The Show Must Go On

BY CRAIG SCHWITTER, MICHAEL RYSDORP, AND OLIVER OSTERWIND

Grimshaw

Art and science work together to put on an elegant, complex show at a new performing arts center in Upstate New York.

THROUGHOUT THE COUNTRY, LIBERAL ARTS COLLEGES ARE INVESTING IN CULTURAL BUILDINGS AND OTHER VISUALLY DARING FACILITIES, FROM STUDENT CENTERS TO MUSEUMS. Yet it is much more surprising for a school that is reputed for its engineering and technology programs to launch one of the most ambitious performing arts complexes in recent years.

But that's just what Rensselaer Polytechnic Institute (RPI) is doing. The Experimental Media and Performing Arts Center (EMPAC), a cultural hub for theater and research, will expand RPI's programs beyond the sciences. Scheduled to open this fall, EMPAC is located on RPI's campus in Troy, N.Y. For a university that typically graduates top engineers, the technically challenging and complex project is actually quite appropriate. Although the arts and sciences are generally considered to be opposites, here they attract. As Albert Einstein said, "The greatest scientists are always artists as well."

EMPAC is really two buildings in one. The architects spliced the 221,200-sq.-ft complex into two parallel structures that are tucked inside the sloping site, separating the traditional theater components from their experimental counterparts.

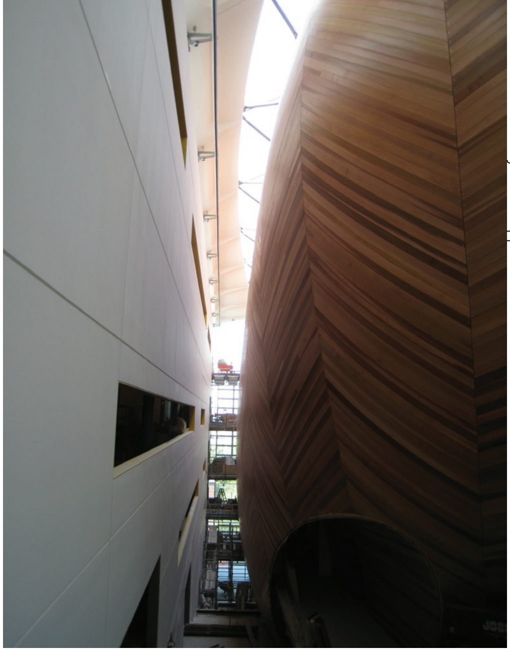
The north wing of the building features a 1,200-seat concert hall, which is EMPAC's centerpiece. The hall is visually anchored by an atrium at the top of the hill and the Founder's Room, an event space that overlooks the Hudson River Valley, at the bottom of the slope. The south wing contains a 400-seat theater and two performance studios for experimental performance and research, as well as a rehearsal studio and four artist-in-residence studios.

Perceived Lightness

Sleek materials, such as metal, glass, and wood, conceal the building's complicated steel framework. By using structural steel, Buro Happold's engineers maintained the perception of lightness for a facility that is actually quite large. Although the space limitations of the architectural forms made it challenging to coordinate the structural and M/E/P systems, the flexibility of steel helped to resolve the complexities of the building.

Buro Happold used building information modeling (BIM) extensively to design, synchronize, and test the highly customized components of the project, which generated complex geometries. Since there were few typical conditions, the design team devised a carefully calibrated structural system in which many of the components perform multiple functions.

A 3D CAD model created with Rhino software, coordinated with the architects, defined the architectural forms and their curving geometries. To ensure full coordination of the structural and



Photos by Buro Happold

Left: Steel framing for the concert hall.

Right: The concert hall with cladding completed and installed.

M/E/P systems, the design team used Architectural Building Systems (ABS) software to model the mechanical rooms and large duct runs. The engineers analyzed the steel structures using RAM Advanse and developed ETABS models for the concrete structures of the theater, studios, and the concert hall, for which a modal review was required to assess its dynamic behavior.

With the adoption of the International Building Code by New York State in 2002, the engineers had to incorporate seismic design with respect to the building's geometries and the variety of its lateral systems. Full of glacial deposits, the site is rated at a higher seismic design designation (category C) than is typical for the region. Seismic forces controlled many of the steel systems, and the multiple structural separations between the various building components meant that all venues had differing drift characteristics. All movements were carefully coordinated with up to 4-in. joints in many areas.

At the Core

The north wing is organized around a central concert hall, which is the jewel of the complex. A large, curved object, it appears to stand structurally apart from the glass envelope that contains it.

Working with an acoustics consultant, the engineers created a curved concrete form that provides optimal acoustics. Although hidden from view, the concrete structure provides the basis of support for the north wing of the building. Large steel trusses span the hall, creating support for the roof and defining the shape of its double-curved surface. The trusses have Vierendeel panels, which allow large return air ducts to penetrate the space. Their bottom chords are integrated with a composite slab that forms an acoustic barrier to the hall, as well as a large space for performance equipment.

Inside the hall, stainless steel cables suspended from the roof support the fabric ceiling, which absorbs and filters sound, and maintain its convex shape, which is necessary for performance quality. Below the floor and to muffle noise, the engineers designed a steel-framed acoustic isolation barrier for the ceiling of the mechanical room that is located under the stage.

Hidden Framework

The hall is concealed by an outer wrapping of cedar planks, which transform the concrete box into a rounded, sensuous form. This "hull" consists of a series of individual panels that are fastened onto double-curved, cold-formed steel stud wall panels that divide its curved surface into a series of rational elements. The panels are attached to a complex steel framing that connects the exterior surface of the hull and the concrete box.

The sophisticated steel grillage that frames the wood paneling also provides support for the access bridges to the performance space. The bridges act as catwalks over the atrium as it descends in three levels down to the concert hall, which is partially submerged in the hill. At the entrances to the concert hall galleries, which puncture the shell, the steel framing pulls back to create interstitial spaces. The bridges rest on acoustic isolation barriers that block sounds from traveling back and forth between the lobby and the concert hall.

A Complex Support System

The hull's steel frame also forms part of the structural system. Serving as a series of vertical columns that surround the concrete box, the framing is braced between the roof slab and the acoustic slab of the concert hall to form load paths that carry the roof.

At the west end of the building, the roof is structurally divided into two parts. The atrium portion is constructed from pairs of 125-ft tied steel arches with 3½-in. Macalloy rods that provide stability at their bases. The stability of the lobby roof is derived from in-plane diaphragm action with connections back to the concert hall roof, which eliminates any cross-bracing along the walls or in the lobby, keeping it visually uncluttered and open.

The atrium roof splits around the concert hall and forms two wings on either side. Between the wings is a skylight over the concert hall that is made from "pillows" of Ethylene tetrafluoroethylene (ETFE), a type of transparent and lightweight plastic that provides insulation and transmits light. The skylight follows the curved form of the hall and is constructed from hollow structural sections. Selected bracing through the skylight allows the lobby roof diaphragm loads to pass through it.

The north wing of the roof is further supported by the steel mullions of the glass façade, which are heated by a water-glycol solution that circulates within the steelwork to prevent condensation. The mullions of the north wall resist wind loading and support the wings of the atrium roof. They have a trapezoidal section and taper as they rise as high as 100 ft to the top of the building. In order to maintain the mullions' delicate profile, the columns are braced to the concert hall with tapered steel struts. Although the pin connections allow movement of the vertical structure, the concrete box provides lateral stability. Both the mullions and struts are architecturally exposed structural steel (AESS).

The lobby roof beams and trusses of the south wall are supported by Fire-Trol columns with slide bearing connections that accommodate wind and seismic movements between the roof and the south wing.

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A physical model of the completed project.

Buildings within a Building

In contrast to the north wing, the south block consists of six independent structures linked by a spine that connects the experimental theater spaces and support facilities. The engineers used steel rather than concrete, which best resolved the structural demands of the intricate program, maintained acoustical separation, and facilitated M/E/P coordination.

The two studios are located at the top of the hill, where the site is shallower. The 400-seat theater is located at the bottom of the slope, which has a greater depth, to allow room for the fly space that holds the stage equipment.

The program components are structurally independent puzzle pieces that look and function as one continuous building. The studios and theater have separate concrete wall systems that are distinct from the laterally braced steel frames of the exterior wall. Each of the performance venues is a building within a building, an acoustically isolated unit with a lobby, offices, artist-in-residence studios, and mechanical support spaces that are wrapped inside a steel-framed structure. The largest studio, which is supported on a grid of steel spring isolators, measures 48 ft by 70 ft long and rises 50 ft in height.

When students and visitors approach the building, the architects have said that the performance venues will look like objects arranged behind the glass walls of a display case. The eye-popping design may certainly steal the show. But although EMPAC's structural system is largely concealed, the engineering team helped support the architects' vision. Just like in theater, what takes place behind the scenes is as important as what takes place on the stage. MSC

Craig Schwitter is a partner and regional director, Michael Rysdorp is an associate structural engineer, and Oliver Osterwind is a senior structural engineer, all with Buro Happold.

Architects

Grimshaw Architects, New York
Davis Brody Bond Aedas, New York
(Architect of Record)

Structural Engineer

Buro Happold, New York