At the Heart of SCIENCE

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The newly renovated headquarters of "the Temple of Science in America" reinvigorates the exploration of the various branches of science.

THE HEADQUARTERS of the National Academy of Sciences (NAS), set along Constitution Avenue in Washington, D.C., has been home to the Academy since 1924.

At its dedication, President Calvin Coolidge declared the building "the Temple of Science in America." Over the years, there have been four additions and multiple minor renovations to accommodate engineering and circulation upgrades. The building, one of the few privately owned properties on the National Mall, was listed on the National Register of Historic Places in 1974.

An architectural gem, the NAS building is also a living monument to the nation's scientific and engineering achievements. However, following decades of use as an office, library, conference center, performing arts hall and art gallery, the building was showing its age. HVAC systems were dated and inefficient, the building envelope was in disrepair and finishes and fixtures were worn. The grand entrance overlooking Constitution Avenue had long been closed, and circulation, functionality and accessibility were compromised and ill-suited to the Academy's work and public outreach programs.

With a history of four separate construction periods, beginning with the 1924 Bertram Grosvenor Goodhue Hall and ending with the marble-clad Auditorium in 1970, a comprehensive $45 million modernization project began in 2007—construction started in 2010—to bring the headquarters into the 21st century by reorganizing the space and integrating the latest building technologies. Accomplishing this required careful coordination of new systems with existing elements while providing research and analysis to support the principles of historic preservation in the context of the building's unique heritage.

Public Spaces

The first floor of the building, which functions as the conference center and visitor area, was redesigned to expand conference space for NAS committees and other scientific groups. The reconfiguration also reintroduced two of the original art galleries and improved circulation and accessibility. Without substantially altering the footprint of the existing building, the design team was able to double the amount of meeting and support space in the building. This was accomplished by enclosing three exterior courtyards—the east, west and north courtyards—with steel-supported skylights to create new, climate-controlled areas for pre-function use, displays, dining and meetings. Each courtyard was treated with a distinct exposed structural steel-framed system to support the new glazing elements that enclose the spaces below; the systems



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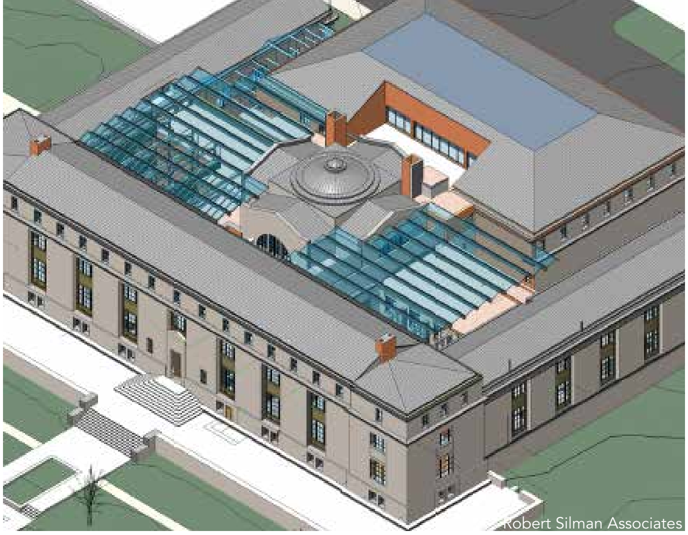

➤ An Autodesk Revit model showing architectural building elements for the renovation of the NAS building. Courtyard skylights are overlayed, showing the new enclosed spaces.

were created with horizontal rectangular HSS and diagonal round HSS members. This structural intervention, while functioning to create new, usable space, also provides a visual contrast between the new elements and the historic fabric of the surrounding marble and brick façades.

In addition, the skylights in the east and west courtyards support the project's efforts to achieve LEED Gold

▲ The National Academy of Sciences as viewed from Constitution Avenue at night.

➤ A view of the completed east courtyard enclosure, with queen-post trusses and stiffened tube columns supporting BIPV skylights and channel glass side lights.

certification and incorporate building integrated photovoltaics (BIPVs) to harvest solar energy and control daylight entering the spaces below.

By providing a stark contrast between the old and new, the historic materials and construction are highlighted, rather than obscured, a celebration of the building's past, present and future. New structural elements that are exposed to view were designed to be consistent with principles of historic preservation, and disturbances to the historic edifices that surround each space were minimized and detailed to be reversible. In keeping with this strategy, the new structural installations in each of the three courtyards are supported by slender circular HSS columns, strengthened with reinforcing fins, that provide a unifying visual element in the newly created spaces below. (Unlike the skylight framing, this steel, which is near the floor and easily viewable, was fabricated to Architecturally Exposed Structural Steel standards.) The new skylights in the east and west courtyards are supported, respectively, by steel queen post trusses and by a two-way grid of dendritic steel truss work, and both truss systems were constructed with rectangular and round HSS members. Joints at the bottom of the trusses were constructed with plates and pins to create a true pinned connection. The hybrid two-way grid and truss system of the west courtyard was the most challenging aspect of the steel design, as it became a balancing act between maintaining the required structural stiffness for load paths while achieving the light and airy aesthetic desired by the architect for the geometries of the member sections.

The north courtyard features a multi-pitch skylight supported on coped wide-flange beams (W16×100). Additionally, the north end of this courtyard, previously open to the street, was enclosed with a new 12-ft-tall vertically cantilevered bronze-clad entryway that references the bronze door and window frieze panels on the original south elevation of the Goodhue wing. Surrounding this new bronze portal is a glass curtain wall system that provides a transparent connection from the entrance to the sides of the courtyard. To accommodate differential movements between the various phases and building wings surrounding the courtyards, the design integrates both expansion joints and slide bearing-type connections.

Threading the Needle

As with the structural system, the complete modernization of the mechanical systems was implemented under a strict mandate that it work within the historic building. As a result, new building systems had to be routed through several congested spaces within the complex geometry of the existing building, particularly in the basement and attic. Penetrations were carefully coordinated through both concrete bearing walls in the basement and through masonry walls on the floors above. To reinforce these penetrations, a variety of steel strategies were implemented. The design of the lintels for the bearing walls in the basement was carefully coordinated with loading above and was governed by deflection to protect historic elements, including an impressive Guastavino tile dome. Deflection was limited as appropriate to prevent cracking and movement.

Roughly 12 new air-handling units and two cooling towers were added to the existing roof, adding a substantial amount of load. The weight of the units ranged from 2,500 lb to 25,000 lb, more than the capacity of the existing roof joists and steel girders. To support the extra weight, new steel wide-flange beams were added directly underneath the roof and framed into existing girders. The existing steel girders were reinforced with steel plates and WTs with sizes up to WT15×178.5, and riveted connections of the existing steel girders to the columns also had to be reinforced with welds.

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➤ A pinned truss joint connection during construction.

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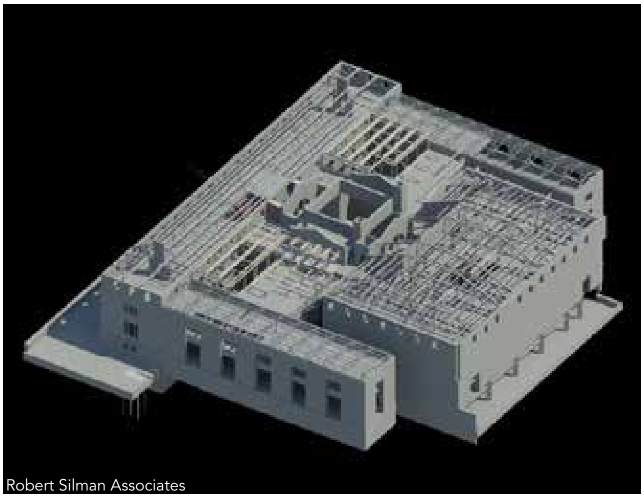
➤ The west courtyard. The project team introduced glass skylights with BIPVs and curtainwall enclosures to three existing open-air courtyards, reclaiming these as new two-story interior gathering spaces.



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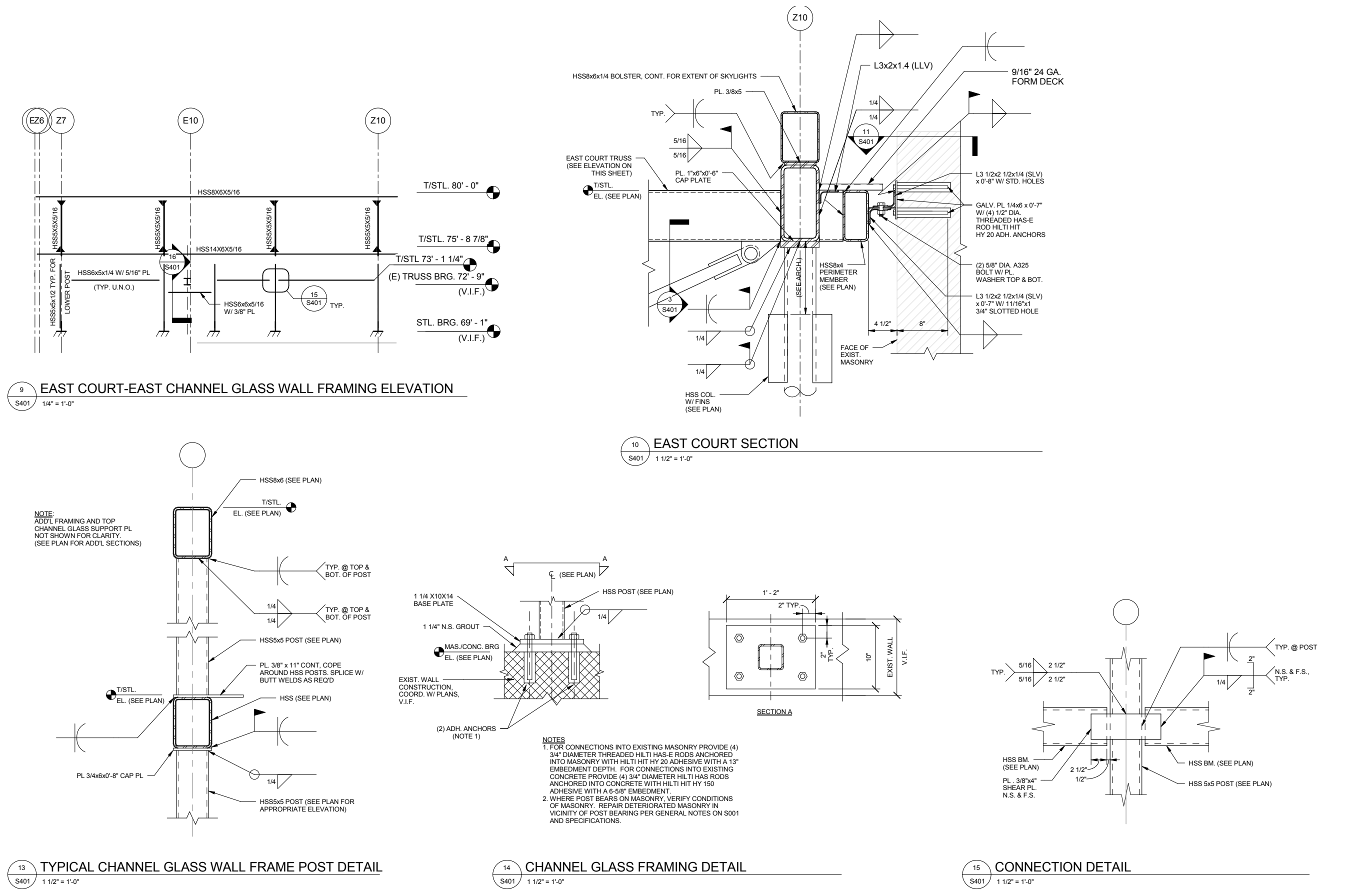
➤ A 3D model highlighting the existing framing with the new construction.



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Details of a pinned truss joint connection.

In coordinating this work, a survey of the existing conditions was performed during construction administration and after all demolition had occurred.

Air-handling units were also placed in the attic, which was framed with two-story-high steel trusses. These existing steel trusses were also surveyed and modeled to evaluate their capacity to support the units and associated miscellaneous steel. The dunnage was located at the panel points of the truss to prevent the need to reinforce the bottom chord.

Over the course of the project, building information modeling (BIM) was used to facilitate coordination between the structural, mechanical, electrical, plumbing and architectural systems throughout the building. At the time (design began in 2007) this application of BIM technology to a renovation project was relatively new. The BIM-aided design, overlaid with 3D existing building information, used original construction documents that spanned nearly 50 years. A significant challenge in modeling the existing structure was determining how much to model and what would be important for the new construction. In addition, customized structural BIM elements were developed for many of the antiquated structural components and member profiles. Using the MEP, architectural and structural model, the design team was able to clash-detect and determine what structural elements were needed and how they would affect the architecture. During design, BIM was essential to interweaving the new structural elements within the existing building, accounting for the varying periods and methods of the existing construction, as well as coordinating with new architectural systems. During construction, the steel fabricator also used the BIM detailing models to coordinate the uncovered conditions and field-surveyed measurements in the existing building.

At its core, the renovation of the NAS complex sought to preserve the rich historic fabric of the Academy's headquarters, evident with every turn through its many corridors, while enhancing its functionality and safety and the comfort of its occupants and visitors. Through innovative collaboration, the design team successfully modernized a genuine national treasure. Whether spanning above or hidden in the spaces within the building, an understanding of the history and potential of steel framing was pivotal in creating a new era for the NAS headquarters. The end result of this carefully coordinated effort to enclose spaces and modernize the building for future use is a tribute to the art—and science—of steel construction. ■

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