RK Powers

High Performance

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Structural steel roof trusses helped solve an acoustical dilemma for the new home of the Nashville Symphony Orchestra.

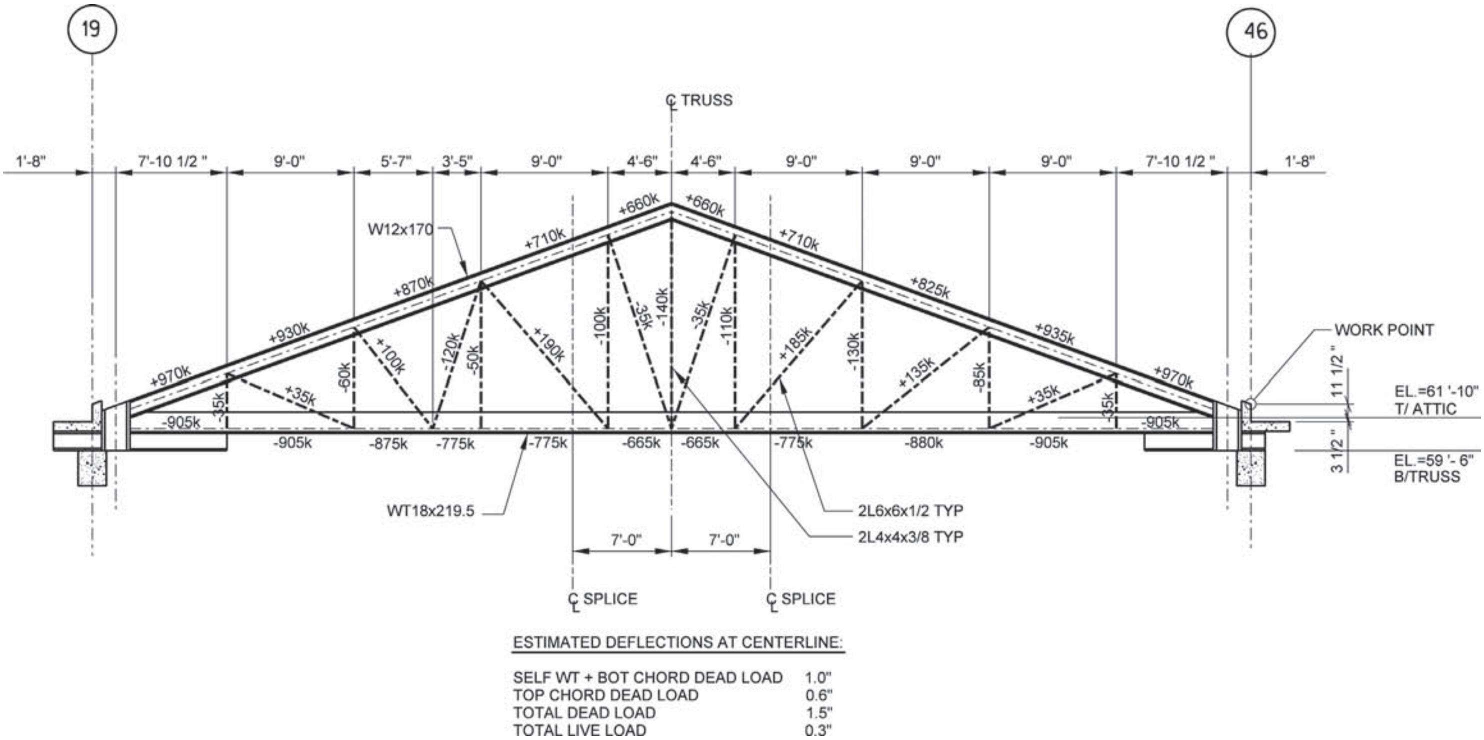
FOR YEARS, THE COMBINATION OF NASHVILLE, STEEL, AND MUSIC MEANT BARBARA MANDRELL AND HER LAP STEEL GUITAR. Today, though, it has a new meaning thanks to the completion of the Schermerhorn Symphony Center, the new home for the Nashville Symphony Orchestra. Using an accelerated four-year track and structural steel, the architects were able to bring their vision to life. On September 9, 2006, some 60 years after the inaugural season, the Orchestra performed in its new $120 million home at the Schermerhorn Symphony Center, marking a new era for the symphony.

The symphony center encloses 197,000 sq. ft of space on four main floor levels and three partial floor levels. The project includes the 1,872-seat Laura Turner Concert Hall, the Mike Curb Family Education Hall, the Founders Hall, a Green Room, administrative offices, music library, catering kitchen, and required support space. The Concert Hall itself has seating on three levels, a full concert organ, a stage with room for 115 musicians, and a 144-seat choral loft. The Concert Hall is of the classic "shoebox" shape for enhanced acoustic performance measuring 80 ft wide, 165 ft long, and 60 ft high. The Concert Hall portion of the Symphony Center also includes 19,000 sq. ft of support space.

The structural system includes cast-in-place concrete framing with critical elements in structural steel. Approximately 650 tons of structural steel systems can be found in numerous areas, including trusses and steel framing supporting the ceiling and roof of the concert hall, composite framing over the mechanical rooms and tunnels, composite columns, stair framing, and miscellaneous mechanical and architectural supports.

Weighing the Options

During construction, steel provided a solution to many problems. In certain areas, high floor-to-floor heights—combined with tight floor plans or aesthetic requirements—required steel columns. Elsewhere, steel framing was required by restricted clearances and complicated geometries. During schedule development of the project, it became apparent that placement of the large HVAC units in the basement would be a problem. Due to their size, they could not be installed after the first elevated level was in place. Because of the project's acoustic requirements, it was advantageous to place the units in one piece, eliminating



Above: Elevation of a typical roof truss. Deflection requirements were stringent because the plaster ceiling finish is applied directly to the underside of the precast panels.

Below: The eastern half of the Concert Hall ceiling. Precast panels have been installed on the bottom chord of the roof trusses.

costly and time-consuming field assembly and assuring acoustic integrity of the units. To satisfy this requirement, the floor systems above the basement mechanical rooms were revised from concrete to a structural steel composite floor system. These floors were designed as unshored construction, and were designed to support the framing for shoring of the floors above.

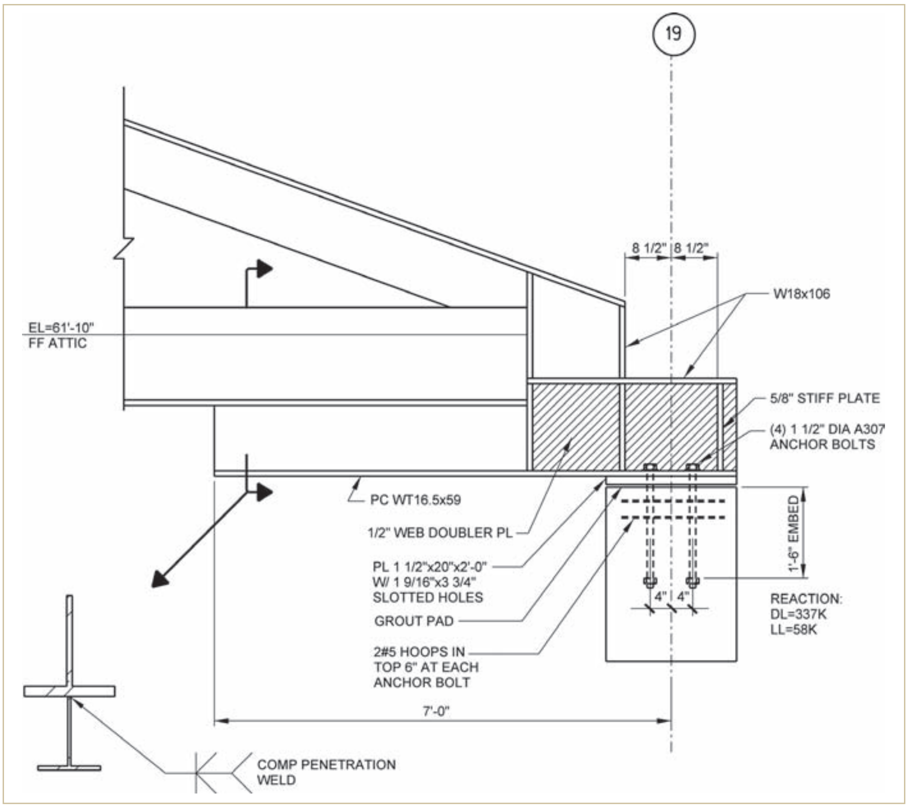
From Top to Bottom

From the beginning, the acoustics were the primary factor in determining structural requirements for the project. The acoustician specified two solid concrete slabs between the interior and exterior of the hall to provide protection from outside sound and to reflect interior sound. In order to achieve this, the slabs had to be separated by placing one slab on the roof and the second as part of the ceiling or attic. To provide sound reflection, furring could not be used in the placement of the ceiling finishes. This complicated the construction of the hall ceiling because plaster had to be placed directly on the surface.

While planning the massive but architecturally finished ceiling, the design team realized that due to cost and schedule limitations, typical concert hall ceiling solutions would not suffice. After consideration of the other options, the decision was made to combine the structural and ceiling systems into one plane by setting precast panels on the bottom chord of steel trusses spanning the 80 ft across the concert hall. The finished plaster system, consisting of several layers of sheathing with a hand-applied plaster finish layer, was to be applied directly to the precast panels. Ceiling coffers provided for aesthetic reasons, acoustic properties, and ductwork were framed with structural steel, cold-formed framing, and several layers of gypsum board. The roof slab consisted of 10 in. precast, prestressed panels supported from the top chord of the trusses.

Challenges of Combining Systems

The team saw many challenges with implementation of this plan using archi-



Detail at the roof truss outriggers used to transmit truss reactions to the bearing points.

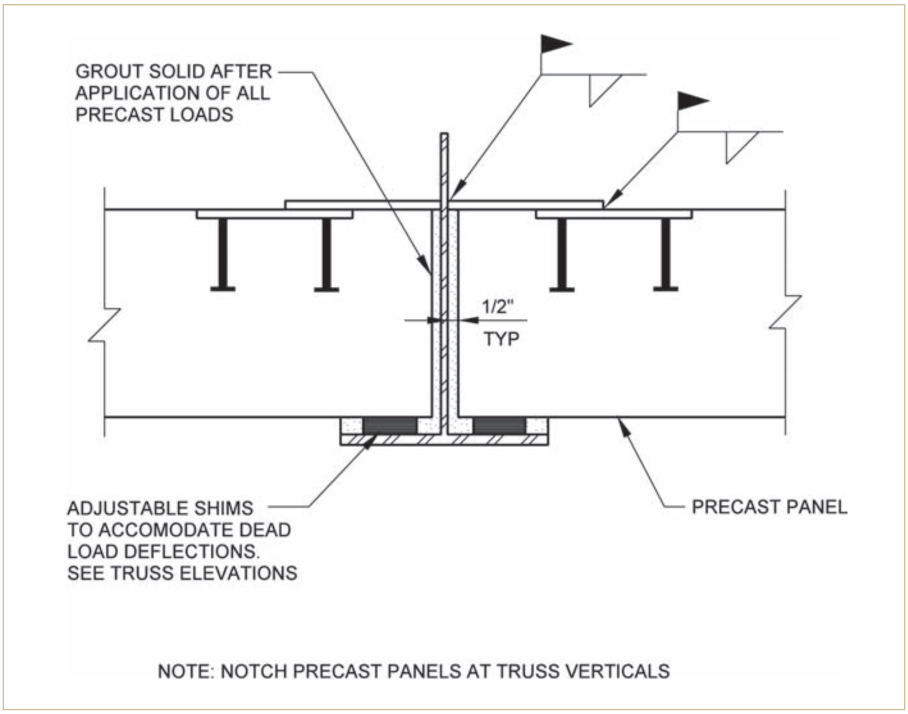
tectural finishes applied directly on precast panels supported by long-span trusses. Architecturally, the tolerances of the plaster finish were very tight, placing tolerance requirements on the placement and deflection of the steel truss/precast panel system. Concern over cracking of the plaster due to deflection of the structural trusses and/or precast resulted in an increase of the precast prestressed ceiling panels from 10 in. to 12 in., and a maximum truss deflection of ³⁄₈ in. under superimposed loads.

From a construction viewpoint, the team was concerned about the tolerances required for placement of the trusses and erection of the precast panels, as well as the interference of temporary permanent bracing with erection of the panels. Sweep or lateral movement of the trusses prior to and during precast erection was also a concern, as well as the vertical alignment of the panels after they were applied.

The resulting system included structural steel gable trusses consisting of WT section chords and double angle web members spanning approximately 80 ft and weighing approximately 350 lb/ft. The trusses were spaced approximately 19 ft on center. The truss verticals were aligned with the precast panel joints, allowing bridging to have minimal impact on panel placement. One unusual feature of the trusses was the "outrigger" detail used to transfer loads to the columns at truss-bearing points. The outrigger resulted from exterior architectural constraints, acoustic requirements, and mechanical duct sizes.

Due to concern about coordination, constructability, and tolerances, the design and construction team worked closely during the development and review of drawings, and in the planning of erection sequencing. As a result, several specific items were included in the truss design and construction:

- The truss panel widths and erection bracing locations were coordinated with the precast panel geometry.
- Permanent bracing was eliminated from the design. All lateral and bracing forces were transmitted through the precast panels and the connections of the truss to the concrete frame.
- The truss chord and web sizes were adjusted based on the precast supplier/erector requirements for bearing and tolerances.
- The estimated deflections for each loading condition were noted on the documents to aid in the coordination of leveling activities prior to placement of the final plaster ceiling surface.



Detail of precast panel support at ceiling

- The precast engineer provided a detail to allow for vertical adjustment of the panels from the top, using a set screw and weld plate.
- Openings in the precast panels for theatrical lighting and speaker systems were closely coordinated with precast reinforcing and flange plates that supported the precast panels.
- The steel erector worked with the precast erector to coordinate the erection and removal of specific members to allow for sequential installation of the steel and precast panels.
- The structural steel was surveyed before and after installation of the precast panels, to insure proper location of the structural steel.
- Bearing details included oversized holes in bearing plates and weld plate washers to allow precise location of the trusses independent of tolerances in anchor bolt locations.

As a result of this close coordination between the design and construction team, the combined structural steel and precast concrete ceiling/roof system was installed on schedule and on budget. In fact, the new system was far quicker and more cost-effective than if a traditional concert hall ceiling systems had been used. MSC

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