Setting the Stage

by Vincent J. DeSimone, P.E. and A. Christopher Cerino, P.E.

Steel sets the stage for the new Frank Gehry-designed Fisher Center for the Performing Arts at Bard College in Annandale-on-Hudson, NY.

While many Frank Gehry-designed buildings have graced the covers of architectural and engineering publications, the Richard B. Fisher Center for the Performing Arts at Bard College is the first of its kind. Located in Annandale-on-Hudson, NY, the center is the first sculpted steel building where the structure is permanently exposed to view from the interior.

Gehry's work typically resembles a random metal shroud that alters the perception of interior space and manipulates the natural light it receives. When designing Gehry buildings, it is important to separate the shroud from the structural space of the interior. Irrespective of the architecture, a theater must have a stage tower, proscenium, orchestra, balcony, and a roof over the entirety. The Gehry exterior is a sculpted shell that appends, but never supports, the functionality of the theater element.

The $62-million center opened in April 2003, and houses the campus's opera, dance, and orchestral productions as well as theatrical teaching facilities. The complex comprises two distinct buildings that are linked with public assembly spaces and the back-of-house infrastructure. The signature metal surfaces, featured in the lobbies and practice studios, soar up to 80′ above the occupied space. The exposed stainless-steel shingles are field-applied to shop-built light-gage metal panels that also provide the thermal and moisture envelope. The structural frame used to support the panels in the expansive volumes could be achieved only by efficient steel truss design. Only the primary wide-flange shapes are curved to match the undulating surface.

All of the structural steel for the project was defined, dimensioned, and coordinated with three-dimensional CATIA modeling software. Three-dimensional modeling was an integral part of the design process, from concept to system-interference checking, to shop drawings.

The Main Stage

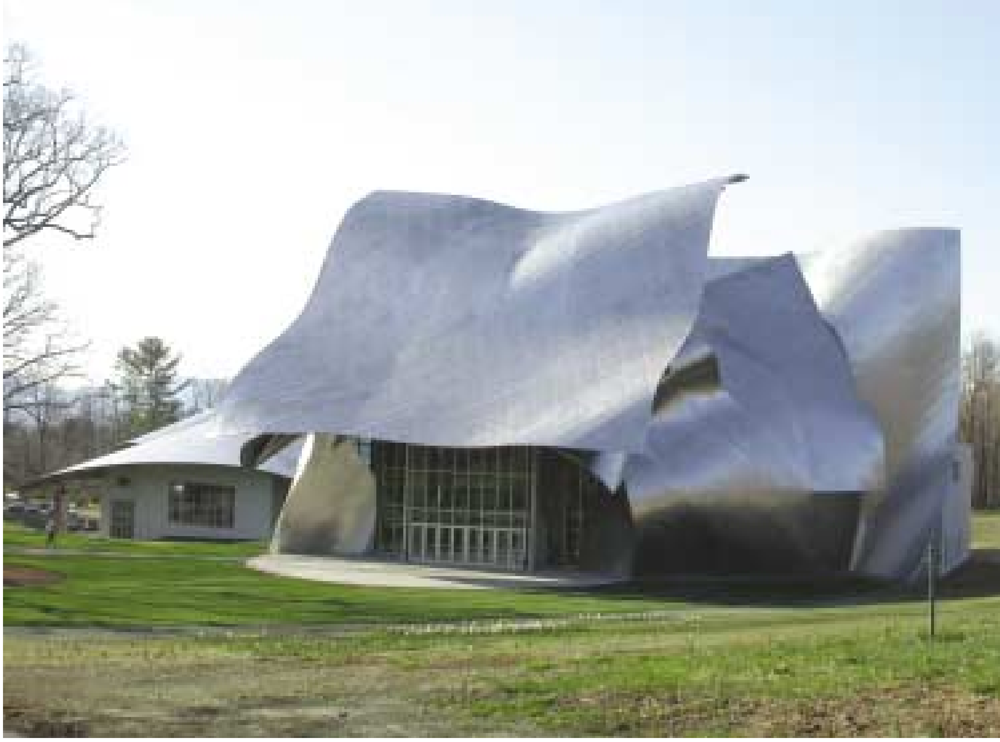
The main building of the complex, the Sosnoff Theater, is an 860-seat, 64,000-sq.-ft feature performance auditorium. While the 100′-tall stage tower and adjoining auditorium walls are cast-in-place concrete for acoustic reasons, the long-span roof system and the signature curved metal façade are supported by structural steel.

The 12′ zone between the top of the roof and the bottom of the acoustical ceiling panels houses the working machine of the theater. The 75′ clear span between auditorium walls is achieved with structural steel trusses. Hanging from these trusses are hundreds of steel sections that make up the catwalks, light bridges, trolleys, and rolling ladders. In addition to the theatrical needs, this area also serves as the main air-distribution passage for the auditorium below. Large ducts weave through the truss diagonals, filling much of the already-crowded ceiling cavity. This cavity was modeled completely in CATIA. A three-dimensional interference check was performed to confirm the required dimensions and that no object interfered with another.

The side walls of the lobby and the front entrance feature exposed, custom-built wide-flange steel shapes. These shapes were all built from high-strength structural plate, where the web plate was cut from computer data using computer numerically controlled (CNC) machines to match the shape exactly. The flanges were CNC-bent on the weak axis, adjusting the curvature along each inch of length. Finally, the plates were assembled on a large setting bed and machine-welded. Many of the shapes were long and irregular, and required splices for trucking purposes. The bolted splices were all assembled in the shop to ensure bolt fit-up as well as continuity of the desired curvature.

The erection of the 60′ to 90′ ribs went smoothly due to key decisions made in the design process. First, the curved vertical elements could not act as columns. Placing load on what is essentially a buckled shape substantially increased the lateral deflection and member size required. In addition, using the ribs as columns would necessitate fire-protecting the steel for the first 20′, which would ruin the desired aesthetic. With these constraints, it was decided that all of the roof steel would cantilever from the cast-in-place walls. The ribs, supporting only their own weight and the weight of the metal panels, sit on the foundation walls and lean against the diaphragm of the main roof with slotted connections to accommodate deflection.

Around the entire Sosnoff Theater are six different clusters of ribs that function as a braced unit. Setting each rib would have required a complex system of temporary guying for stability until the permanent bracing was in place. To save time and cost, the permanent bracing needed to be installed concurrently with each pair of ribs. There are approximately 1000 brace-member connections, each with a unique vertical and horizontal angle. After many design iterations, each bracing condition was satisfied with one detail. The length of the horizontal and diagonal steel angle braces was extracted from the CATIA solids model for fabrication. Then, the horizontal angle spanned between ribs at a constant elevation, pivoting on a single-end hole to achieve any plan angle. Male- and female-ended D-shaped gusset plates secured the members above and below. These plates have the ability to rotate independently to receive single-bolted diagonal members at different and unique angles. While the single-bolt connections needed minor field-welding to work for the design loads, they were more than adequate to



Above: Overall view of the Fisher Center for the Performing Arts with the Sosnoff Theater on the right and the teaching theater on the left.

Below: Interior view of the “eyelid” in the Drama Room.

What's CATIA?

CATIA, or Computer-Aided Three-Dimensional Interactive Application, was developed in France in the late 1970s by Dassault Systemes, and initially was used to design aircraft. It is now an extremely powerful three-dimensional solids and surface modeling program, and is used extensively by the automotive and aerospace industries. Until last year, the program ran only on a UNIX operating system and required the use of a reduced instruction set computer (RISC) rather than a standard personal computer (PC). This necessitated not only a substantial monetary investment for the software, but for the hardware as well. With the release of Version 5, CATIA can now run through the Windows environment on a high-powered PC. For more information about CATIA, visit **www.catia.com**.

serve as temporary braces. In the end, two adjacent ribs were set and the temporary/permanent bracing was pivoted into place in a matter of minutes.

Other noteworthy steel forms include: a 6,400 sq.-ft entry canopy with 85′ center ribs that cantilever more than 20′ feet beyond the support at the top and bottom edges; continuous, kinked horizontal HSS that pass through the last rib of the side wall to cantilever the surface 8′; two space frames of mitered 8″-diameter pipes that support 20′ cantilever surfaces; and a 150′-long plan truss 85′ above-grade, supporting the tops of the ribs that shield the front of the stage tower.

A Teaching Theater

The second building of the complex, a 420-seat teaching theater, is similar to the first in that the anchor structure of the stage tower and auditorium is made massive for acoustic reasons. Surrounding the theater box, is a lightweight structure with a compound-curved steel roof that houses teaching areas for drama and dance. Even though the teaching wing features roof elements, the design concepts and details are similar to the undulating walls of the Sosnoff theater. The built-up wide-flange ribs also are trussed with brace members using the single-bolt pivoting connection; however, kinked girders resting on columns below support these ribs. Fire protection was not required because the members exist more than 20′ above the occupied floor.

There are many other noteworthy steel forms in the teaching wing, such as a 30′ canopy beyond the drama room supported by three kickers down to the ground floor; and two "eyelid" ribs that split to frame the extents of skylights in the dance and drama rooms.

For the project, the design documents not only included customary plans and specifications, but also the three-dimensional CATIA models. While fully coordinated CATIA models are required to understand the complexities of Gehry projects, they also can result in substantial change-order savings in any project. Structural change orders for the Fisher Center, including several minor owner-directed changes, totaled 1.3% of the contract value. This result would be desirable for any project, let alone one with the theatrical and architectural complexity of the Fisher Center. ★

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Steel Detailer
Angle Detailing, Inc. (AISC member), Wilsonville, OR

Architectural Modeling Software
CATIA

Structural Engineering Software
RISA-3D, ETABS, SAFE

Detailing Software
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