REVISED CONCEPT REPORT: CLADDING PROPOSAL SUBMISSION

Smithsonian Institution
National Air and Space Museum
National Mall Building
Envelope and HVAC Revitalization

SF Project No. 1206101
QEA Project No. 31301800

28 June 2017
Revised Concept Report: Cladding Proposal Submission
National Mall Building Envelope and HVAC Revitalization

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CONTACT
Smithsonian Institution
Smithsonian Facilities (SF)
Office of Planning, Design and Construction (OPDC)
Capital Gallery
600 Maryland Avenue SW Suite 5001
MRC 511, PO Box 37012
Washington, DC 20013-7012

Jane Passman, Senior Facilities Master Planner
Phone: 202.633.6549
Email: passmj@si.edu

PROJECT NAME
National Mall Building Envelope and HVAC Revitalization

LOCATION
Smithsonian Institution
National Air and Space Museum
Washington, DC
Introduction

National Mall Building Envelope and HVAC Revitalization

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Introduction

The Smithsonian has selected Colonial Rose granite (also known as Lac Du Bonnet) as the cladding material for the NASM envelope based on an extensive evaluation of the aesthetics, technical performance, procurement, and risk for a wide range of stone and man-made options. Colonial Rose is an elegant stone with monumental presence. This report documents the analysis leading to the selection.

A preliminary evaluation of paving materials is also presented in this report, including an analysis of the paving options as paired with Colonial Rose. The selection of the paving material will be included in the Preliminary Design Submission.

The front end of the report focuses on the short list of cladding options that were identified for further review. The broader range of materials initially evaluated is documented in the appendices as located at the end of the report.

NASM Vision: “Transforming NASM for the future”

The Smithsonian’s National Air and Space Museum will assess and improve our programs, processes, and tools; revitalize our facilities and refresh our exhibitions to better engage and educate the public; preserve and share our collections; and perform original research in planetary science and the history of aviation and spaceflight.

NASM Mission: “Commemorate, Educate, Inspire”

The Smithsonian’s National Air and Space Museum collects, preserves, studies, and exhibits artifacts, archival materials, and works of art related to the history, culture, and science of aviation and spaceflight and the study of the universe. Its research and outreach activities serve all audiences, within and beyond its walls. The Museum commemorates the past and is committed to educating and inspiring people to foster appreciation for the importance of flight to humanity.
### National Mall Building Development Timeline

#### Smithsonian Institution

**National Air and Space Museum**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>Public Law 722 made the National Air Museum (NAM) a new bureau of the Smithsonian Institution.</td>
</tr>
<tr>
<td>1947</td>
<td>The National Air Museum Advisory Board determined that the museum should be located in the Washington, DC area.</td>
</tr>
<tr>
<td>1955</td>
<td>The firm McKim, Mead and White was selected to study the original site located on Independence Avenue between 9th and 12th Streets, south to C Street.</td>
</tr>
<tr>
<td>1958</td>
<td>Congress authorized preparation of plans and specifications for the National Air Museum (NAM) on The National Mall.</td>
</tr>
<tr>
<td>1960</td>
<td>Feasibility study completed by Harbeson, Hough, Livingston, and Larson.</td>
</tr>
<tr>
<td>1962</td>
<td>Only to later reverse the decision. The firm Hellmuth, Obata and Kassabaum (HOK) was selected to design the NAM.</td>
</tr>
<tr>
<td>1963</td>
<td>HOK design completed and approved by review agencies.</td>
</tr>
<tr>
<td>1964</td>
<td>Congress authorized construction but deferred funding due to the cost of the Vietnam War.</td>
</tr>
<tr>
<td>1966</td>
<td>Congress authorized construction but deferred funding due to the cost of the Vietnam War. Museum design approved by CFA and NCPC.</td>
</tr>
<tr>
<td>1969</td>
<td>Museum groundbreaking.</td>
</tr>
<tr>
<td>1970</td>
<td>Museum construction completed.</td>
</tr>
<tr>
<td>1971</td>
<td>Exhibit installation completed and museum opened to the public on July 1, 1976. Source: Smithsonian Institution’s Archives.</td>
</tr>
<tr>
<td>1972</td>
<td>Removal of collapsible revolving doors due to concerns with emergency egress.</td>
</tr>
<tr>
<td>1975</td>
<td>The &quot;Tin Shed,&quot; a temporary metal building located along Independence Avenue behind the Smithsonian Castle, displayed the aircraft collection until 1975.</td>
</tr>
<tr>
<td>1976</td>
<td>Grand Opening.</td>
</tr>
<tr>
<td>1976</td>
<td>National Mall Building Envelope and HVAC Revitalization construction targeted commencement.</td>
</tr>
<tr>
<td>1980</td>
<td>Emergency exit doors rehabilitated.</td>
</tr>
<tr>
<td>1981</td>
<td>Stone facade restored with widened joints and the installation of plastic weep holes and new sealant assemblies.</td>
</tr>
<tr>
<td>1985</td>
<td>Terrace renovated with the replacement of precast concrete pavers and steps with granite pavers.</td>
</tr>
<tr>
<td>1986</td>
<td>Emergency exit doors rehabilitated.</td>
</tr>
<tr>
<td>1988</td>
<td>Restaurant addition and associated site modifications constructed.</td>
</tr>
<tr>
<td>1989</td>
<td>Restaurant addition and associated site modifications constructed.</td>
</tr>
<tr>
<td>1990</td>
<td>Restaurant addition and associated site modifications constructed.</td>
</tr>
<tr>
<td>1992</td>
<td>Skylights and curtain wall replaced.</td>
</tr>
<tr>
<td>1995</td>
<td>Skylights and curtain wall replaced.</td>
</tr>
<tr>
<td>2000</td>
<td>Perimeter security installed.</td>
</tr>
<tr>
<td>2001</td>
<td>Perimeter security installed.</td>
</tr>
<tr>
<td>2004</td>
<td>Perimeter security installed.</td>
</tr>
<tr>
<td>2006</td>
<td>Smithsonian Architecture.</td>
</tr>
<tr>
<td>2010</td>
<td>NCPC Revised Concept Report: Cladding Proposal Submission</td>
</tr>
</tbody>
</table>

**National Mall Building Envelope and HVAC Revitalization**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Exhibit installation completed and museum opened to the public on July 1, 1976. Source: Smithsonian Institution’s Archives.</td>
</tr>
<tr>
<td>2020</td>
<td>Proposed Revitalization 2024.</td>
</tr>
<tr>
<td>2024</td>
<td>Proposed Revitalization 2024.</td>
</tr>
</tbody>
</table>

**Introduction**

National Mall Building Envelope and HVAC Revitalization construction targeted commencement in 2020.
Introduction

National Mall Building Envelope and HVAC Revitalization

Existing Elevations

Smithsonian Institution
National Air and Space Museum

Existing North Elevation

Existing South Elevation
Existing Elevations

Smithsonian Institution
National Air and Space Museum

Existing East Elevation

Existing West Elevation
1.1 PROJECT DATA

**Project Area & Building Area**

The project comprises the renovation and restoration of the existing 687,000 gsf (63,824 m²) National Air and Space Museum (NASM) National Mall Building, including 112,000 gsf (10,405 m²) terrace revitalization. The overall site area is 448,530 gsf (41,670 m²). The cladding replacement includes 160,600 gsf (14,920 m²) stone facade, 40,000 gsf (3,716 m²) curtain wall, 52,000 gsf (4,830 m²) skylight, and 70,000 gsf (6,503 m²) roof. The proposed vestibule additions are a combined 4,800 gsf (446 m²).

**Assigned Employment**

There is a combined total of approximately 530 employees and volunteers assigned to the NASM Mall Building. No change of assigned employees is envisioned as a result of this project.

**Schedule**

The project is scheduled to be constructed beginning in early 2018 with an estimated six year period of construction. Public access to the Museum will be maintained but restricted while under construction.

**Project Funding**

Federal funding for revitalization is expected to be requested in increments over FY18-FY22.

1.2 PROJECT NARRATIVE

The proposed design for the National Mall Building envelope and HVAC revitalization addresses the need for upgrades to a facility with out-of-date systems and significant deferred maintenance. The project objectives include the following goals:

- The revitalization of the museum to protect its mission for a century or more to come.
- The replacement of the currently failing Tennessee marble cladding envelope with a material that is compatible with the original design of the building, has a life span of 100 years with proper maintenance, and meets requirements for energy performance and insulation.
- Select materials and systems that accommodate the project schedule and cost without increasing risk.
- Maintain eligibility of the museum to be added to the National Register of Historic Places.
- The replacement of currently outdated utility systems with upgrades that are to be designed and selected to endure for prolonged service timespans, maintainable and serviceable without major renovations.
- The enhancement of the visitor experience with greater accessibility and amenities.

**Development History**

The Smithsonian’s aeronautical collection was established in 1876 with a group of kits acquired from the Chinese Imperial Commission. In 1946, Congress established a National Air Museum to memorialize the national development of aviation. In 1966, the name of the museum was changed to the National Air and Space Museum to memorialize the development of both aviation and spaceflight. In 1971, Congress passed a funding measure for $40 million toward the new building.

NASM became an important beacon of cultural and technological innovation in Washington, D.C. when it was added to the promenade of the National Mall in 1976. With the largest collection of historic aircraft and spacecraft in the world, the design of this museum offered both unique architectural opportunities and complex challenges.

In 1965, Hellmuth Obata and Kassabaum Architects (HOK) was commissioned to design the museum and surrounding landscape by the GSA, who at that time managed design and construction of Smithsonian facilities. Lead Architect Gyo Obata aspired to design a building that was in harmony with the character of the National Mall and reflected the architectural elements of the surrounding buildings, while also pursuing modern architectural principles. Through several iterations, Obata explored design ideas including the way the building meets the ground, attention to scale, the interplay between solids and voids, and the relationship to the surrounding buildings on the Mall.

Obata’s solution was skillfully simple: four large marble-clad pavilions, separated by three recessed steel-and-glass atria. Drawing inspiration from neighboring buildings, primarily the National Gallery, Obata reflected formal massing and materials in his design. The alternation of solids and voids are placed and proportioned to respond to corresponding projections and recesses of the West Building of the National Gallery, which sits directly across the Mall. Equivalent volumes face Independence Avenue, but the recessed glass-enclosed bays of the Mall façade have been replaced by floating marble cubes, cantilevered to be flush with the south façade. The volumes are clad in Tennessee Pink marble, as used in the construction of its neoclassical predecessor.

In 1972, the design was approved by the federal review commissions after several revisions, as GSA oversaw the design of SI facilities at that time. Construction began later that year. The museum was opened on July 1, 1976. With this, the project requirements were accomplished by opening in time for the Bicentennial and within the $40 million construction budget. The project was awarded with the “anti-golden fleece” prize by Senator William Proxmire in honor of this feat.

The popularity of the museum brought more visitors than anticipated, creating increased impact on certain building systems. The weathering of the building was also accelerated by the limited longevity of certain building components that were downgraded as part of the original construction in order to reduce cost and meet the budget.

The initial building system repairs and replacements began in 1978 with the replacement of the collapsible revolving doors due to concerns regarding emergency egress. Later renovations included the replacement of precast concrete exterior pavers with granite in 1995. The acrylic skylights, which were introduced as a value engineering substitution for the glass enclosure originally proposed, were replaced in glass in 2001 as part of glazing replacement that included the curtain wall and vestibule as well.

The envelope and HVAC studies conducted by Quinn Evans Architects in 2013 determined the stone cladding system is failing, as well as the HVAC systems, which have reached the end of their usable life. Due to the integration of the exterior cladding with the mechanical air distribution system, it is necessary to undertake these upgrades together. Further analysis established that the waterproofing enclosure of the plaza and the main roof are similarly aging and beyond their projected life span.

**Historic Preservation**

NASM was identified as a contributing building to The National Mall, which was listed on the National Register of Historic Places in 1966 as an historic site. NASM is not currently listed individually on the National Register of Historic Places or the District of Columbia Inventory of Historic Sites. However it is potentially eligible for individual listing. A Determination of Eligibility study for NASM has been initiated by the Smithsonian. At the time of this report the building is 40 years old.

**Organization of Report**

The remainder of the report is divided into five sections: (1) cladding replacement, (2) paving replacement, (3) appendix a: stone survey, (4) appendix b: global stone research list and stone filtering matrix, and (5) appendix c: cladding and paving aesthetic mockup.
2.0 TRANSPORTATION MANAGEMENT PROGRAM
Not applicable to this project because the assigned employees are below 500.

3.0 ENVIRONMENTAL DOCUMENTATION

NEPA Compliance
In accordance with the National Environmental Policy Act of 1969, the Smithsonian Institution has initiated an Environmental Assessment study for the National Air and Space Museum with public and agency scoping meetings having been conducted. NCPC serves as the Lead Federal Agency for this NEPA process. The NEPA scoping meeting was conducted on 12 November 2014. The Draft Environmental Assessment was issued on March 31, 2017. The Environmental Assessment public review period concluded on 1 May 2017.

4.0 HISTORIC PRESERVATION DOCUMENTATION

Compliance
Refer to adjacent letter from the SI office of Architectural History and Historic Preservation that formally initiates the Section 106 process for this project on 3 September 2014. Four meetings with consulting parties have been conducted to date. Additional consultation will be conducted as needed in the future.

5.0 FLOOD PLAINS MANAGEMENT AND WETLANDS PROTECTION

Located Within Floodplain, No Impact on Wetlands
The north and east portions of the site are within the 100-year (1% annual chance) flood plain as designated by FEMA’s 2010 map. This flood plain, with Base Flood Elevation (BFE) +/- 12.5 feet, overlaps the east garage ramp, which serves as the entrance to NASM’s loading dock. Mitigation will include waterproofing and a flood wall at the garage entrance ramp that accommodates the 100-year flood plain plus 3 feet per Executive Order 13690.

This project does not impact a wetlands area.
Smithsonian Institution

Architectural History and Historic Preservation

5 September 2014

Mr. C. Andrew Lewis
Senior Historic Preservation Specialist
D.C. Historic Preservation Office
1100 4th Street, SW, Suite 6650
Washington, D.C. 20024

Dear Mr. Lewis,

The Smithsonian’s National Air and Space Museum is one of the most highly visited museums in the world. Since September 11, 2001, the threat level has increased to the museum, and security was elevated upon entering the museum. These security measures consist of magnetometers and X-ray machines manned by security officers.

Presently the security screening is conducted just as one enters the museum at the north and south entry points. In the summer and during school holidays, this creates long lines outside the museum and overcrowding inside. During inclement weather there is no place for visitors to shelter. Moreover there is no transition point between the security screening and the museum.

Pursuant to 36 CFR 80.35(a), the Smithsonian has determined that the proposed addition of security points at the north and south entrances to the National Air and Space Museum is an undertaking as defined in 805.16(d) and that it has the potential to cause effects on historic properties. In particular, the National Mall, a site listed on the National Register of Historic Places.

The Smithsonian wishes to initiate the Section 106 review process and seeks the assistance of the District of Columbia Historic Preservation Office (DCHPO) in applying the criteria of adverse effect (805.35) to determine the effect the undertaking will have on historic properties.

The Smithsonian looks forward to working with you on this project, and will ensure that you receive proper documentation.

With kind regards,

Amy Ballard
Senior Historic Preservation Specialist

cc: Jennifer Hirsch, National Capital Planning Commission
P.O. Box 37212 MRC 531
Washington, D.C. 20037-7012
Tel: 202-633-6055 direct

GOVERNMENT OF THE DISTRICT OF COLUMBIA
STATE HISTORIC PRESERVATION OFFICE

October 3, 2014

Ms. Amy Ballard, Senior Historic Preservation Specialist
Smithsonian Institution
Architectural History and Historic Preservation
P.O. Box 37212 MRC 531
Washington, D.C. 20037-7012

RE: Initiation of Section 106 Consultation; National Museum of Air & Space Façade Replacement Project

Dear Ms. Ballard,

Thank you for formally initiating consultation with the District of Columbia State Historic Preservation Office (SHPO) regarding the above-referenced undertaking. We are writing in accordance with Section 106 of the National Historic Preservation Act and in implementing regulations, 36 CFR Part 805, to provide our initial comments regarding effects on historic properties.

As you are aware, the National Air & Space Museum is a contributing element of the National Register of Historic Places-listed National Mall Historic District. Based upon our review of the project submitted and our participation in the site visit and informal discussions held on June 17th and September 27th of this year, we understand that the original, tan wooden panels that make up the exterior façade – and the museum’s most prominent character-defining feature – are failing to the point that they must be completely replaced. Replacing the original material is not an option because the panels are very thin and most of the deterioration consists of significant rotting. However, we are encouraged that the Smithsonian Institution is actively investigating the possibility of reproducing the original material and acquiring matching stone to complete the project. Since this approach has the potential to completely avoid adverse effects, we strongly encourage in-kind replacement if at all possible. Alternative materials such as granite, metal or synthetic panels are likely to result in adverse effects on the museum and the surrounding historic district.

Please keep us posted as more is learned about the possibility of obtaining matching material panels. In the meantime, we look forward to continuing consultation with the Smithsonian Institution and other parties, including assistance in the preparation of an Area of Potential Effects (APE) and an initial list of potential consulting parties. If you should have any questions or comments regarding this matter, please contact me at kayneke@dc.gov or 202-442-8841. Otherwise, thank you for providing this initial opportunity to comment.

Sincerely,

Amy Ballard
Senior Historic Preservation Specialist
DC State Historic Preservation Office

1104 4th Street, SW, Suite 618
Washington, DC 20024
Phone: 202-442-7648; Fax: 202-442-7647

1100 4th Street, SW, Suite 6650
Washington, DC 20024

NCPC Revised Concept Report: Cladding Proposal Submission | 28 June 2017
PREVIOUS NCPC COMMENTS ON CLADDING:

July 2016 Concept Submission of Vestibules and Site Improvements:

(NCPC) Recommends that the applicant continue to work closely with NCPC, the U.S. Commission of Fine Arts, and the District of Columbia State Historic Preservation Office to identify an appropriate cladding material that meets the performance criteria. If Tennessee Pink Marble, the original stone, is determined to be infeasible, consider ways to achieve a seamless transition between the exterior cladding and the interior stone treatment, and to avoid, minimize, or mitigate adverse effects on the National Air and Space Museum Building and the National Mall Historic District.∗

April 2017 Comments on Informational Briefing and Mockup Site Visit:

Commissioners who visited the mockup in the rain commented during the Informational Briefing on the value of having the mockup to evaluate cladding options but varied in their preferences and dislikes. Several commissioners favored the Ultra High Performance Concrete, several found the Echo Lake Granite to be too busy, and one suggested that Tennessee Pink be considered if technical and cost issues could be resolved. The Commission expressed flexibility regarding manmade vs. natural stone as well as emphasizing the criterion of an inherently beautiful material over that of matching the National Gallery of Art. The Colonial Rose (Lac Du Bonnet) granite was not part of the mockup seen on April 6, 2017.

JUNE 2015 COMMISSION OF FINE ARTS CONCEPT HEARING

Following several months of consultation from agency staff, a concept report and presentation was provided in June 2015 of the following scope items for the NASM revitalization project:

- Terrace
- Vestibules
- Envelope Replacement
  - Stone Cladding
  - Glazing
  - Roof Solar Panels
  - Solar Wall

COMMISSION OF FINE ARTS CONCEPT APPROVAL

The concept proposal was granted concept approval for all aspects of the scope, with comments providing direction on how to advance the design. The letter from the Commission of Fine Arts is included on this page for reference.
Following several months of consultation from agency staff, a revised concept report and presentation was provided in June 2016 of the following scope items for the NASM revitalization project:

- Terrace
- Vestibules

The revised concept proposal was granted concept approval for site design Scheme A and the updated vestibules, with comments providing direction on how to advance the design.

The letter from the Commission of Fine Arts is included on this page for reference. The request from the Commission to present the proposed exterior cladding is documented in this report.
The project has been developed with an ongoing application of due diligence. This includes an extensive consultation program with the federal design review agencies, as well as multiple risk analyses and third party technical reviews. This process began with the initial building studies, and will continue through the completion of design and documentation.

A summary of the project development and consultation milestones completed to date is outlined here for reference. Consultation with federal design review agencies is highlighted in bold font.

**Consultation Milestones and Associated Dates**

- October 18, 2013 – Final building envelope study by Quinn Evans Architects
- December 18, 2013 – Final feasibility study by Quinn Evans Architects
- March 10, 2014 – Peer review report/study validation by Jacobs/WJE
- September 5, 2014 – SI HP letter to DC HPO to formally initiate Section 106 process. Acknowledged by October 3, 2014 letter from Andrew Lewis of DC HPO.
- November 12, 2014 – Agency and public scoping meetings.
- January 15, 2015 – EA Alternatives Presentation to NCPC Staff
- June 15, 2015 – Concept Presentation to CFA Commissioners
- January 12, 2016 – Agency staff consultation (with all, at NASM)
- February 9, 2016 – Agency staff consultation (with all, at NASM, including viewing of onsite cladding options)
- February 12, 2016 – NCPC Staff consultation in preparation for Consulting Parties
- February 22, 2016 – Consulting Parties session (at NCPC)
- March 14, 2016 – Receipt of preliminary WJE/Jacobs Stone Feasibility Report
- April 14, 2016 – Agency staff consultation (with all, at CFA)
- June 16, 2016 – Revised Concept Presentation to CFA Commissioners
- July 7, 2016 – NCPC Commissioners’ site tour & Concept Presentation
- October 17, 2016 – Agency staff consultation & viewing of updated cladding options (with all, at NASM)
- March 30, 2017 – Agency staff consultation & viewing of updated cladding options (with all, at NASM)
- April 6, 2017 – NCPC Commissioners’ site visit & Informational Briefing
- April 7, 2017 – Section 106/Consulting Parties Public Meeting
- April 20, 2017 – CFA site visit & Informational Briefing
- April 21, 2017 – Receipt of WJE/Jacobs Stone Testing Report (with full results of Tennessee Marble battery of stone tests)
- May 19, 2017 – DC HPO staff site visit & consultation
- May 22, 2017 – NCPC/CFA staff site visit & consultation
- June 8, 2017 – Section 106/Consulting Parties Meeting - viewing of additional stone
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Existing and Proposed Stone Cladding Replacement Details 24
June 2016 Revised Concept CFA Report and Commission Response 25
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Colonial Rose Granite Cladding Selection and Visualizations 32
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Cladding Replacement Narrative

Smithsonian Institution
National Air and Space Museum

1.2.3 CLADDING REPLACEMENT

This section summarizes the need for and methodology of the replacement of the stone cladding wall assembly, as well as the incorporation of sustainability initiatives within the revitalized building envelope.

The revitalization of NASM will involve significant improvements to the building envelope systems (water, air, thermal, and vapor barriers) and require modifications to all of the building envelope components, including the exterior cladding, curtain walls, skylights, and roofing. This renovation project presents tremendous opportunities to improve the overall envelope performance through establishing water, air, thermal, and vapor barrier continuity. This will have significant impact on building energy use, provide appropriate system durability/service life, and establish NASM as a model for sustainable design.

1.2.3.1 STONE CLADDING REPLACEMENT

Original Design and Existing Conditions

The existing exterior walls consist of a 1 1/4" (32mm) thick Tennessee Pink Marble barrier wall system with backer rod and sealant filling the joints between 2'-6" (610mm) tall x 5'-0" (1220mm) wide panels and spray applied urethane foam insulation covering the back of the stone. A vertical plenum within the wall cavity provides air flow through the interstitial space.

The stone facade must be removed for several reasons. Extensive warping (“hysteresis”) and cracking is irreversible as exacerbated by the spray-foam insulation applied to the back of the stone panels, introducing a risk that some of the stone panels could fall from the building; temporary protection has been installed where needed to protect people from this risk. The existing exterior wall construction does not provide adequate resistance to water penetration or air infiltration. It also lacks effective flashings and does not include any means for air barrier continuity between the exterior walls and other building envelope systems (curtain wall, skylight, roofing, or soffits). Further, the reintroduction of mechanically-controlled humidification will create significant potential for condensation within the wall cavities inboard of the exterior wall assembly (particularly those used as return air plenums for the HVAC system) and this will drive certain design decisions related to the exterior wall concept.

Envelope Performance Criteria

The exterior wall assemblies must meet the following performance criteria:
• Provide the durability of a 100 year envelope with proper maintenance
• Prevent water infiltration
• Provide a continuous air barrier
• Minimize the potential for moisture accumulation within the exterior wall assembly and condensation, while maintaining interior operating conditions
• Provide thermally broken cladding attachment system to prevent condensation within the wall
• Provide blast resistance and limit fire propagation
• Provide the longest service life possible

Cladding Material Option Analysis

The analysis of cladding options included consideration of a wide range of options in order to find the material that best suits the extensive performance criteria. Both natural and manufactured panel systems were studied, with metallic, ceramic, stone, and composites reviewed among others along the way. Whereas many progressive systems provide the desired longevity, that was only one of many requirements that must be met. The unique nature of the building context was both inspiring and demanding of a material that not only meets technical standards, but numerous design objectives and regulatory requirements as well. Ultimately, the selection will be based on the material that appropriately meets the longevity, performance, stewardship, and mission criteria.

In order to preserve NASM’s eligibility for potential future listing in the National Register of Historic Places per project requirements, the revitalization project must maintain the existing character of the building. Thus the design intent is to implement stone cladding with the facade replacement with a similar appearance to the original stone cladding installation.

Current analysis has indicated that 3" thick limestone or 2" thick granite provides the desired balance of strength and weight, while offering an enclosure system that can be expected to meet the targeted lifespan requirements. The additional thickness also permits increased allowances for anchorage positioning within the panel thickness which in turn translates to increased construction tolerances.
Stone Cladding Options

Over 80 different stones and numerous manufactured materials were analyzed in the search for the most suitable cladding replacement. This included a risk analysis of the procurement of Tennessee Pink Marble relative to alternate stone materials due diligence. Both the original stone and the replacement candidates were evaluated based on extensive criteria including aesthetics, technical performance, procurement, and risk. From this process, numerous alternates have been identified, all of which have a slightly different appearance than the existing.

Excerpts from the evaluation of the broader range of materials initially considered is documented in Appendices A and B, located at the end of this report.

The criteria for the cladding replacement material includes aesthetic, technical, and procurement objectives.

Aesthetic
- Provide a material with a warm tone
- Provide a material that has a limited veining pattern
- Provide a material that has tonal variation among adjacent panels
- Provide a material that has a mineral composition
- Provide a material that has a monumental appearance appropriate for application on the National Mall
- Provide a material that has limited visual contrast relative to the existing interior stone to remain
- Provide a material that supports the original design concept

Technical
- Provide a material that supports a 100 year envelope with proper maintenance
- Provide a material that is suitable for application on a light steel framed building without masonry backup
- Provide a material that is resistant to pollutants, surface mold and algae growth

Procurement
- Provide a material that is quarried within North America and fabricated within the United States
- Maintain the eligibility of the building to be added to the National Register of Historic Places

Risk
- Material to be available in a sufficient quantity that can be extracted at a rate that accommodates the construction schedule

From an aesthetic perspective, a limited number of alternates have a striated pattern that closely resembles the sedimentary nature of Tennessee Pink Marble. Other alternates have been identified which have a warm color tone similar to Tennessee Pink Marble. However, an alternate stone has not been identified which has both the linear veining pattern and the warm tone of Tennessee marble as installed on the building. Tonal variation among adjacent panels was also considered in the analysis of cladding options as it helps modulate the facade for a more human scale, articulating the existing volumetric stone clad pavilions that are otherwise void of architectural ornamentation.

The technical aspects of the replacement cladding are also of significant importance to help ensure the sufficient durability and mitigate the risk of the performance issues evident with the existing installation. Although the development of the wall assembly details can be based on the design criteria as informed by petrographic analysis and performance mockup testing, one of the most effective methods of predicting how it will perform long term is based on the performance of similar installations on other buildings through the study of exemplar projects. The study of exemplars has shown that limestone cladding performs adequately when installed on a wall assembly with masonry back for thermal mass. Unfortunately, the introduction of a masonry backup is cost-prohibitive with the NASM revitalization project due to the subsequent need for extensive reinforcement of the existing structural frame and foundation, as it was originally designed for the light steel cladding support system per the existing condition. This was considered when analyzing the various cladding replacement options.
### Cladding Selection Criteria Matrix

<table>
<thead>
<tr>
<th>Material</th>
<th>Tennessee Marble</th>
<th>Saint Clair Echo Lake</th>
<th>Colonial Rose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Limestone</td>
<td>Limestone</td>
<td>Granite</td>
</tr>
<tr>
<td>Maintains Existing Stone Character</td>
<td>Closest (Tone and Texture)</td>
<td>Closest (Texture Only)</td>
<td>Closest (Tone and Some Texture)</td>
</tr>
<tr>
<td>Color Range (Panel to Panel)</td>
<td>Good</td>
<td>Limited</td>
<td>Some</td>
</tr>
<tr>
<td>Texture / Banding</td>
<td>Stipulations</td>
<td>Stipulations</td>
<td>Variegated with Large Dark Swirls</td>
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<tr>
<td>Tonal Warmth</td>
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<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Finish</td>
<td>Bush Hammered (one step)</td>
<td>Light Water Jet / Sand Blast (two step)</td>
<td>Sand Rubbed (one step)</td>
</tr>
<tr>
<td>Technical</td>
<td></td>
<td></td>
<td>Textured (two step: washed and sand-rubbed)</td>
</tr>
<tr>
<td>Full Fabrication Infrastructure (in place as of today)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ability to Meet Project Schedule / Construction Rate</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Recovery Rate (% Yield) Anticipated</td>
<td>25-30%</td>
<td>25-30%</td>
<td>25-35%</td>
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<tr>
<td>Quality Control (QC) of Panel Materials</td>
<td>Significant Additional QC Required</td>
<td>Least Complicated</td>
<td>Least Complicated</td>
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<tr>
<td>Quarry Site Lay-Down / Area Available</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Procurement</td>
<td>Location of Quarry (within/beyond 500 miles)</td>
<td>Within (Friendsville, TN)</td>
<td>Beyond (Marble City, OK)</td>
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<tr>
<td>Analysis</td>
<td>Location of Production (within/beyond 500 miles)</td>
<td>Within (Friendsville, TN)</td>
<td>Beyond (Tate, GA)</td>
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<td></td>
<td></td>
<td></td>
<td>Beyond (Cold Spring, MN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beyond (Cold Spring, MN)</td>
</tr>
</tbody>
</table>

| Schedule Impacts (QC / Yield / Constructability) | High | Low |
| Availability of Acceptable Material & Range | Certain | Uncertain |
| Durability (100-year material lifespan) | Good | Good |
| Available for Future Selective Replacement | Fair | Good |
| Analysis | Acceptable | Requires Further Consideration | Not Ideal |
| | 5 | 2 | 1 |

Capacity assumed good at all quarries. Available variation to be confirmed through further analysis of stones other than Tennessee Marble, this impacts recovery rate.

* Lay-down area refers to controlled space at the quarry that is large enough to assemble one entire NASM stone facade bay.

** No long-term precedent of these materials in a rain-screen, steel frame construction installation in a similar climate.
Existing and Proposed Stone Cladding Replacement Details

Smithsonian Institution
National Air and Space Museum

Cladding Replacement
National Mall Building Envelope and HVAC Revitalization

Existing Wall Section
The typical exterior wall construction consists of the following from exterior to interior:

1. 1.25” Tennessee Pink Stone panels with spray foam insulation
2. Steel framing
3. Steel column
4. Air Cavity (Return Air Plenum)
5. Interior metal stud wall with gypsum sheathing

Proposed Wall Section
Proposed new wall construction consists of the following upgrades from exterior to interior:

1. Proposed 2” Granite or 3” Limestone Panel
2. Proposed Insulated Metal Panel
3. Proposed Air and Water Barrier (Rain Screen)
4. Proposed Air and Vapor Barrier
5. Proposed Structural Strengthening
6. Proposed Aluminum Framing
7. Proposed Aluminum Column
8. Proposed Fire-Proofed Steel Column
The photos on this page document hysteresis, or warping, of the existing stone cladding. This process was exacerbated by the application of spray foam insulation on the back face of the exterior stone panels, which trapped moisture at the interface with the insulation. Exposure to the exterior allowed water to evaporate, causing differential expansion conditions within the section of the facade material.

Comments from the Commission of Fine Arts, Revised Concept Design

“For the entrance pavilions, [the Commissioners] expressed support for their elegant, curvilinear forms, but noted that full review of the design of the structures requires understanding their relationship to the building’s new cladding material. The Commission looks forward to the next review of this important project, which should include documentation of the proposed exterior cladding.”

From the letter, June 23, 2016, from Thomas E. Luebke, FAIA, Secretary

Smithsonian Institution Consideration of CFA Comments

The Smithsonian has addressed the comments of June 16, 2016 with the following actions:

- This report summarizes the analysis of the numerous different material options for the basis of a proposed cladding selection.
- The proposed cladding selection is shown in a composition with the proposed north vestibule on page 31. The further development of the vestibules will be documented in a forthcoming report dedicated to overall exterior design development.
- There has been an exploration of more than 80 different alternate stone and manufactured cladding options to find the most suitable replacement to the Tennessee marble of the existing building.

The photos on this page document hysteresis, or warping, of the existing stone cladding. This process was exacerbated by the application of spray foam insulation on the back face of the exterior stone panels, which trapped moisture at the interface with the insulation. Exposure to the exterior allowed water to evaporate, causing differential expansion conditions within the section of the facade material.

June 2016 Concept CFA Report and Commission Response

Smithsonian Institution
National Air and Space Museum
The analysis of cladding alternates included consideration of a wide range of options in order to find the material that best suits the extensive performance criteria. The images shown here are renderings of the museum based on a photograph of the southwest elevation, with a digital application of scanned images of the various materials.

The Tennessee Pink Marble rendering represents a replacement of the existing stone cladding with a thicker panel. Among the alternate stones being considered are materials that have a similar pattern or tone to Tennessee Pink Marble, as well as numerous technical advantages. The curtain wall jamb detail could be developed to help mitigate the visual contrast between the new exterior cladding and the existing Tennessee marble to remain on the interior of the north atrium galleries.

The analysis of man-made materials included the study of ceramic and titanium panels among others. Both materials offer a substantial duration of usable life, but do not meet the performance criteria for 100 years. Although there is a benefit of using such lightweight materials that include contemporary, technological associations similar to that of the exhibits within the museum, their monochromatic appearance lacks the visual randomness and scale-giving modulation of the existing cladding. Further, a man-made material would significantly alter the character of the building, and was considered the least desirable option by the DC HPO and the Smithsonian's preservation office.
Following the analysis of over 80 different stones and numerous manufactured materials, a list of four different cladding options was identified as the most worthy of consideration as the selected material based on the extensive criteria noted on the previous pages in this report.

A summary of each of the four short-listed cladding materials is documented in this section, including the information and images listed below.

- Advantages and Disadvantages -- based on aesthetic, technical, and procurement criteria
- Detail Photo -- image provides an indication of the appearance of the material as photographed at close range, formatted not to scale
- Photomontage -- digital representation of an 80' x 80' facade (approximate dimensions of the northern half of the NASM east elevation), based on photos of the applicable stone panels used in the cladding aesthetic mockups installed at NASM
- Comparable Examples -- photos of similar installations are provided where applicable; in some cases, “other examples” are referenced in lieu of a relevant precedent
- Quarry Photo -- shows an areas where at least some of the material would be extracted

### CLADDING OPTIONS CONSIDERED:

**Tennessee Pink Marble**
The existing cladding on the museum offers aesthetic benefits, however the failing state of the installation is indicative of its technical limitations as exacerbated by the existing wall assembly. Whereas the technical limitations could be mitigated with proper detailing, an exemplar installation has not yet been identified that demonstrates the successful long term performance of Tennessee marble on a steel frame without masonry backup as would be required with the cladding replacement at NASM. Acquiring new Tennessee marble may impact the project schedule.

**St. Clair Limestone**
The horizontal veining pattern for St Clair limestone is similar to that of Tennessee Marble, and available at relatively lower risk to schedule impacts. However the lack of a warm tone similar to Tennessee marble was noted during the agencies’ review of the cladding aesthetic mockup. St Clair is available with a beige tone (as integrated into the photomontage, but not in the aesthetic mockup), however there would not be sufficient quantity to clad the entire museum with beige St Clair. As a limestone, St Clair has technical disadvantages as a rain screen cladding relative to granite.

**Echo Lake Granite**
As a granite, Echo Lake offers the advantages of a material that is more dense and durable than limestone in a rain screen cladding application. Due to its warm tone similar to Tennessee marble, a limited number of Echo Lake panels were installed in the NASM facade in 2014 as a replacement for existing cladding panels with a substantial degree of visual integration when seen from a distance. However the pronounced flueri pattern and broad range of color that would be required when applying Echo Lake to the entire facade due to the availability creates a significant amount of variegation.

**Colonial Rose (aka Lac Du Bonnet) Granite**
Colonial Rose combines the technical advantages of granite, with the aesthetic benefit of a warm tone that is void of a pronounced flueri pattern. It was recently installed across the National Mall from NASM at the National Gallery of Art East Building roof terrace in a planter wall cladding and paver application in lieu of Tennessee marble. Although it is typically installed with consistent tone and pattern, tonal variety and accent color bands are available to help establish the visual modulation of the existing facade as an important characteristic of the original design.

### CLADDING OPTIONS CONSIDERED AND DISMISSED:

**Ultra High Performance Concrete (UHPC)**
UHPC was installed in the cladding aesthetic mockup as the only manufactured material, but was later dismissed due to numerous concerns, and thus is not included in the following pages of cladding replacement options summary. The capability to reuse a portion of the existing Tennessee marble cladding as a non-structural aggregate was an advantage with UHPC, in addition to substantial durability, high density, and customizable color and tone. However, this material is relatively new with a longevity that is promising but as yet unproven as a 100 year rain screen cladding. Further, the replacement of the existing stone cladding with a manufactured material was objectionable among some of the design review agencies with preservation concerns, and may not be compatible with monumental, iconic buildings on the National Mall. Additional quality control requirements were also considered problematic.
Cladding Replacement Options
National Mall Building Envelope and HVAC Revitalization

Tennessee Pink Marble

Advantages:
• Matches existing exterior cladding in kind (warm color tone and fine linear veining pattern modulates scale of monolithic façade) and intended to match National Gallery of Art West Building
• Matches existing interior wall cladding that will remain
• High density, durable limestone (100+ year stone longevity when installed with 3” thickness and properly detailed wall section)

Disadvantages:
• Procurement will include time for quarry start-up and longer fabrication schedule
• Broad color range requires more extensive quality control
• Requires less aggressive cleaning process to avoid surface damage
• Less resistant to pollutants, and surface mold and algae growth
• Fabrication facility does not have space available for on-site dry lay of facade

Comparable Example: National Gallery of Art East Building on the National Mall in Washington, DC, Opened in 1978, Sandblasted Finish

Recently expanded Tennessee Pink Endsley Quarry in Friendsville, Tennessee
St Clair Quarry in Marble City, Oklahoma

Cladding Replacement Options

St Clair Limestone
Smithsonian Institution
National Air and Space Museum

Advantages:
- Fine, linear veining pattern comparable to Tennessee marble
- High density, durable limestone (100+ year stone longevity)
- Fabrication facility has space available for on-site dry lay of facade

Disadvantages:
- Light grey color tone is too grey and not appealing for the large areas of stone involved on the NASM exterior facade
- Less resistant to pollutants, and surface mold and algae growth
- Requires less aggressive cleaning process to avoid surface damage

St Clair Sample
St Clair Photomontage

Comparable Example: Pioneer Building in Oklahoma City, Oklahoma, Opened in 1906, Sandblasted Finish

St Clair Quarry in Marble City, Oklahoma
Echo Lake Granite

Smithsonian Institution
National Air and Space Museum

Echo Lake Granite Sample

Advantages:
- Warm tone (when dry) comparable to Tennessee marble
- High density, durable granite (100+ year stone longevity)
- Best cost value
- Resistant to pollutants, and surface mold and algae growth
- Allows more aggressive cleaning process
- Fabrication facility has space available for on-site dry lay of facade

Disadvantages:
- Fine, linear veining pattern not present (busy swirling texture that is less compatible with interior Tennessee Pink)
- Broad range of color and pattern requires more extensive quality control
- Darkens considerably when wet

Echo Lake Quarry in Ely, Minnesota

Other Example: Granite Community Bank in Cold Spring, Minnesota, Opened in 2003, Sandblasted Finish
Cladding Replacement Options
National Mall Building Envelope and HVAC Revitalization

Colonial Rose (aka Lac Du Bonnet) Granite

Advantages:
- Warm tone comparable to Tennessee marble
- High density, durable granite (100+ year stone longevity)
- Local precedent on the National Mall; installed at the National Gallery of Art East Building roof terrace planters and pavers as a substitute for Tennessee marble
- Bands of color accents could be arranged in a horizontal orientation
- Best cost value
- Resistant to pollutants, and surface mold and algae growth
- Allows more aggressive cleaning process
- Fabrication facility has space available for on-site dry lay of facade

Disadvantages:
- Fine, linear veining pattern not present

Comparable Example: BYU Museum of Art in Provo, Utah, Opened in 1993, Honed Finish


Colonial Rose Quarry in Lac du Bonnet, Manitoba

Colonial Rose Panel, National Japanese American Memorial
Colonial Rose Photomontage

Comparable Example: BYU Museum of Art in Provo, Utah, Opened in 1993, Honed Finish

Comparative Example: Colonial Rose (aka Lac Du Bonnet) Granite
Proposed Cladding: Colonial Rose Granite

Colonial Rose is the most appropriate selection for the cladding replacement of the National Air and Space Museum as it most effectively meets the goals of the project. The aesthetic, technical, and procurement criteria are accomplished as listed below.

- Warm tone comparable to Tennessee marble
- High density, durable granite (100+ year stone longevity)
- Can be installed 2” thick, which is thinner and lighter than limestone, allowing corresponding reduction in frame reinforcing
- Successfully installed at the National Gallery of Art East Building roof terrace as a substitute for Tennessee marble
- Tonal variation among adjacent panels modulates facade
- Bands of color accents could be arranged in a horizontal orientation similar to linear veining
- Relatively low impact to project schedule
- Resistant to blue green algae and pollutants
- Allows more aggressive cleaning process
- Fabricated within the United States
- Full fabrication infrastructure is installed as of today
- Extensive quantity and fabrication capability available, reducing risk for procurement
- Fabrication facility has space available for on-site dry lay of facade
- Fabricator has demonstrated that the procurement schedule can be accommodated
- Stone recovery rate (quarry yield) is 30% to 35%, highest among the short-listed cladding options documented in this report
- Least complicated quality control required for panel materials among the short-listed cladding options documented in this report
- Good availability for future selective replacement

Colonial Rose Granite Cladding Proposal and Visualization

Smithsonian Institution

National Air and Space Museum
Selected Cladding

Colonial Rose Granite Exterior Renderings

Partial North Elevation with North Vestibule Option

Building Section with Colonial Rose Cladding Applied to Exterior and Existing Tennessee Marble Cladding to Remain on the Atrium Interior

Full North Elevation with North Vestibule Option

Smithsonian Institution
National Air and Space Museum
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## Paving Replacement

### National Mall Building Envelope and HVAC Revitalization

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  - Concrete Pavers: 41
- Northwest Corner Pavers Option Renderings: 42
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Paving Stone Options Considered

Smithsonian Institution
National Air and Space Museum

The paving option summary is being presented for information as an update on the project development, but is not being submitted as a proposal as part of this report. The paving material proposal will be submitted with the forthcoming revised concept design for the updated site design.

The analysis of paver materials is summarized in this section with the shortlist of five different options considered for selection. This list was culled from a broader range initially studied, which was later informed by the 6 options included in the cladding and paving aesthetic mockup. The existing Stoney Creek paving has been added for consideration as a value engineering option.

A summary of each of the five short-listed cladding materials is documented in this section, including the information and images listed below.

- Advantages and Disadvantages -- based on aesthetic, technical, and procurement criteria
- Detail Photo -- image provides an indication of the appearance of the material as photographed at close range, formatted not to scale
- Comparable Examples -- photos of similar installations are provided where applicable; in some cases, “other examples” are referenced in lieu of a relevant precedent.

PAVING OPTIONS CONSIDERED:

Stoney Creek Granite
The existing paving currently installed at NASM is Stoney Creek granite. This was introduced to the site in 1986 to replace the concrete pavers that were installed as part of the original construction, but had substantially deteriorated. Correspondence with HOK included the statement that the original design intent was for granite pavers, however the lowest bidder won the commission based on the substitution of concrete for granite. The selection of Stoney Creek was based on its use elsewhere on the National Mall at the time, according to anecdotal evidence. Whereas the brightness of the tones and intensity of the pattern of the Stoney Creek paving visually dominates the existing Tennessee marble cladding, it may be better suited for granite cladding proposed as Colonial Rose in this report.

Chester Grey Granite
The use of grey paving may be more compatible with pink cladding than pink paving. Chester Grey has a darker tone than the other grey paving materials referenced in this section, with limited discernible pattern.

Chelmsford Grey Granite
Chelmsford Grey has a lighter tone than the other grey paving materials referenced in this section, with linear veining pattern.

Hanover Prest Paver “Natural” Concrete Pavers
The use of concrete is being explored as a means of incorporating the reuse of the existing Tennessee marble cladding as an aggregate. The Hanover Prest Paver “Natural” has a lighter grey tone than the other concrete paver referenced in this section. Earlier considerations included the use of a less durable paving material such as concrete if it is to be discarded in approximately 30 years when the terrace plaza waterproofing is to be re-installed, however it was determined that stone can be reused, as facilitated by the specification of a sand-cement setting bed in lieu of a bituminous setting bed.

Hanover Prest Paver “Limestone Grey” Concrete Pavers
The Hanover Prest Paver “Limestone Grey” has a darker grey tone than the other concrete paver referenced in this section, and can also receive Tennessee marble aggregate as a reuse of the existing cladding.
1.2.3. STONE PAVING

Original Design and Existing Conditions

It is believed that the original design intention for the paving was a stone paver. However, it is known that an exposed aggregate, concrete paver was ultimately installed as the terrace paving, a decision that was likely influenced by budget concerns. By the mid-1980s, less than ten years after the opening of the museum, the concrete pavers had begun to show noticeable signs of failure. In 1986, during the construction of the restaurant addition, all concrete terrace pavers and stairs were replaced with Stony Creek granite pavers. The 30"x30"x2" Stony Creek terrace pavers and stairs were replaced with Stony Creek granite pavers exist on the terrace today.

Stony Creek is a reddish-pink granite with a dynamic color composition that includes variegated black and white elements. The stone is sourced from a quarry by the same name in Branford, Connecticut.

Performance Criteria

The exterior paving assemblies must meet the following performance criteria:

- Integrity in strength and durability
- Ability to bear the 60' boom lift
- Flexible assembly to allow pavers to be easily lifted and reused
- Continuous drainage surface
- Hand tight joint for accommodation of heels and wheels
- Skid and slip resistance
- Relatively easy to maintain
- Resistance to staining and weathering
- Resistance to surface wearing in consideration to heavy foot traffic
- Large and small module size to accommodate pedestrian and large vehicles respectively
- An appropriate albedo ratio that balances the reduction of heat island and sunlight glare

Aesthetic Criteria

The aesthetic criteria for the exterior paving material as outlined below:

- A muted character that doesn’t compete with the liveliness of the building cladding stone
- Continuity in color and texture
- Applicable for on-structure terrace
- Maintain the monumental appearance of the historic place
- A paving module that will integrate with the building cladding and planter wall module
- Consideration that the proposed paving module and pattern have been approved by CFA, NCPC and SHPO

Paving Material Option Analysis

Twenty-three North American stones and two concrete pavers were analyzed in search for a paver that met both the established performance and aesthetic criteria. Ultimately these options were narrowed to three granites, including the reuse of the existing Stony Creek (2” thickness) and one concrete paver.

Current structural analysis indicates that a 3” thick paver is necessary to support the maintenance vehicle (60’ boom lift) point load. The large vehicle access corridor along the western end of the building requires a 4” paver and a smaller unit size to support the point loads of exhibit transport vehicles.

<table>
<thead>
<tr>
<th>Paving Stone</th>
<th>Building Stone Options</th>
<th>Type</th>
<th>Image</th>
<th>Color</th>
<th>Compressive Strength Psi</th>
<th>Absorption by Weight (%)</th>
<th>Country source</th>
<th>Samples finish received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone Paver</td>
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<td>Stony Creek (reuse existing)</td>
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<td>Hanover Prest Paver - ‘Natural’</td>
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<td>Hanover Prest Paver - ‘Limestone Gray’</td>
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<td></td>
</tr>
</tbody>
</table>

Paving Stone Research Matrix
Advantages:

- The existing stone can be re-used, perhaps with some cost savings – to be confirmed
- Square pattern and east-west running bond paving pattern matches HOK 1970’s hand-drawn paving sheet but provenance of that sheet is unknown with respect to original design and execution – to be confirmed (Section 106 issue)

Disadvantages:

- Color varies from tan, yellow to pink, may compete with pink building stone options - Tennessee Pink, Echo Lake and Colonial Rose
- Cost of lifting, moving, storing, cleaning, moving back to site and replacing stone pavers needs to be confirmed
- Existing pavers are 2” thick and 3” is proposed to meet the structural load capacity of service vehicles on the main terrace
- Ability to match both finish and character of existing pavers, once cleaned, to new pavers of the same stone and finish, is unknown; some variation can be expected
- Square pattern of existing pavers does not match the CFA/NCPC/SHPO approved paving design, which proposes a similar east-west running bond pattern of pavers cut in a module related to that of the building and landscape wall cladding

Existing Paving Stone - Stoney Creek

Comparative Example:
Stoney Creek Granite, National Air and Space Museum, SW service corridor
Advantages:
• 3” proposed thickness meets the structural load capacity of service vehicles on the main terrace
• Proposes a similar east-west running bond pattern of pavers cut in a module related to that of the building and landscape wall cladding
• Dark Grey color has complementary natural ‘liveliness’ appropriate to the pink building stone options - Tennessee Pink, Echo Lake and Lac Du Bonnet
• Re-useability: can be lifted and put back when replacing the waterproofing
• Compared to concrete paver, granite is less likely to chip, crack, higher resistance to staining

Disadvantages:
• Higher initial cost compared to concrete paver
Paving Stone Options - Chelmsford Grey

Advantages:
- 3” proposed thickness meets the structural load capacity of service vehicles on the main terrace
- Proposes a similar east-west running bond pattern of pavers cut in a module related to that of the building and landscape wall cladding
- Light Grey color has complementary natural ‘liveliness’ appropriate to the pink building stone options - Tennessee Pink, Echo Lake and Colonial Rose
- Re-useability; can be lifted and put back when replacing the waterproofing
- Compared to concrete paver, granite is less likely to chip, crack, higher resistance to staining
- Low SRI contributes to heat island effect reduction

Disadvantages:
- Higher initial cost compared to concrete paver

Comparable Example: CLADDING: Tennessee Pink - sandblasted finish
PAVING: Chelmsford Grey granite (Note: photo taken in shade)
**Paving Replacement**

**National Mall Building Envelope and HVAC Revitalization**

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**Paving Stone Options - Concrete Pavers**

*Smithsonian Institution*

*National Air and Space Museum*

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**Colonial Rose Cladding (not to scale)**

**Natural (not to scale)**

**Limestone Grey (not to scale)**

---

**In Comparison to Stone Pavers**

**Advantages:**
- Lower initial cost
- Custom mixes likely available to integrate recycled building stone or to make the most complementary match with the proposed building stone
- Designed with 'tabs' for interlocking moment

**Disadvantages:**
- More difficult to match 'lively' stone façade
- Likely higher life cycle cost (replacement, repair)
- Less durable; more likely to chip, crack; more wastage when lifted
- Less resistance to staining and weathering; more porous
- Less likely to carry 'character' and aesthetic for life of the slab
- Typically beveled edges, reduces tight rectangular feel, tougher on heels and wheels
- Bevel can be removed by grinding the entire surface of the paver, resulting in custom costs and a thinner paver
- Surface grinding may require sealing
- Bevels create more open joints / transition issue at top and bottom of gentle walkways
- When pavers are saw-cut to fit, bevel is put on cut edge by on-site grinding – less control
- Interlocking tabs mean wider joint - which must be filled (typically with sand)
Cladding and Paving Visualizations

Colonial Rose Granite/Stoney Creek Pavers

Colonial Rose Granite/Chester Stone Pavers

Colonial Rose Granite/Chelmsford Pavers

Northwest Corner Pavers Option Renderings

Smithsonian Institution
National Air and Space Museum
Cladding and Paving Visualizations
National Mall Building Envelope and HVAC Revitalization

North Entrance Pavers Option Renderings

Colonial Rose Granite/Stoney Creek Pavers

Colonial Rose Granite/Chelmsford Pavers

Colonial Rose Granite/Chester Stone Pavers
APPENDIX A: Initial Cladding Matrix
National Mall Building Envelope and HVAC Revitalization

Concept Design Report Cladding Matrix

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Smithsonian Institution
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## National Mall Building Envelope and HVAC Revitalization

### Concept Design Report Cladding Matrix

#### Smithsoniend Institution

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- **Reinforcement for Weight:**
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required
  - Required

- **Adhesion to Other Backup Systems:**
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult
  - Difficult

- **Recommended Endurance System:**
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - No
  - No
  - No
  - No
  - No

**Notes:**

- **Material:**
  - Natural
  - Manufactured

- **System:**
  - Cladding on Existing Stone
  - Cladding on Existing Panel

- **Additional:**
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes

- **APPENDIX A: Initial Cladding Matrix**

- **NCPC Revised Concept Report: Cladding Proposal Submission**
  - 28 June 2017

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**Source:**

- NCPC Revised Concept Report: Cladding Proposal Submission | 28 June 2017

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APPENDIX B: Global Stone Research List

National Mall Building Envelope and HVAC Revitalization

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<table>
<thead>
<tr>
<th>Stone Name</th>
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### Global Stone Research List

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APPENDIX B: Global Stone Research List

Stone Filtering Matrix

Smithsonian Institution
National Air and Space Museum
APPENDIX C: Cladding and Paving Aesthetic Mockup

National Mall Building Envelope and HVAC Revitalization

Cladding Aesthetic Mockup Isometric

- **TENNESSEE PINK MARBLE**: Under skylight at all locations.
- **ECHO LAKE**: Textured finish
- **CHESTER GREY**: Thermal finish
- **HANOVER PREST PAVER**: "Natural" color, Tudor finish, "Limestone Gray" color, Tudor finish, "Natural" color, Tudor finish, "Natural" color, Tudor finish
- **SKYLIGHT**: Double paneled glazing with 26% VLT, 50% frit
- **CHELMSFORD**: Thermal finish
- **ST. CLAIR LIMESTONE**: Thermal finish

**NOT TO SCALE**

Smithsonian Institution
National Air and Space Museum
APPENDIX C: Cladding and Paving Aesthetic Mockup

National Mall Building Envelope and HVAC Revitalization

Existing Tennessee Marble
East Elevation

Tennessee Marble Mockup
North & East Elevations

Tennessee Marble Mockup
South & West Elevations

TENNESSEE MARBLE COLOR RANGE KEY


Tennessee Marble Existing Cladding and Mockup

Smithsonian Institution
National Air and Space Museum
APPENDIX C: Cladding and Paving Aesthetic Mockup
National Mall Building Envelope and HVAC Revitalization

St Clair, Echo Lake, and UHPC Mockups

St Clair Mockup
South & East Elevations

Echo Lake Mockup
South & West Elevations

UHPC Mockup
South & West Elevations
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Echo Lake Mockup - Select Range
A second mockup of Echo Lake was installed to demonstrate a select range of panels that exhibit more of the targeted color range, and less of the pronounced fleuri pattern relative to the initial Echo Lake mockup. The select range would represent 25% of the total building cladding, with the remaining 75% of the cladding represented by the initial Echo Lake mockup.

Colonial Rose Mockup
Mockup represents the more consistent color tones with limited pattern available. If selected, the design intent is to incorporate more tonal variation and pattern to modulate the facade for a more human scale.

Echo Lake and Colonial Rose Supplemental Mockups
<table>
<thead>
<tr>
<th>Cladding Type</th>
<th>Finish Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tennessee Pink</td>
<td>Sandblasted</td>
</tr>
<tr>
<td>Colonial Rose</td>
<td>Sandblasted</td>
</tr>
<tr>
<td>Tennessee Pink</td>
<td>Sandblasted</td>
</tr>
<tr>
<td>Chelmsford Grey</td>
<td>Thermal</td>
</tr>
<tr>
<td>Chester Grey</td>
<td>Thermal</td>
</tr>
</tbody>
</table>

Colonial Rose Cladding With Paving Pairings
APPENDIX C: Cladding and Paving Aesthetic Mockup

National Mall Building Envelope and HVAC Revitalization

Colonial Rose Cladding With Paving Pairings

Colonial Rose Cladding with Chelmsford Grey Granite Pavers

Colonial Rose Cladding with Concrete Paver ‘Natural’

Colonial Rose Cladding with Concrete Paver ‘Limestone Grey’

Colonial Rose Cladding with Chester Grey Granite Pavers