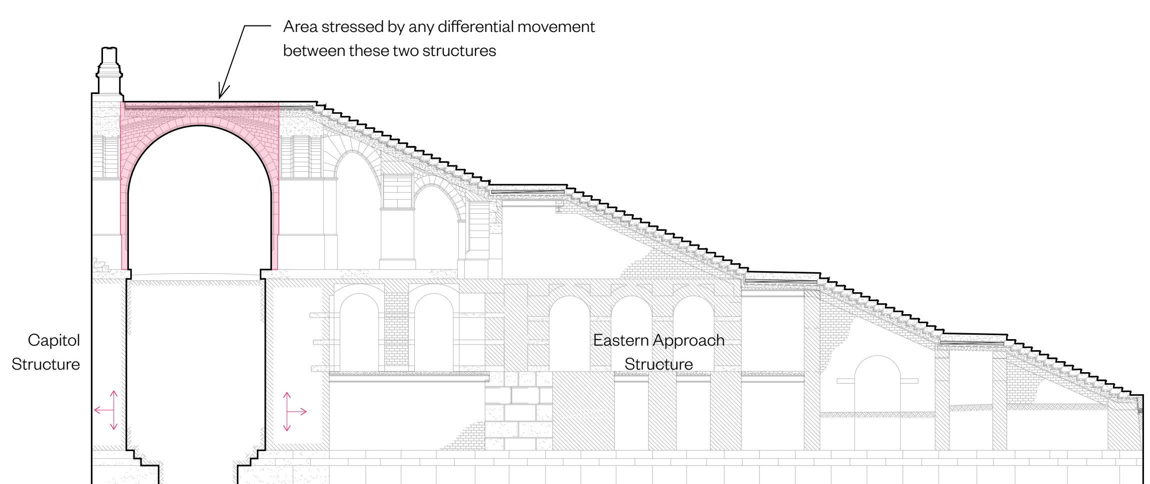


Figure 32d Capitol and Eastern Approach structures connected only by narrow Landing 4 span.

Arcade Vaults There are five areas of displaced granite in the vaults and arches of the Arcade, the most noticeable of which are two stones in both the north and south archways (Figure 32a). This displacement is symmetrical about the staircase, though the south arch stones have greater displacement (roughly 2 inches out of original position). This displacement is not clearly visible in historic photos (Figure 32b) or explicitly noted in the 1950s drawings (these drawings do note "open joints" at the location of the two displaced arch stones). When compared to photographs taken during our 1997 inspection this condition appears relatively unchanged (Figure 32c). This is the only significant area of distress that is not directly attributable to leakage or rust jacking, though water infiltration may worsen these conditions. Based on RSA's structural analysis, the displacement is not due to any deficiency in the masonry's designed configuration.

Our conclusion is that the vault and arch displacement is due to previous, but potentially ongoing, differential movement between the separate Capitol and Eastern Approach structures. Ongoing water infiltration in this area exacerbates the displacement by deteriorating mortar joints, which allows the arch stones to slide downward. We believe that differential movement is possible because both the original stair drawings and 1950s drawings show the Eastern Approach structure with an independent mat foundation separated from the Capitol's foundation by the Executive Ramp (Figure 32d). While we could not verify either of these structures' foundation condition or configuration in the field, this arrangement makes sense given that the Eastern Approach was constructed decades after the Capitol's foundation had been laid. As such, the only connection between these two massive masonry structures is the relatively narrow bridge formed by Landing 4 and the granite vaults below.

It is unclear when this displacement occurred or its rate of occurrence. The specific cause and magnitude of the differential movement cannot be identified without a long-term study to measure. Reasons for the differential movement may be soil settlement or seismic events. The conclusion of differential movement is supported by the following evidence:

- There are previously documented settlement issues with the Capitol's southeast quadrant; RSA's March 2004 Structural Survey and Analysis Report notes that "the Capitol's southeast corner is more than 5 inches lower than the other three" corners. This correlates to the greater displacements observed on the southern portions of the Eastern Approach.
- While the magnitude varies, the displacement is consistent across the full width of the staircase's connection to the building. This indicates global movement rather than localized distress within the vault.
- The vertically displaced arch stones indicate a loss of compression in the arch, allowing these wedged stones to slide downwards. In a load bearing masonry arch, the only ways to lose compression are widening the arch, or lifting or lowering one side of the arch. These two conditions require lateral or vertical movement, respectively, of one or both of the two structures on either side of the arch.
- Upstate New York is not an earthquake-prone region, but there are regular small to moderate earthquakes in the upstate area. Heavy and unreinforced structures, such as the Capitol and Eastern Approach, can experience movement from even small seismic loading.

The magnitude of the movement to date has not undermined the structural performance of the vaults, and further deterioration will likely be limited by managing water entry from above. We recommend continued monitoring to gauge if further displacement is occurring over time.

Repair Remediations The only way to reliably prevent water infiltration through masonry in horizontal applications, without altering the appearance, is to provide a dedicated waterproofing or flashing system below the stone. In concept, this is similar to the approach taken at Landing 4 more than sixty years ago; however, the existing stone landing slabs should be reinstalled to maintain the historic fabric and staircase appearance, and the waterproofing system should include a means of membrane-level drainage to greatly increase the durability and lifespan of the waterproofing membrane used.

The staircase substructure is generally intact, so to provide a waterproofing system we propose removal of all stair balustrades and wearing surfaces; removal of deteriorated landing brick jack arch floor systems and pre-cast concrete shoring below; new structural decks at all locations, and installation of a new continuous waterproofing system over the entire staircase (Figures 36a and 37a–b). Waterproofing will be drained via internal drains and storm piping to limit saturation of the masonry and buried waterproofing materials.

Proposed Waterproofing System

For pricing, we selected a hot rubberized asphalt waterproofing system. These systems have a long-track record of successful performance in buried applications and have the most flexibility to work around unique geometries and various stone anchors. The system is also cost effective. This system is commonly used and relatively simple to install, though it is workmanship sensitive, and the installation needs to be carefully monitored and contractor pre-qualifications built into repair documents to ensure a quality product. To improve the membrane's long term performance, the design also incorporates a sloped deck at the waterproofing level and the inclusion of a drainage mat immediately above. To provide a level surface for the granite landing slabs, a no-fines concrete layer is included above the waterproofing and drainage mat. No-fines concrete is a concrete made without fine aggregate, and is designed to have large void spaces to allow water to permeate through it. The stones can then be set on a discrete mortar bed above (Figure 34a).

The existing granite is generally in good condition so it can be salvaged and reinstalled on top of the new waterproofing system. We also recommend providing replacement granite for Landing 4 to increase the wearing surface's durability and restore the historic appearance. While the massive landing stones and staircase configuration are unique, this buried waterproofing approach is similar in concept both to contemporary plaza systems and the large-scale rehabilitation work already performed on the Capitol's stone towers and other roof areas.

Without the Upper Basement level pre-cast shoring, the Sub-Basement shoring does not appear to be a major cause of distress within the structure; however, left unchecked the shoring's shims will continue to corrode, causing stress or possible destabilization of basement floor areas. Assuming the basement is to remain accessible, or be used for any purpose, we recommend removing the basement floors and all associated Sub-Basement pre-cast shoring and providing a new floor structure over these Sub-Basement vaults.

The current repair scheme does not include resetting the displaced vault and arch stones in the Arcade (Figures 35a–b). Resetting these stones would require near reconstruction of the vaults, a major investment for a condition where we cannot confirm if ongoing displacement has halted, and which is currently structurally stable unless there is substantial additional displacement. Assuming that the stone movement is primarily caused by differential movement between the structures, the only way to address the movement between the massive Capitol and Eastern Approach, and thus prevent future stone displacement, is to reconstruct the foundations to provide continuity between them. We would recommend long-term study to confirm the deterioration mechanism before such repairs are implemented. We are not recommending rebuilding the displaced stones and the current scope at these areas is to point joints and leave these displaced stones in their current configuration. Crack gauges should be installed to track movement across these displaced areas; it may take years or decades to show any appreciable movement (as evidenced by the limited change at displaced arch stones between 1997 and 2013).

Figure 34a Typical hot-rubberized asphalt installation.

To complete the work above and based on discussions with OGS, our repair set also includes the following periphery items for pricing. Refer also to the Repair Scope Summary and Estimate section on page 49.

- Repair of all the currently spalled, cracked, or missing granite components. Stone repairs will strive to match the existing appearance; however, we note that even the best repairs using salvaged stone will be visible and not initially match the existing stone appearance, which is the result of more than one hundred years of weather and soiling
- Clean masonry to remove general soiling and heavy rust and efflorescence stains
- Point all exterior masonry joints.
- Replace existing failed storm drainage.
- Replace all windows, louvered transoms, and doors, with new wood windows, glass transoms, and doors to match the original.
- Provide a concrete topping throughout the Upper Basement to provide a level walking or storage surface and install new ladders to allow safe access between basement levels. Provide new utility lighting within accessible basement areas to aide future access and storm drainage maintenance.
- Provide custom metal gates or railings at Landing 2 to limit public access into the restricted Executive Ramp area (Figure 35c).

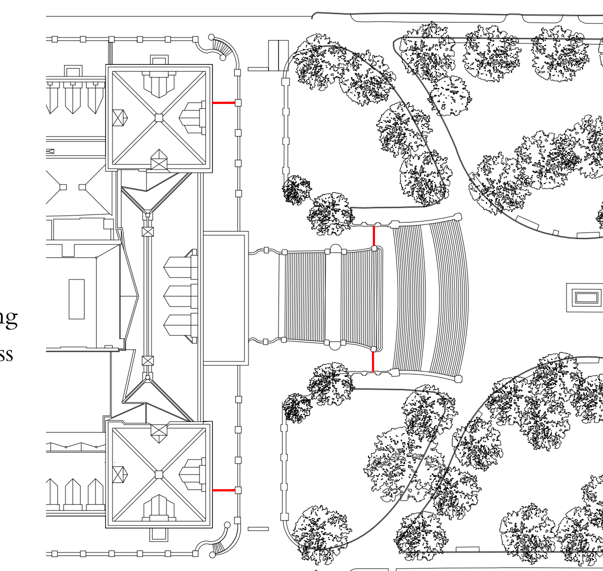


Figure 35a Displaced arch stones at south elevation.

Figure 35b Displaced vault adjacent to arch displacement shown in previous figure.

Figure 35c Site plan of proposed gate locations (in red).

Figure 36a Extent of structure to remaining after proposed removal work.

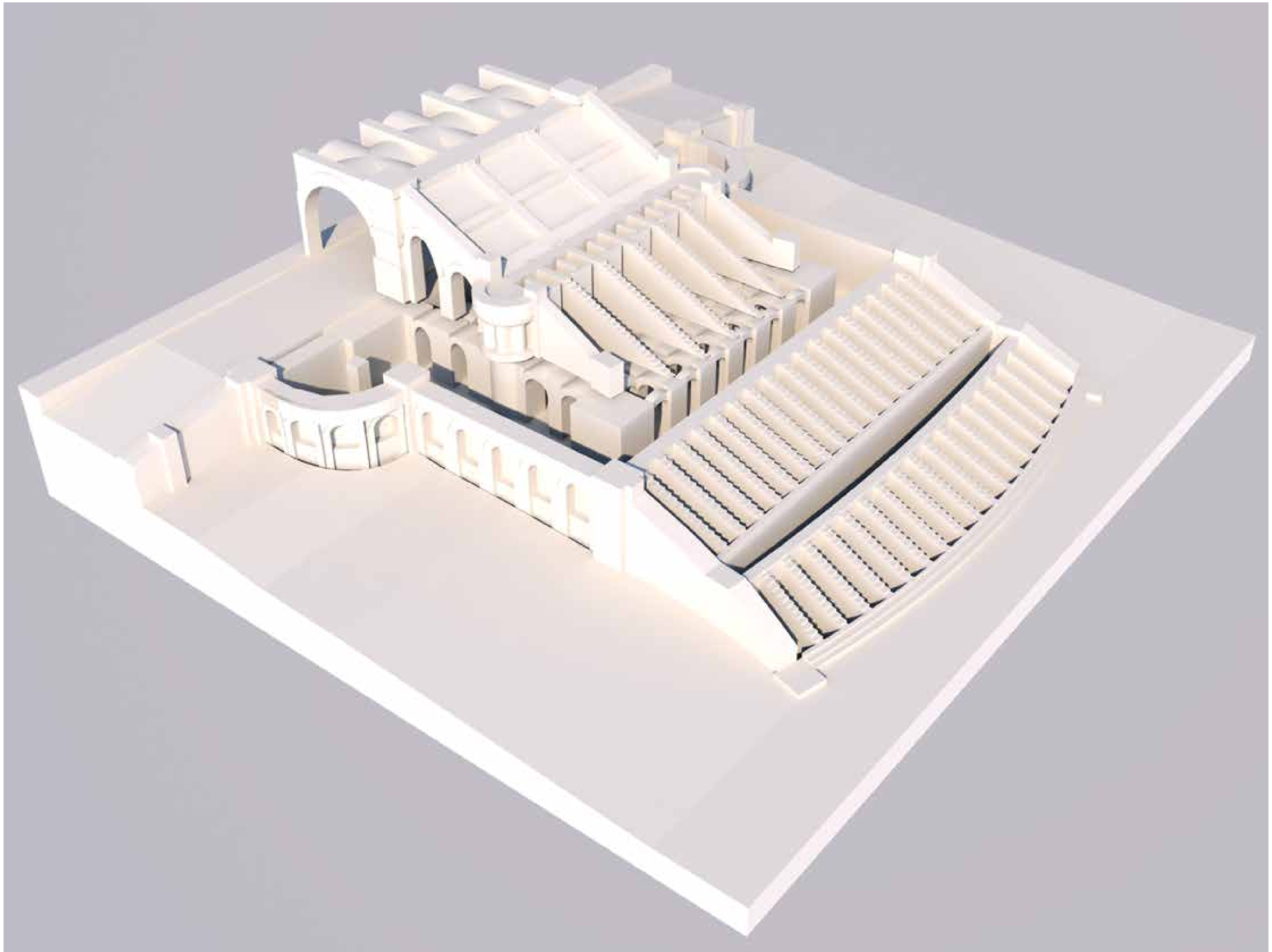
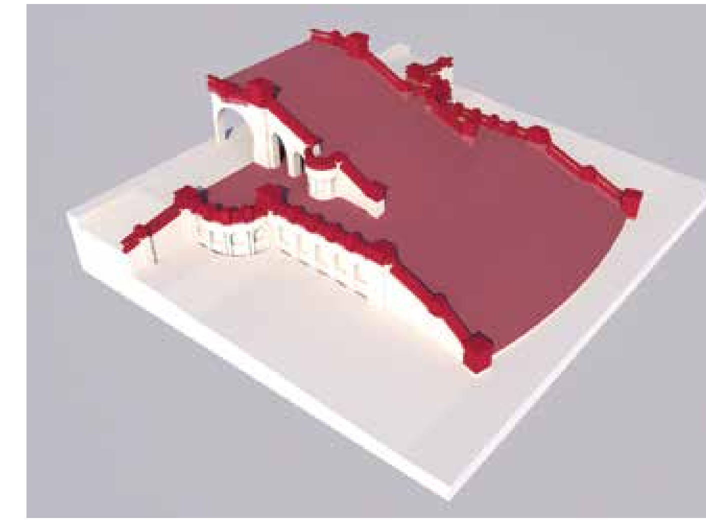
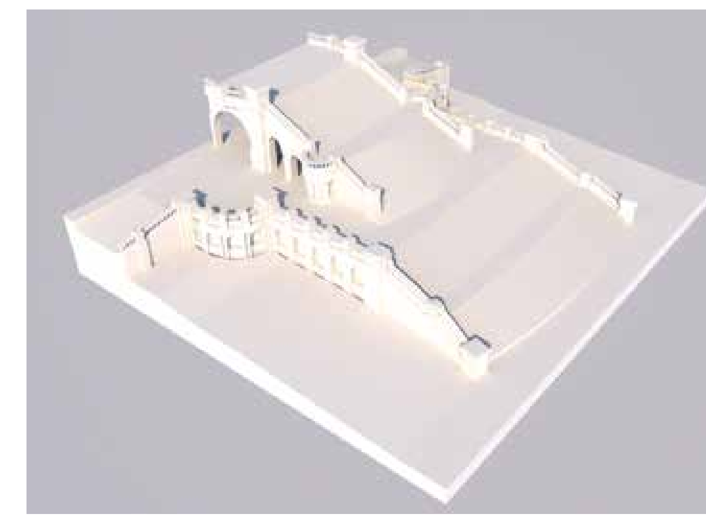


Figure 37a Extent of proposed waterproofing and flashing work.
Figure 37b Completed work will restore Eastern Approach to original appearance.





Executive Ramp

The Executive Ramp is an approximately 300 foot long, ramped driveway connecting Washington Avenue and State Street, and running below the upper portion of the Eastern Approach (Figure 39a). The west edge of the ramp abuts the Eastern Promenade masonry walls. Granite masonry retaining walls with granite balustrades, which connect with the lower Eastern Approach walls, bound the east edge of the ramp (Figure 39b). The drive surface is a 4.5-inch, reinforced concrete slab on grade, with a granite curb separating the drive surface from the retaining wall. All retaining wall and curb joints are filled with sealant, which is typically split, crazed or failed.

Immediately below the drive surface is a 1.5-inch gravel sub-base. The soil below is a moist, grayish brown sand and gravel material with very little fines and moderate drainage properties. The soil abuts the retaining wall, which lacks any dedicated drainage system or damp proofing to limit ground water infiltration into the wall (Figure 39c).

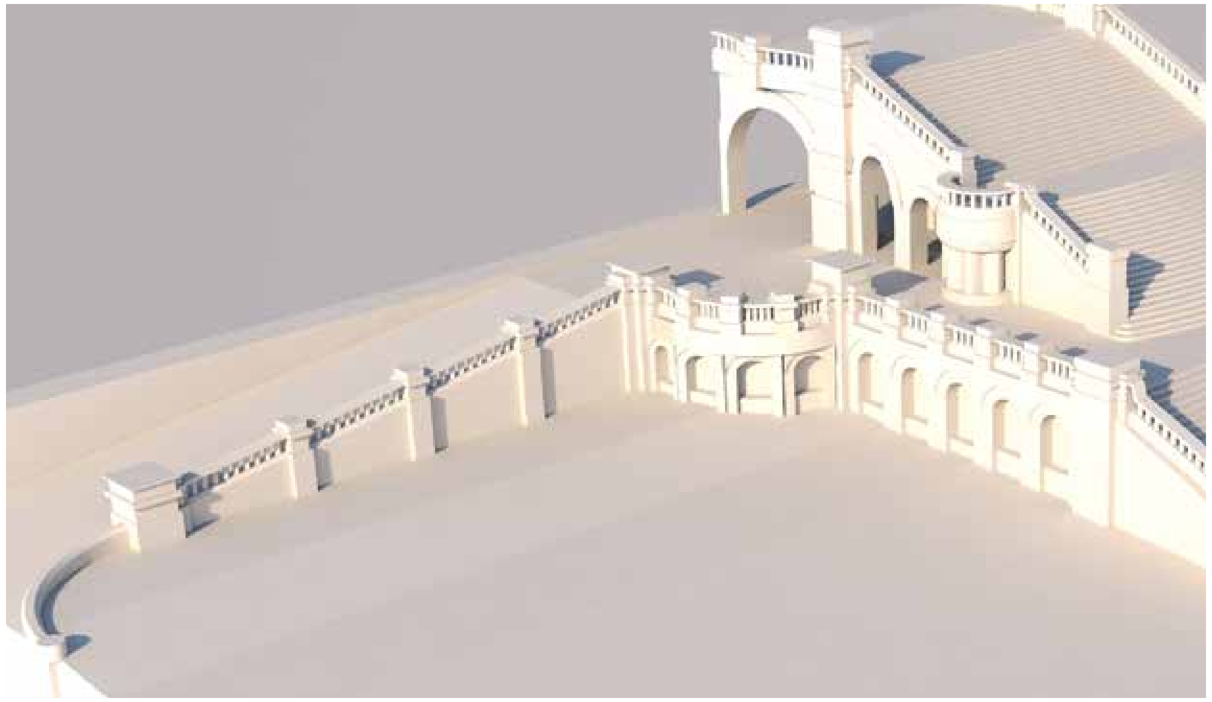
Snow Melting Systems

Hydronic snowmelt systems circulate heated glycol or water through tubing embedded in the slab; these systems can use the Capitol's existing high pressure steam system as their heat source. Electric snowmelt systems use electrical wires embedded in the slab to emit heat. Electric snow melt systems are often less costly to install than hydronic systems, but are typically much more costly to operate, which is why a hydronic system was selected for pricing. The class rating for the system relates to the heat output for the system: Class 1 systems may allow some snow buildup during extreme snow or low temperature conditions, while Class 3 systems melt all snow and keep the heated surface dry, but require a much greater amount of heat (and cost) to operate. We selected a Class 2 system as it should melt all of the snow under typical conditions, but not expend additional energy to dry the surface.

At each end of the ramp is an operable security gate set on a raised concrete curb (Figure 39d). The Washington Avenue entrance also has a guard booth on a raised concrete curb. These are all recent construction and in good condition. All repairs will need to preserve and maintain the gate and guard booth operability throughout construction (thus accommodating the services that run below the drive). The State has also stipulated that a portion of the drive must remain operable at all times, and thus designs need to include phasing and soil shoring.

The Executive Ramp is aged with deterioration at the drive surface, curb and retaining wall. Deterioration relates to water infiltration, freeze/thaw cycling, and general use. Recommended repairs include rebuilding portions of the retaining wall and replacing the drive surface, incorporating a snow melt system. Deterioration and recommended repairs are discussed in more detail below.

Retaining Walls and Curbs Water enters the masonry retaining walls through failed sealant in stone joints and from ground water in the poorly drained soil below the drive surface. This water entry is causing stone damage, including rotation of the granite balustrade due to general mortar joint deterioration and freeze-thaw jacking and ratcheting due to ice lenses in the horizontal bed joints (upper portion of piers have rotated outward toward the East Capitol Park by roughly three degrees, typically the point of rotation aligns with the driveway level) (Figures 39b and 41a). This ratcheting occurs when collected water freezes and expands, causing the masonry to lift incrementally. As the ice melts, debris partially fills the joint and prevents the stone from settling back into place. This repetitive process accelerates with time, as the displaced stones allow more water entry. In addition, the displacement results in localized stress due to differential movement, which is causing cracks and spalls in isolated balustrade and wall stones.



Clockwise from top left:

Figure 39a Executive Ramp and tie-in to Eastern Approach.

Figure 39b South retaining wall with outwardly rotated piers.

Figure 39c Executive Ramp exploratory opening.

Figure 39d Guard booth and gate at Washington Avenue entry.

At the upper (approximately 12 feet tall) wall section, the retaining wall stones are horizontally displaced a few feet above the East Capitol Park grade (Figure 41a). We performed a structural analysis at this location, conservatively assuming saturated soil for the highest soil pressure. We assumed saturated soil because the deteriorated joints and damaged stone in the curb and balustrade above likely allow significant water entry into the soil below, which lacks a drainage system to manage this water. Our analysis indicates that under this conservative load, and not accounting for restraint due to the integration with the adjacent Eastern Approach walls, **soil pressure exceeds the retaining wall's calculated capacity and the depth of overloading correlates with the noted horizontal displacement.**

At the ramp, we recommend disassembling and reconstructing the displaced or rotated portions of the retaining wall and the balustrade. The reconstructed wall will incorporate stainless steel pins to prevent movement between courses and damp proofing and soil drainage along the backside of the wall to both limit soil pressures and water deterioration of the wall. Similar to the Eastern Approach, the existing masonry will be repaired and cleaned (Figure 41b). Flashing will also be incorporated into the base of the balustrade to limit water entry. Reconstructing the retaining wall and related backside excavation requires partial removal of the driveway slab.

Curb stones are typically covered with linear rust stains, indicating scraping (and possible displacement) from plowing or snow removal (Figure 41c). Aggressively plowing against these unreinforced retaining walls and curbs increases the displacement. A snow melt system is recommended to limit maintenance and potential related deterioration.

Drive Surface The concrete drive surface is in poor condition with cracks, extensive patch areas, and regular surface wear. Surface deterioration is indicative of freeze-thaw damage, and is compounded by plowing and salting of the drive surface (Figure 41d). Given its poor condition and the partial removal required to complete the retaining wall work, we recommend replacing the entire drive surface.

A snow melting system within the drive surface will limit salting and plowing concerns. For pricing, we have assumed a Class 2 hydronic snow melt system; this system will utilize existing heat and electrical sources within the Capitol basement. A snow melt system will perform best when installed in a new concrete drive slab. If the snow melt option is not selected in the final design, we would recommend installing a concrete sub-paving slab and paving the drive with asphalt, which is more durable if plowing and salting continue.

KEY FINDINGS EASTERN APPROACH

- Ramp retaining walls are displaced and rotated away from the drive due to saturated soil loads and freeze-thaw ratcheting. Partial rebuild of the wall is recommended with flashing, damp proofing and drainage to limit future water entry.
- The drive surface is aged and deteriorated, and will need to be partially removed to complete retaining wall work. Full replacement is recommended, including the incorporation of a snow melt system to limit plowing and salting that can decrease the drive surface durability.

Clockwise from top left:

Figure 41a Outwardly displaced retaining wall stones.

Figure 41b Cracked balustrade stones require repair.

Figure 41c Rust stained and displaced granite curbs along drive surface.

Figure 41d Drive surface is deteriorated with extensive patch areas.

Eastern Promenades

The Eastern Promenades consist of two roughly symmetrical, elevated pedestrian walkways that connect the North, South, and East Porticos. The promenades are constructed with exterior granite-clad reinforced concrete walls and a reinforced concrete slab that spans between concrete encased steel beams that bear on the Capitol's main exterior walls and the reinforced concrete walls (Figure 43a). The decks have no waterproofing system incorporated, and rely on surface drainage to internal drains in the concrete deck. Each promenade has a perimeter granite balustrade. Below each promenade is an unused crawl space that has limited electrical and storm piping to service the deck drains, historic lights on balustrade above, and utility lighting. The crawl space is accessed through a limited number of doors and the Capitol basement window well grates built into the deck. The crawl space is vented through grates in the exterior walls. Both promenades are similarly constructed and the configuration closely matches the 1960s rehabilitation drawings.

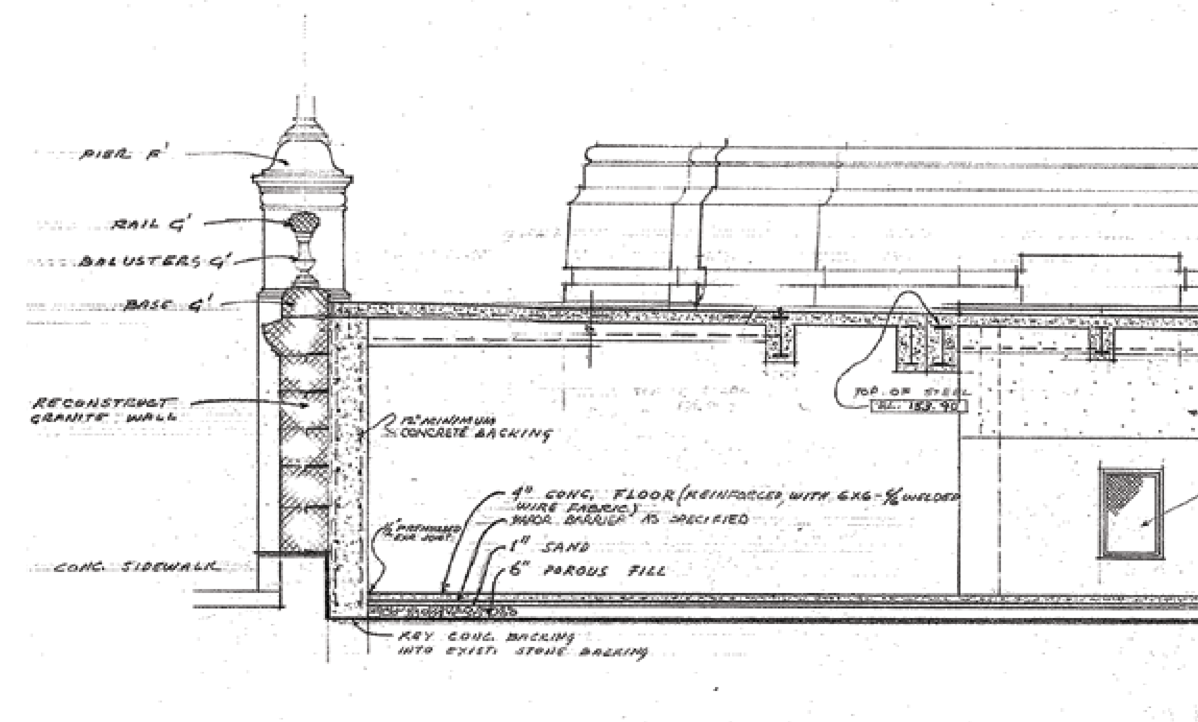
Structural Analysis—Promenade

RSA performed analysis of the promenade decks based on the structural system shown in the 1960s drawings and conservative concrete material assumptions (confirming concrete properties, as-built reinforcement layout, or as-built encased beam size/condition was beyond the scope of this current study). The structural analysis indicates the capacity of the promenade decks substantially exceeds code required loads. These decks were perhaps oversized in design to accommodate loads from scaffold or other heavy access equipment needed to access the Capitol facade and roofs above (such as the scaffold system used in the recent roof restoration project which sat on these decks).

The Eastern Promenades are in serviceable condition with isolated damage to the concrete decks and walls, and granite cladding and balustrade (Figures 44a–d). Significant efflorescence and rust staining on the interior and exterior of the walls and on the underside of the deck slab indicate substantial water entry through deck deterioration (cracks, surface wear, and spalls at exposed form remnants cast into the deck); poor drain integration; deteriorated mortar joints; and failed sealants in the balustrade, control joints, and perimeter conditions (daylight is visible through control and perimeter joints). This water entry is causing the isolated damage due to freeze/thaw deterioration of the concrete and corrosion of embedded reinforcement and encased beams. Adding to the problem is the use of deicing salts, which can chemically modify the concrete and accelerate corrosion. The inadequate slope-to-drain of the concrete deck also allows water to pond on the concrete surface, accelerating deterioration.

Both freeze-thaw damage and corrosion of embedded steel can be arrested by limiting water infiltration into the system. At the deck, this is most efficiently done by repairing the existing deck surface and providing a waterproof traffic coating over the promenade decks. A traffic coating will have a minor impact on the deck's appearance and will require periodic maintenance or reapplication, but a durable coating can provide decades of service at a fraction of the cost of reconstructing these decks. Because of the complex geometry at the balustrade, a more invasive approach is necessary to reliably stop water leakage through both the granite masonry and the perimeter transition joint. The installation of a flashing below the balustrade base provides a durable water management solution, which is consistent with similar flashing work performed elsewhere on the building. Flashing installation requires removal and reinstallation of the granite balustrade. Once water is controlled, the heavy staining that mars the perimeter walls can be cleaned and masonry joints pointed.

Figure 43a Construction drawing of current promenade configuration.



The promenades are reached by staircases at the northeast and southeast corners and from each portico landing. The general public can only access the north and south portions of the promenades; access to the east areas is discouraged by a chain draped across the promenades. Based on discussions with OGS, we have budgeted to replace these chains with decorative custom metal gates sympathetic to the design of the Capitol. In addition, we included scope for periphery items such as replacement of the existing pre-cast concrete benches with new architecturally appropriate metal benches and replacement of the aged, bent, and deteriorating painted steel grates and doors at window wells and crawl space entrances.

KEY FINDINGS EASTERN PROMENADES

- The concrete decks are generally intact and structurally sound, but ongoing leakage has caused surface deterioration and isolated spalls/deterioration at the underside that requires repair.
- Perimeter masonry walls are intact, but heavily stained, and require extensive cleaning.
- Long-term repairs require addressing the Promenade's lack of any dedicated flashing or waterproofing system. Reconstruction of the balustrade to include a flashing and application of a deck coating are designed to address.

Steel Corrosion in Concrete

Steel embedded in concrete is protected from corrosion by concrete's alkaline environment. This protection is lost over time as concrete loses its alkalinity due to carbonation (a slow-occurring chemical reaction between the concrete and the environment) or when it is destabilized by the presence of chloride ions. The chlorides can enter the concrete either through direct application (such as the use of de-icing salts) or by being mixed into the original concrete mix (to accelerate the setting time for the concrete as an aid in cold-weather construction). Material sampling to determine depth of carbonation and chloride content was beyond the scope of this study; however, we observed isolated locations within the promenade crawl space where reinforcement has corroded and caused spalls at the concrete surface. This corrosion indicates some the loss of alkaline protection is already advancing.

Clockwise from top:

Figure 44a Staining on promenade exterior walls.

Figure 44b Staining and deterioration below promenade decks.

Figure 44c Leakage observed at water testing location.

Figure 44d North promenade deck and barricades.

East Portico

The three-story, terraced East Portico anchors the center of the east facade, and provides building access at the first- and second-floor levels (Figure 45a). A full survey and study of this area was not included in the scope of the project, but SGH previously investigated the roofs as part of the recent East Quadrant roof reconstruction project and noted stone damage during our recent survey work. Our recommended repair scope includes cleaning, pointing, and repair of the limited stone damage observed.

Based on our previous and current investigations, we know that the upper roof is an old EPDM membrane and water is likely leaking into the stone work, causing moisture-related damage. We are recommending replacement of this roof and repair of related stone damage as part of the comprehensive Eastern Approach project, as the area will already be disrupted by scaffolding and construction equipment. Previous flashing installed below the fourth-floor balustrades can be reused when the roof is replaced. Roof replacement work will need to address hazardous materials found during previous investigation work. The lower roof is a newer modified bitumen roof that appears to be functional. This lower roof was not considered for inclusion in the East Quadrant roof reconstruction project (Phase 4) and thus is not included in the current recommended repair scope either.

Figure 45a East elevation of Capitol and East Portico.

Exterior Lighting and Miscellaneous Items

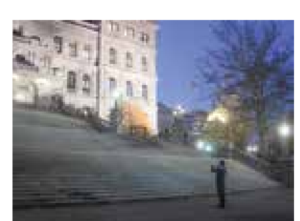
Exterior Lighting Historic decorative cast bronze light fixtures adorn the Eastern Approach, Eastern Promenades and Executive Ramp balustrades. The light fixture posts are original, though the lanterns were replaced in the 1930s, and the lamps are a contemporary system installed somewhat recently (Figures 46a–b). While the lanterns are not original, they match the lanterns used in the West Capitol Park. All exterior lighting is reported to work (Figure 46c), though we observed a few fixtures that did not illuminate; we assume these non-functional fixtures simply require lamp replacement. The bronze fixtures have a patina, being unsealed and exposed to the elements, and there is some runoff staining the granite below.

Clockwise from top left:
Figure 46a Typical cast bronze fixture.
Figure 46b Original cast bronze base.
Figure 46c Light fixtures in operation.
Figure 46d Contemporary flood light below Landing 4.

We did not observe any damage or visible defects with these existing fixtures. To complete the recommended masonry balustrade work, the light fixtures will need to be removed and reinstalled. The Capitol Master Plan recommends restoration of these fixtures to their original clustered globe lamps; however, lamp restoration is beyond this study's scope. For this project, we recommend replacing the fixture wiring; making any necessary small repairs and cleaning the limited surface soiling; re-lamping all fixtures; and coating with a clear sealer to prevent future runoff but retain the desirable aged patina. If desired in the future, the original globe lamps can be restored, though pricing for this is not currently in the cost estimate.

Six utilitarian flood lights are installed within the Eastern Approach vaults that span the Executive Ramp (Figure 46d). These fixtures are architecturally inappropriate and not original. The project includes rewiring and replacing with historically appropriate fixtures that will maintain the current level of illumination.

Utility Lighting Utility lighting is installed intermittently in the Eastern Approach basement and below the Eastern Promenades. The project includes replacement of the basement fixtures and supplemental lighting to provide a code minimum lighting levels in these spaces.



Security Cameras Three security cameras with exposed surface-mounted conduit for the wiring are installed within the Eastern Approach vaults. As installed, the cameras detract from the appearance of the vaults (Figure 47a). The project includes providing hidden conduits and replacing the cameras to limit the appearance impact of the cameras.

Security Gates and Site Appurtenances
The East Portico first-floor entry and driveway currently serve as the executive parking area and entrance to the building. As such, the public is restricted from these spaces by signage and limited barriers. Current barriers consist of plastic chains spanning portions of Landing 2 and the Eastern Promenade and portable bicycle racks at various points on the Eastern Promenade. As noted in the individual project areas, the intent is to provide a permanent, decorative gate or fence to limit access from the restricted areas. The simple metal window grates used in the Capitol's Central courtyard are representative of the type of custom-made, historically appropriate, intervention proposed.

Landscaping The Eastern Approach and Executive Ramp form the west boundary of the East Capitol Park. Concrete walkways surround the base of the stair and extend along the north and south edges to the basement-level doors. The adjacent park area was originally just a grass lawn, but sometime before 1997, a gravel planting bed, decorative bushes, and four trees were added along the Executive Ramp retaining walls (Figure 47b). These planting beds have since been removed, but the four trees remain. These now full grown trees encroach on the stair, blocking access to some of the rich carvings and are staining the stone (Figure 47c). The trees would also impede cranes or removal equipment needed for any large-scale Eastern Approach rehabilitation project. We have therefore included their relocation as part of the project scope (assuming replanting either in Lafayette Park across Washington Avenue or at the Executive Mansion on Eagle Street). The East Capitol Park lawn will be repaired to its pre-construction appearance when the work is complete.

Hazardous Materials Fisher reviewed the project area for potential hazardous materials. No suspect lead-containing materials were identified, and no lead sampling or testing was performed. Various sealants, waterproofing samples from Landing 4, storm pipe insulation, and miscellaneous cementitious materials throughout the project area were tested for asbestos. No asbestos containing materials were identified.

Figure 47a Surface-mounted security cameras and conduit in Arcade.
Figure 47b East Capitol Park north of Eastern Approach circa 1997.
Figure 47c East Capitol Park south of Eastern Approach.

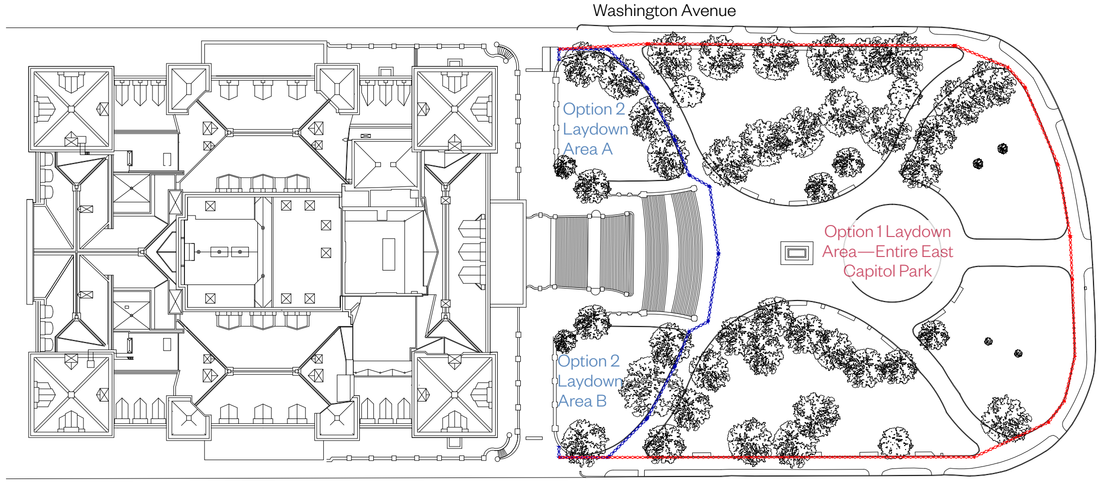
Construction Logistics and Site Usage

Based on direction from OGS, our Conceptual Repair documents and estimate assume all work recommended in previous sections and shown on our Conceptual Repair documents will be completed in a single construction phase. **If the project is not implemented immediately, repairs and/or shoring needs to be provided at the Flight 3 deteriorated walls to maintain adequate support of the tread stones. In addition, the rotating Landing 2 balustrades need to be monitored to verify they do not rotate beyond the point of supporting code-required loads (calculated at 9 degrees past plumb) and netting over the Executive Ramp needs to be maintained to mitigate potential falling hazards.**

OGS provided the following parameters, which are included in the repair documents and accounted for in the estimate:

- We understand a portion of the Executive Ramp must remain continuously open for use. Specific sequencing of this work requires further analysis, but for pricing, we have assumed the ramp work, including all of the related snow melt system, will be completed in two long north-south strips. This approach will require engineered soil retention shoring to allow for excavation and reconstruction of the ramp retaining wall.
- Proposed laydown and storage area for the massive number of balustrades, treads, and landing stones is uncertain. For pricing, we have included two options: first, allowing the contractor the use of the entire East Capitol Park (Figure 48a) for storage and laydown; second, providing only limited laydown area adjacent to the Eastern Approach, an option that assumes all stone must be trucked off site for storage and trucked back for reinstallation.
- East Portico second-floor doors are not designated emergency exits, but are accessible and could be used in the event of an emergency. Continuous access must therefore be maintained between this portico level (i.e. Landing 4) and grade. To provide this access, our Conceptual Repair documents and estimate provide for a temporary stair connecting the portico to the promenade deck below.
- Exterior work is restricted to occur between 1 April and 1 December.

Figure 48a Site plan of Capitol and East Capitol Park.



Repair Scope Summary and Estimate

The primary intent of our recommended repair scope is to address ongoing or chronic problems with the existing staircase, driveway, and promenade systems, while preserving existing historic material to the greatest extent possible. Our proposed repair scope is discussed in each respective report section, and summarized below.

Eastern Approach

- Remove all stair balustrades, displaced masonry, and wearing surfaces; salvage all granite for reinstallation
- Remove deteriorated landing and basement floor brick jack arch floor system and pre-cast concrete shoring below.
- Provide new structural concrete decks at flights, landings, and the basement floor.
- Provide continuous hot rubberized asphalt waterproofing system with perimeter flashing. Provide drainage layer, no-fines concrete leveling layer, and reinstall existing masonry on discrete mortar beds. Provide replacement granite wearing surface at Landing 4.
- Repair and reinstall stair balustrades and displaced masonry with metal through-wall flashing
- Replace failed storm drainage system.
- Replace all windows and doors with new wood windows, transoms, and doors.
- Provide new ladders to allow access between basement levels.
- Provide custom metal gates or railing at Landing 2.
- Point and clean all granite surfaces.
- Repair all isolated stone damage.
- Replace and supplement utility lighting in basement and attic spaces of Eastern Approach.

Executive Ramp

- Disassemble and reconstruct the displaced and rotated portions of the retaining wall and balustrade with the same stone pieces.
- Excavate adjacent to the retaining wall and provide damp proofing, flashing, and soil drainage behind retaining wall.
- Replace the drive surface and incorporate snow melt system.

Eastern Promenades

- Repair the concrete deck and provide a waterproof traffic coating.
- Remove and reinstall the granite balustrade to provide flashing at base.
- Provide custom metal gates.
- Replace concrete benches with architecturally appropriate metal benches.
- Replace painted steel grates and doors.

East Portico

- Replace fourth-floor roof.
- Clean, point, and repair isolated stone damage.

Exterior Lighting and Miscellaneous Items

- Remove and reinstall decorative bronze light fixtures; provide new wiring for fixtures. Repair and conserve light fixtures. Re-lamp and provide clear coating.
- Replace Executive Ramp pendant fixtures and provide new wiring.
- Replace security cameras and rewire to hide wiring.
- Relocate the trees.
- Restore the East Capitol Park lawn when the project is complete.

Cost Estimate

In collaboration with our cost estimator, VJA, we generated a cost estimate for the work described above and shown in the Conceptual Repair documents. The estimated cost for construction is $16,952,000.

Immediate Work

As noted previously, we recommend the following immediate actions:

- Repair and/or replace shoring at the Flight 3 deteriorated walls to maintain adequate support of tread stones and prevent localized brick masonry collapse.
- Monitor the rotated Landing 2 balustrades; provide signage or close landing if these railings rotate beyond the point of supporting code-required loads (calculated at 9 degrees past plumb).
- Continue to maintain netting over the Executive Ramp until repairs are complete and water ingress at Landing 4 is mitigated. This netting is necessary to mitigate potential falling hazards.

Project Credits

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Glossary of Terms and Construction Systems

Balustrade A parapet or railing consisting of typically cylindrical pillars (or balusters) supporting a coping stone.

Bituminous Containing asphalt or tar (i.e. bitumen).

Collar joint Vertical joint between separate wythes, or stacks, of masonry.

Course (of masonry) A continuous row of brick or stone at same height within wall.

Dutchman Stone masonry repair made by selective removal and replacement of a damaged portion of stone using a tightly fit and closely matching new or salvaged piece of stone. Replacement stone is typically secured with metal pins or epoxy.

Efflorescence White crystalline salt deposits on the surface of masonry or concrete; typically caused by water infiltration which draws salts to the surface where they are deposited as the water evaporates.

Finite Element Analysis (FEA) An analytical method that involves dividing a structure into a mesh of small elements to mathematically determine material stresses and deformations produced from both external and internal loads on the system. This method of analysis was developed in the mid-twentieth century and continues to be widely used, aided by the development of automated analysis programs.

Hallowell granite Gray granite quarried from Hallowell, Maine. The quarry for this original stone source of the Capitol's granite facades was re-opened in 2010.

Lintel A piece of stone, wood, or steel framing that spans the top of a masonry opening and supports the weight of the masonry above the opening.

Pier A vertical structural support, such as a masonry column.

Plinth A block serving as the base of a pillar, arch, or other architectural element.

Pointing The process of removing and replacing the exterior portion of exposed masonry mortar joints; interchangeable with "repointing" or "tuckpointing."

Portico A covered colonnade or walkway, typically at a building's entrance.

Pre-cast Concrete Concrete cast in a reusable mold, often in controlled conditions away from the final installation location. Differs from cast in place concrete in that it is usually modular units that are not fit or formed to specific field conditions.

Promenade A public walk area intended for leisure, exercise, or display.

Retaining wall A structural wall and footing system designed to restrain soil, either vertically or to an unnatural slope.

Romanesque Architectural style characterized by massive masonry wall construction, rounded arch openings, groin and barrel vaults, and a restrained use of decorative mouldings.

Jacked, Jacking, or Rust Jacking Lifting or displacement, in this case due to the expansive force created by corroding steel and iron oxide (or rust) byproduct.

Jack Arch, Brick Typical early 20th century structural floor system consisting of shallow brick barrel vaults spanning between parallel I-beams. The top surface is typically covered with concrete to provide a level wearing surface.

Sill The horizontal member at the bottom of a window or structural frame.

Spall A fragment or chip, commonly of stone or concrete, broken off of a larger element.

Vault (barrel or groin) Barrel vault is a continuous semi-circular span of masonry; a groin vault is the intersection of two equally sized barrel vaults.

Wythe A continuous vertical stack of masonry, one unit in thickness. Adjacent wythes can be locked together or bound with a mortar collar joint.

Crack gauge A device installed across a crack or joint to monitor movement; depending on data precision required, may range from an electronic device that continuously records movement and environmental conditions, down to a basic pair of plastic target strips that visually show extent of movement since their installation. Can be interchangeable with "strain gauge."

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