TO STEEL or not to Steel?

BY MATT HORNE, PE, MATT KOZMA AND MARY JO MINERICH

The answer is obvious:
Steel is the star at Cincinnati's new Shakespeare theater.

CINCY SHAKES—as in Shakespeare, not earthquakes.

The Cincinnati Shakespeare Company (CSC) is only the fifth theater in the United States to complete the Shakespeare Canon—38 Shakespeare plays performed in chronological order.

For the past 20 years, the company has performed in a converted movie theater, a facility it had outgrown both artistically and physically. But just last month, the group moved into its new home, the Otto M. Budig Theater in the city's Over the Rhine neighborhood.

The new 25,000-sq.-ft steel-framed building (using approximately 160 tons of structural steel) features a thrust stage and 250 seats, 50 of which are located in a single-row balcony. This configuration creates a uniquely intimate experience for patrons, wrapping the audience on three sides, with all seats no farther than 20 ft from the stage. GBBN Architects' design includes multiple sloping roof planes, reaching its highest point above the theater's entrance. The building features a 14-ft-tall trap below the stage, an expansive lobby with a sloping roof structure 45 ft above the floor, a rehearsal room, a loading dock, a high bay for set assembly and tech support rooms. New openings between the theater and the adjacent historic Teamster's Building lead to CSC's offices, dressing rooms and set construction spaces. Structural steel columns, composite floor framing, roof trusses and braced frames were used as the structural system for the building, with cast-in-place concrete walls forming the theater box.

As is common with urban construction, an existing building occupied the proposed site for the new theater. Built in the 1980s, this structure was a two-story steel frame with a full basement and auger cast piles for foundation support; both the existing and

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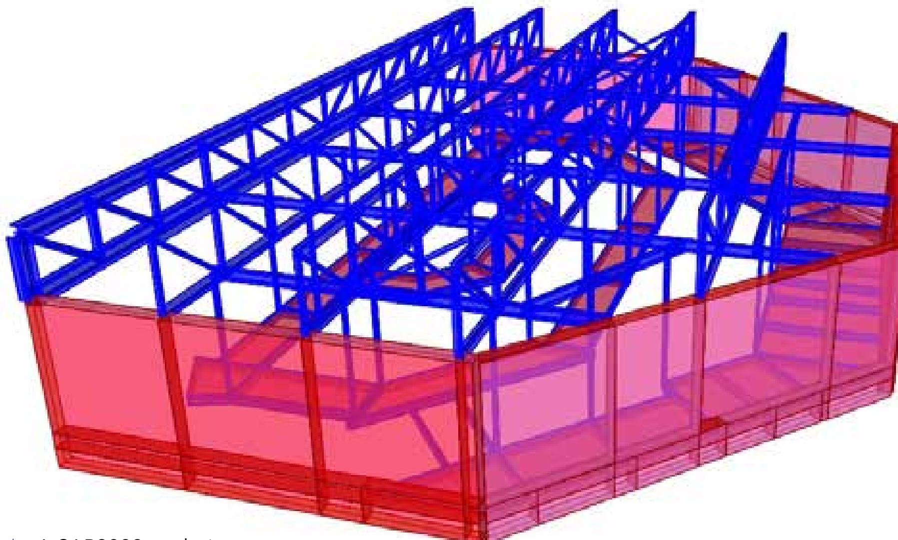
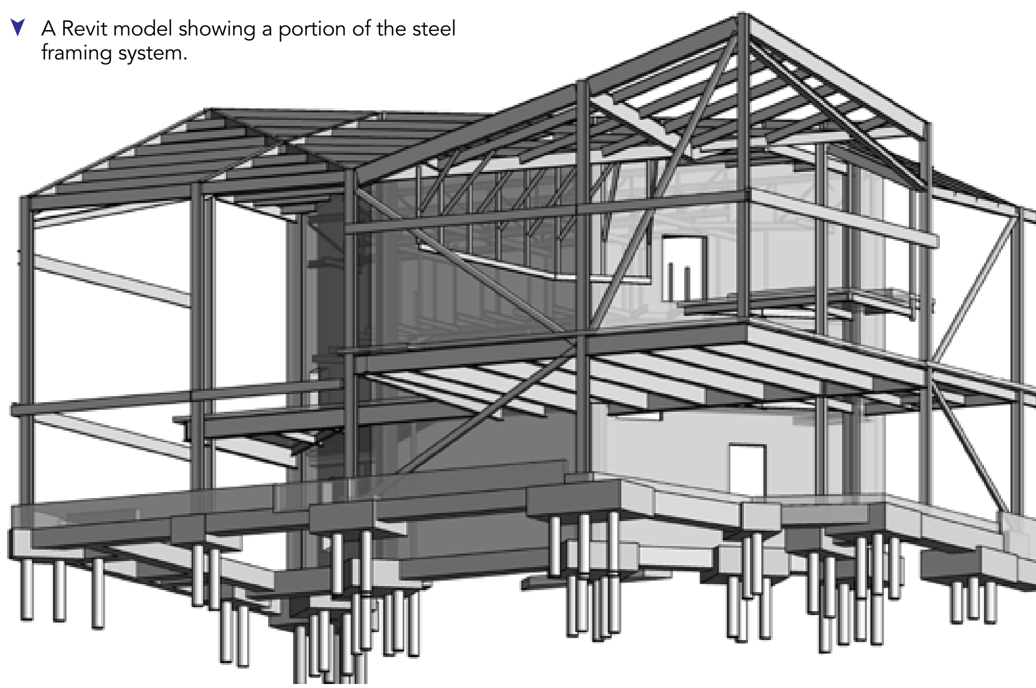
The new theater uses just over 160 tons of structural steel in all.



A SAP2000 analysis model of the theater roof.

A Revit model showing a portion of the steel framing system.



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◄ Erecting the proscenium truss.

▲▼ Erecting the theater roof framing. Wide-flange steel trusses span 70 ft across the width of the theater, and lighter trusses comprised of WT chords and double-angle web members span over the house.

new buildings were designed by structural engineer Schaefer. The new theater also uses auger cast piles, with only a small partial basement to access the trap, which created a complicated coordination effort to install new auger cast piles at grade while avoiding all of the existing piles at the basement elevation left after demolition. In order to facilitate this coordination, Schaefer modeled the entire foundation system of the existing building in Revit, and new transfer grade beams and pile caps were implemented at conditions where the new column grid conflicted with the existing foundations below.

Making an Entrance

Entering the theater at the intersection of 12th and Elm Streets opposite lively Washington Park, patrons immediately see the pitched roof structure formed from seven distinct roof planes wherein only two kinked wide-flange beams were used with conventional framing to create the designed geometry. A structural steel braced frame cantilevers north-south over this street corner, which provides the necessary stiffness to allow a rehearsal space directly above, on the second floor, without the use of an external corner column. The remaining perimeter wide-flange columns span vertically from the ground floor to the roof, permitting hollow structural section (HSS) wind girts to span horizontally from one to the next while supporting the curtain wall system, creating the lobby volume inside. These spaces, as well as the lobby, the second-story rehearsal room and the backstage high-bay, encompass the theater box walls.

To accommodate the small third-level footprint, the north half of the floor is supported with HSS hangers from the roof framing. The lateral system is comprised of the six theater box concrete walls, a braced frame oriented east-west along 12th Street and four more around the backstage high bay, isolated by expansion joints. Sloping collectors transfer the lateral wind loads from the perimeter columns to these braced frames and the theater box walls.

Curtains Up

Inside of the theater walls, structural steel framing was used to achieve the high-performance requirements specified by acoustician Kirkegaard and theater consultant Schuler Shook. A wide-flange steel truss spans 70 ft across the proscenium of the theater, and lighter trusses comprised of WT chords and double-angle web members span over the house. Steel fabricator Geiger and Peters fabricated and shipped the 70-ft-long trusses without a splice, allowing erection of the roof without the need for a shoring tower.

On the stage side of the proscenium truss, composite roof framing supports the 9.5-in.-thick concrete slab on 3-in. acoustic steel deck, which was required to prevent sound penetration from Washington Park. The stage roof framing was also designed for a future rigging system, including a loading gallery and a pin rail gallery. Above the house, the 5-ft-deep roof trusses support four rows of catwalks, the tech booth and twenty half-ton rigging points to accommodate performers flying over the audience below.

Practice Makes Perfect

Steel's role continues behind the scenes as well. The rehearsal room, which could fit the entire theater thrust stage, spans approximatively 38 ft and cantilevers approximatively 19 ft over the undercut entrance, and composite steel floor framing throughout the building yields an efficient, lightweight design. However, the potential for vibration within the rehearsal room presented the design team with a unique serviceability challenge, so Schaefer performed a detailed vibration analysis based on both walking and rhythmic excitations within the rehearsal room using AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (available at **www.aisc.org/dg**).

The iterative analysis considered acceleration limits at three distinct levels of performance, with the vibration response perceived by a stationary occupant due to walking excitation (0.5% g) used as a

▲▼ Steel plate railings in the lobby. The steel stair risers feature laser-cut play titles from the Shakespearean cannon.

➤ The bar area features exposed exterior steel framing.

baseline. The vibration response perceived by a rehearsing performer (5.5% g) was used as an intermediate level of design. Finally, the vibration response perceived by a stationary occupant with respect to the acceleration created by a performer (2% g) was used as the most rigorous level of design, intended to facilitate use of the rehearsal room as a secondary performance venue. These design criteria were evaluated through a value management process, in which Schaefer presented the owner with three levels of structure using W24×68, W24×76 and W24×131 beams, respectively. This coordination effort led to the selection of the W24×76 option, which was specifically geared towards the comfort of the performers as they rehearse.

And perhaps this is the most rewarding aspect for the CSC troupe: the fact that the whole facility is now specifically geared towards its needs. And thanks to the sturdy, attractive steel framing system, the new performance venue, like Shakespeare's plays, will stand the test of time. ■

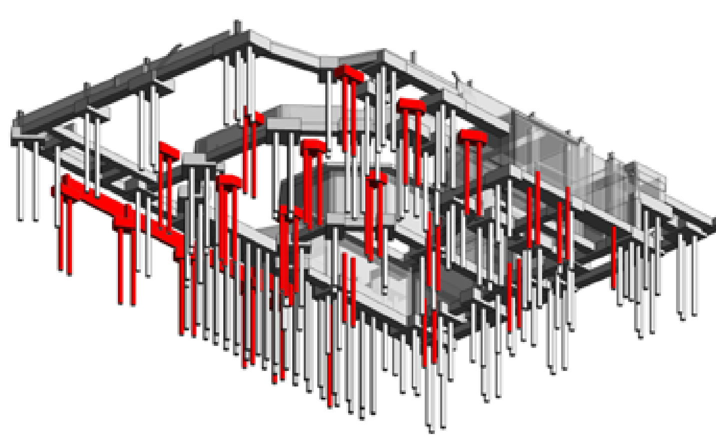
Supporting Role

In addition to its starring structural role, steel also lends its support via its ornamental qualities. For the lobby railing, the architectural team worked with local artisans Greg DeCamp and David Berger to bend, fold and delicately trim nearly full-size sheets of ¼-in. hot-rolled steel into a floating ribbon that wraps the interior space of the lobby, drawing the eye up through the double-height geometry of the space. At the stair, the guardrail extends down to the floor, concealing a coat check along with an HSS stringer that provides the primary support, and bent steel risers feature laser-cut play titles from the Shakespearean cannon.

Notably, the imperfections and surface irregularities from the manufacturing process are prominently displayed as a luxurious natural patina. A light powder coat preserves and enhances this texture, inviting a tactile response.

◀ The building's design includes multiple sloping roof planes, with the roof reaching its highest point above the entrance.

▼ Existing foundations (red) and new foundations (gray) modeled in Revit.



Owner
Cincinnati Shakespeare Company, Cincinnati

Construction Manager
Messer Construction, Cincinnati

Architect
GBBN Architects, Inc., Cincinnati

Structural Engineer
Schaefer, Cincinnati

Steel Team

Fabricator (Main Framing)
Geiger and Peters, Inc., Indianapolis

Fabricator (Catwalks)
CHC Manufacturing, Inc., Cincinnati