

# RISING *TO THE* CHALLENGE:

## Roofing Rehabilitation of the New York State Capitol

By  
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and  
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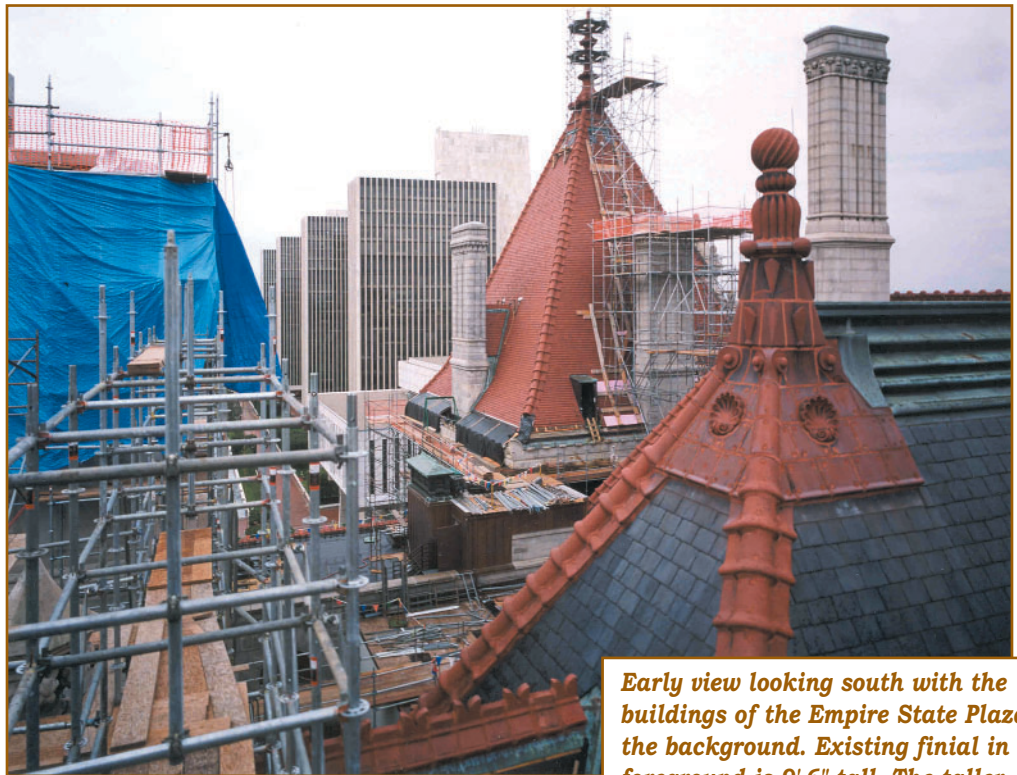
*West facade of the NYS Capitol, Albany, NY, showing the roof project work area. The work platform at the eave of the corner tower (right side) is 185' above grade.*

### A Daunting Task

Consider a list of single conditions that can make any roofing project significantly more challenging:

- Complex roof geometries and conditions
- A plethora of different roofing materials
- Extremely steep roof slopes
- Difficult access
- Lack of knowledge of the original roof structure with heavy construction loads on the roof
- A long history of chronic leakage problems
- Generations of failed attempts to correct leakage problems
- Interior usage that is sensitive to leakage in a building occupied by prominent, powerful individuals
- An historic building with strict review of the proposed reroofing to ensure that the roof appearance remains unchanged

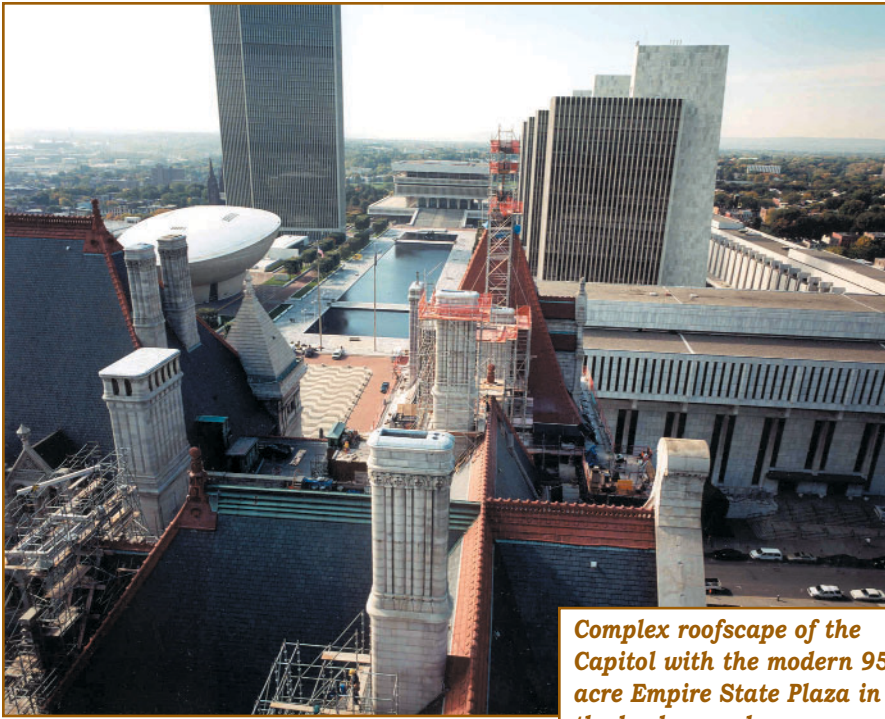
Now imagine all these conditions on one single building, and you have a reroofing project that promised to be, at best, a great



*Early view looking south with the buildings of the Empire State Plaza in the background. Existing finial in the foreground is 9'-6" tall. The taller corner finial in the background is 22'-6" tall, but has already been removed.*

challenge to the owner, designer, and contractor, and at

worst (and perhaps more likely) a nightmare that they would all prefer to forget. Through the hard work and diligence of all



**Complex roofscape of the Capitol with the modern 95-acre Empire State Plaza in the background.**

Group undertook the restoration of the monumental terra cotta tile roof ornament as part of a multi-phased roof rehabilitation program at the Capitol. The work was critically necessary to correct leaking problems that plagued the building since before its completion in 1899. The Office of General Services and its consulting design engineer, Simpson Gumpertz & Heger (SGH) of Waltham, MA, along with Titan Roofing Inc. of Chicopee, MA, and its masonry subcontractor, Monaco Restorations Inc., of Sturbridge, MA, began construction work in April 2000, after publicly bidding the project.

### **The Mission of the Project**

The goal of the project was an aggressive program of replacement to provide the most durable roofs possible. There are sixteen distinct roof areas comprised of built-up roofing, clay tile, monumental terra cotta decoration, single ply and liquid-applied membranes of various types (some concealed under concrete wearing slabs), slate, copper, modified bitumen, and even stone (yes, granite roofing). A major component of the re-roofing was the replication of over 274 different shapes of architectural terra cotta tile. The centerpiece of the project was the reconstruction of a monumental, steeply sloping 3,000-square-foot skylight and restoration of an interior domed laylight over the capitol's Great Western Staircase.

involved, this article describes the former: a great success story in rising to meet formidable challenges on the comprehensive roofing rehabilitation of the New York State Capitol in Albany.

Guided by *The Master Plan for the New York State Capitol* (1982), the Office of General Services Design and Construction

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## The Challenges of the Project

The New York State Capitol Building was designed by a series of architects, including H.H. Richardson and Leopold Eidlitz, and built in various stages between 1867 and 1899. The building is a National Historic Landmark and one of New York State's most

iconic buildings. On the other hand, the building is not a museum, but a true working building that is always busy and crowded as the home of state government.

The roofing project had to meet the requirements of the U.S. Secretary of the Interior's Standards for the Treatment of Historic Buildings. The appropriateness of the design was carefully reviewed by the New York State Office of Parks, Recreation, and Historic Preservation and the Commission on the Restoration of the Capitol. The historic appearance of the Capitol, especially of its signature terra cotta ornamental roof tile, had to remain unchanged. Throughout the entire project, the Capitol was fully occupied as an active seat of government. Not only was the roofing project highly visible to the many tenants of and visitors to the building, but also to the New York State legislature and Governor George E. Pataki, who reports to work each day in the Capitol.



**Existing ornamental terra cotta corner "ram's horn." This piece weighs 275 lbs. and is one of four corner pieces and four center sections that make up the base decoration of the large finials.**

In addition to the diagnosis and design challenges, access to the roof and logistics of construction also presented many obstacles. First, there was the building itself: the job required working up to 220 ft. in the air on steeply sloping roofs with a 24:12 pitch. Since there is no direct access to most work areas, all materials to be removed or delivered had to be hoisted to the roof edge and then hand carried to their final destination. The staging and scaffolding had to jog to follow the work areas up and around the



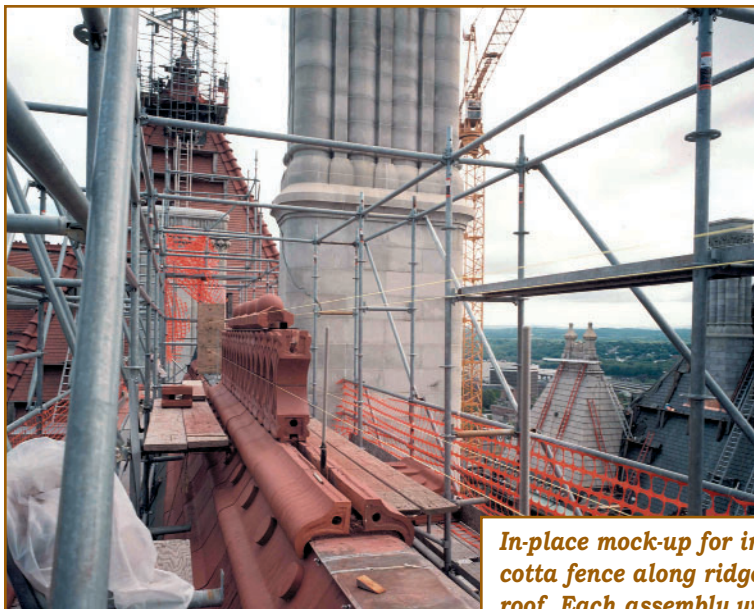
**Existing terra cotta roof tiles removed from the roof hips. These tiles are 22" long and weigh 70 lbs.**

many roofs of the Capitol. In order to safely remove the terra cotta tile with minimal damage (some pieces weighed up to 425 pounds), the project team had to understand how the roof was originally constructed at the end of the 19th century.

## The Details of the Project

Diagnosis of the roofing failures and leakage paths was essential in solving chronic leakage problems. Given the difficult access to the roofs, their steep slopes, and the lack of scaffolding on site during the design phase, the design team used industrial rope access techniques to scale and descend the roofs. The team also designated calibrated water tests and partial disassembly of roof and wall components to diagnose failures and leakage paths, and thus ensure that the new design would solve the chronic problems.

Following initial field investigations and laboratory analysis, the design team concluded that existing terra cotta ornaments along the ridges, hips, and finials of the Capitol (including some of the last remaining original roof materials), were in such poor condition that reuse was unfeasible.



**In-place mock-up for installation of terra cotta fence along ridge of west central roof. Each assembly was mocked-up first, reviewed, and then fine-tuned before approval to install was given.**

*Shell detail from the lower section of finials, new on the left, old on the right. Each shell weighs approximately 75 lbs. and is 28" across.*



the geometry of the concealed portion of the tile for improved attachment and waterproofing details. The new terra cotta tile attachment assemblies integrated custom fabricated steel components to interconnect with off-the-shelf materials, including salvaged and re-used flat clay tiles.

### **The Replication of the Terra Cotta Tile**

Before the existing tiles were removed, their configuration on the roof was carefully documented. All tiles were measured and labeled in place, and all 274 representative types and mounting conditions were photographed. Once this documentation was completed, the tiles were removed and shipped to the terra cotta manufacturing plant.

Since the original construction of the Capitol, little has changed in terra cotta manufacturing tech-

ble. Other technical considerations dictated removal of the tiles. Originally intended merely as a rain screen over an unfinished attic, the large tiles had wide lap joints between individual units, which, along with the transition joint between the terra cotta cresting and the clay tile and slate roofs, had caused leaks into attic spaces for decades. Generations of roofers working on the Capitol had tried unsuccessfully to stop the leakage by applying yet more layers of sealant over the tiles.

When the building was first constructed, terra cotta was a popular roofing material, and dozens of manufacturers produced high-quality product. Today, only three plants in the U.S. produce custom fabricated architectural terra cotta in sufficient quantities for a project of this size and stature. Because of the limited availability of terra cotta, the design team briefly reviewed alternatives, including cast aluminum, fiber-reinforced concrete, and glass fiber reinforced plastics. While each of these materials has some benefits and drawbacks, the team eventually decided that lack of authenticity made these products inappropriate for use on the Capitol, a registered National Historic Landmark. After reviewing the capabilities and products of the remaining major American terra cotta manufacturers, the team concluded that the hundreds of individual terra cotta shapes needed for the Capitol could be remanufactured.

All the new pieces of terra cotta tile were reproduced from existing pieces taken from the roof; their color, texture, and geometry exactly matching the old. Some adjustments were made to



*Ice and water membrane goes on over steel brackets. Threaded bolts sticking through membrane are for attaching the steel support struts to which barrel tiles will be later attached. Notice shingling-in of lead flashing.*

nology, which combines the science of ceramics with the art of sculpting intricate ornament. The first task of the terra cotta makers was to construct a solid wooden model, approximately 12% larger than true size of each piece, to account for shrinkage during the various stages of the production process. Some of the old tiles were so badly damaged that model builders had to carefully assemble a jigsaw puzzle of shards and pieces before they could construct their wooden models.

Next, the wooden model was sent to the mold making shop where a plaster negative mold was made. The plaster mold finally

received the clay - a mixture of clay quarried from the site that was mixed with shale (whose iron content gave the terra cotta its rich, red color), water, and grog. Grog - ground up fired terra cotta tile - was put in the mix to help control shrinkage. The clay mixture was packed by hand into the plaster molds. The pieces were allowed to set and dry for approximately two to three days before they were turned out of the mold and left to air dry for one to two weeks, depending on the size of the piece. During this air-drying process, the pieces shrink by about 6%.

Following the initial air drying, surface detailing, glazing, drilling of required attachment holes, and final fine-tuning to the geometry of the "green" unfired clayware were done. Finally, the pieces were moved by hand to gas-fired beehive kilns, where they were fired for up to 14 days. The final 6% shrinkage occurred during the firing.

But making large-scale, monumental pieces of architectural terra cotta is definitely more art than science. Making a perfect or even an acceptable piece of monumental tile was a challenge. Making multiple copies proved to be nearly an impossible mission. Several factors contributed to these difficulties.

On the larger pieces, inconsistent shrinkage caused a great deal of unpredictability of the final geometry. Sometimes the shrinkage problems were attributed to difficulties with moisture migration in the large molds. Rotating the molds and even cutting "breathing holes" in the molds were attempted to help control the shrinkage process. Turning the huge pieces of unfired clay out of the molds brought about its own set of challenges. Even the simple handling of such large pieces, with the tendency to settle and deform under their own weight, was problematic.



*Corner tower hip roll installation nearly complete. Note every fifth tile with a silicone plug is removable.*

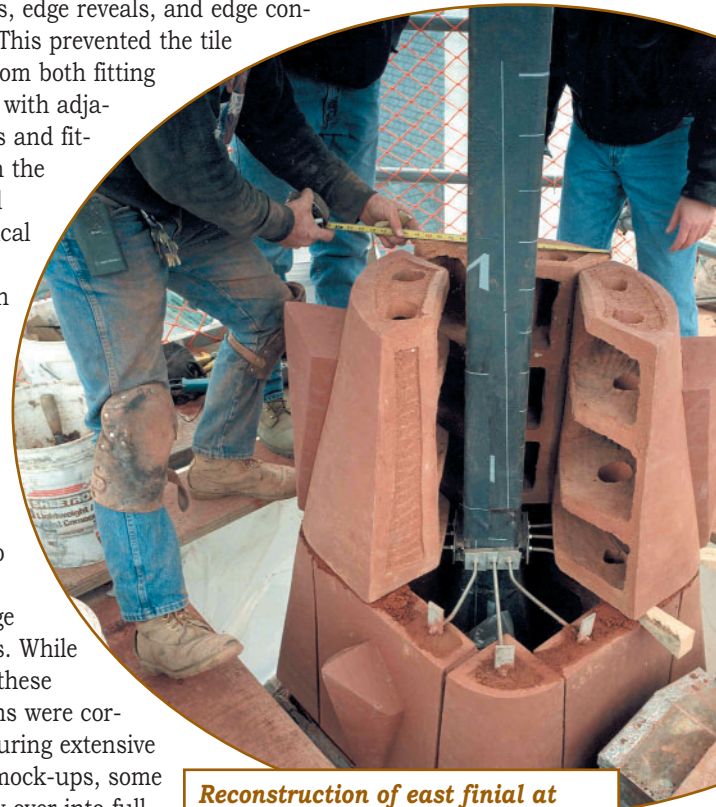
## INTERESTING FACTS ABOUT THE NEW YORK STATE CAPITOL

- The Capitol took 32 years (from 1867 to 1899) to build, and cost more than \$25 million in 1890 dollars.
- Even though Governor Theodore Roosevelt "declared" the Capitol complete on February 4, 1899, the building is still unfinished. Most notably, a tower was planned to rise another 85' beyond the large east central roof.
- The Capitol is the second largest load-bearing masonry building in the United States behind the Philadelphia City Hall, which has a tower.
- There were seven architects responsible for the design of the Capitol. In order, they are: Thomas Fuller, Leopold Eidlitz, Henry Hobson Richardson, Isaac Perry, Frederick Law Olmsted, Franklin B. Ware, and Lewis F. Pilcher.
- On March 29, 1911, the Capitol suffered a catastrophic fire, prompting calls for its demolition.
- The New York State Capitol is one of nine US capitols without a dome.



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There were difficulties with apparent random and unapproved deviations in the design and location of internal web stiffeners, edge reveals, and edge conditions. This prevented the tile pieces from both fitting together with adjacent tiles and fitting with the intended mechanical attachments on the roof. Some of these modifications were made as efforts to stabilize shrinkage variables. While most of these deviations were corrected during extensive on-site mock-ups, some did carry over into full production, requiring modifications to the attachment details.



***Reconstruction of east finial at ridge of skylight. New central steel mast and waterproofing membrane. Note both mechanical and mortar attachment details as new terra cotta tiles are installed.***

### **The Attachment of Massive**

### **Ornamental Tile at Hips and Ridges**

Remounting the massive, custom manufactured ornamental tile along the roof perimeters required a creative integration of waterproofing and structural engineering concepts. The original tiles had been held on the roof with a combination of bolts, wires, and mortar that prevented the removal of individual broken tiles. Over the years, remedial bolts fastened through the tiles caused additional leaks and contributed to tile breakage. One Capitol maintenance manager described pieces of tile sliding down the steep roofs and, fortunately, being caught in the large perimeter gutters before they could fall to the sidewalk below.

The revised tile attachment had to do many things: it had to be watertight, provide reliable attachment with corrosion-resistant components, allow replacement of individual tiles to facilitate future repair and maintenance, accommodate construction tolerances, and be relatively economical to construct. The final design included a special bent steel plate to transfer the load of the tile assembly (up to 100 lbs. per foot along the hips) to the roof's steel support framing. After the steel plate was covered with waterproofing membrane, short lengths of stainless steel struts were installed along the length of the plate. The attachment bolts for each strut were covered with a specially fabricated piece of copper counterflashing that in turn lapped under the strut above. This unique shingled system allowed the installation of the terra cotta

tiles with fasteners that were entirely out-board of the waterproofing membrane, while still providing for solid attachment and some adjustability to account for anticipated manufacturing variations among the tiles.

The waterproofing membrane, struts, and flashing could be installed in advance of the terra cotta tiles, so that the entire roof assembly was watertight prior to the installation of the terra cotta, which the design team expected would require long lead-times for fit-up and production. Extensive jobsite mock-ups were utilized



**Reconstruction of roof rake in preparation for waterproofing membrane and terra cotta barrel tiles.**

to finalize complicated details and enable potential problems to be discovered and corrected before full implementation.

### **A Terra Cotta Tile Success Story**

Restoration of the ornamental terra cotta tile was unusual in every way – in scale, complexity, and the thoughtful merging of technology and preservation. From working over 200' in the air on a steeply sloping roof, to finding the right materials and methods to assemble them, to being flexible and creative when unforeseen field conditions were encountered – this project successfully



**Copper flashing and steel support struts installed over concealed ice and water membrane. Copper flashing is shingled over support struts; terra cotta tiles will be attached to exposed part of support struts and thus never penetrate the copper flashing.**

## **PROJECT TEAM**

### **OWNER/CLIENT**

New York State Office of General Services  
Design and Construction Group  
Kenneth J. Ringler, Jr. - *OGS Commissioner*  
William F. O'Connor, AIA - *Deputy Commissioner for Design and Construction*  
James Jamieson, AIA - *Capitol Architect*  
Richard Hynes - *Engineer-In-Charge*  
David Butynski - *Assistant Building Construction Engineer*  
Trevor Chaisson - *Mechanical Construction Inspector*

### **PROJECT ENGINEERS**

Simpson Gumpertz & Heger Inc.  
Waltham, MA  
Kevin Cash - *Principal*  
Niklas Vigener - *Senior Project Manager*  
Susan Knack - *Senior Engineer*

### **CONTRACTOR**

Titan Roofing Inc.  
Chicopee, MA  
Fred Pazmino - *President*  
Mark Kucinski - *Project Manager*

### **SUBCONTRACTOR (MASONRY)**

Monaco Restorations, Inc.  
Sturbridge, MA  
Paul Monaco - *President*  
Alan Hasbrouck - *Project Supervisor*

### **SUPPLIER (TERRA COTTA TILE)**

Superior Clay Corp.  
Uhrichsville, OH  
Dana Martini - *Technical and Sales Representative*

### **COMMISSION ON THE RESTORATION OF THE CAPITOL**

Albany, NY  
Matthew Bender, IV - *Chairman*



**Completed skylight reconstruction. Notice top of laylight inside through the main skylight. All terra cotta tile ornament was replicated.**

brought all the aspects of preservation, restoration, and quality, innovative roofing together.

With tremendous teamwork, using the highest standards of quality for restoration and preservation, a wondrous landmark has been returned to its former significance and architectural splendor. The New York State Office of General Services, Simpson Gumpertz and Heger Inc., Titan Roofing Inc. and Monaco Restorations, Inc. are proud to be part of the new history and legacy of the New York State Capitol.

The Preservation League of New York State honored this project with its prestigious Excellence in Historic Preservation Award 2003. The project was the subject of a PBS documentary that premiered June 1, 2003, on WMHT Schenectady, NY (PBS) TV-17, entitled, "Flood of Light - Restoring New York's Capitol Roof." Other awards have included Best Architectural Improvement of the Capital Region for 2003 from the *Albany Times Union* newspaper and Best Interior Lighting from *Hudson Valley Magazine*, November 2003. ■

## ABOUT THE AUTHORS



**JAMES JAMIESON, AIA**

As the Capitol Architect for the NYS Office of General Services Design & Construction Group, **James Jamieson, AIA**, has the responsibility for all new construction, reconstruction, restoration, and preservation at the Capitol, the Empire State Plaza, and the Executive Mansion in Albany. He is also the agency's Historic Preservation Officer. Jim attended Carnegie Mellon University in Pittsburgh, PA,

where he received the bachelor of architecture degree in 1981. He is a licensed architect in New York. Jim is a commissioner on the Historic Commission, City of Schenectady, and member of the Downtown Albany B.I.D. Signage Task Force, the Mayor's Washington Park Lakehouse Task Force in Albany, the National Trust for Historic Preservation, the New York State Capitol Restoration Commission, the New York State Preservation League, and the Society of Architectural Historians. He has won awards from the Bomanite Corporation for Best Bomanite Project - Northeast Region, Silver Award in 1998. He also received the New York State Adirondack Park Agency's Special Recognition Award in February 14, 2000, and the New York State Division of Parole's Special Commendation on June 13, 2002.

**Niklas W. Vigener, PE**, joined Simpson Gumpertz & Heger Inc.'s Building Technology division in 1994. He received his B.S. in civil engineering from Clarkson University and his M.S. in structural engineering from the University of California at Berkeley. Vigener has been the project manager on many of Simpson Gumpertz & Heger Inc.'s most notable building technology projects.



**NIKLAS W. VIGENER, PE**

He led the historic consultation, investigation, and remedial design of various building envelope issues at Yale University's Sterling Memorial Library and the master plan condition assessment, historic consultation, and design of major building envelope rehabilitation at the New York State Capitol Building. Mr. Vigener has also designed a number of new structures, including water treatment plants and a composite steel frame airport terminal. He has authored publications concerning historical preservation and masonry and is an active member of a number of professional organizations, including the American Society of Civil Engineers, The Masonry Society, and the National Trust for Historic Preservation.