A space-saving, economical staggered steel truss system is helping Ohio State accommodate more students in better facilities in its South High-Rise Residential District.

Staggered Home

BY STEPHEN METZ, P.E.

WITH A STUDENT POPULATION of more than 55,000, the main campus of The Ohio State University in Columbus is one of the largest in the country. Student housing is therefore a rather large operation—especially with the school's goal of providing accommodations for all its freshmen and sophomores.

The relatively recent goal of requiring sophomores to live on campus created a deficit of about 3,200 beds. To help meet this demand, OSU is building two new 11-story towers in the South Campus Area, each connecting two existing residence halls. The project also involves renovations to and expansion of five student housing facilities.

Beyond Beds

Siebert Hall is 10 stories and, prior to the current construction, housed 326 students. Steeb Hall is 11 stories (plus a basement), housing 460 students. Stradley, Park and Smith Halls are virtually identical 11-story buildings, each with a basement and each housing 460 students, making a total bed count of 2,166.

The project consists of renovating the five existing buildings as well as two additions that will include a total of 360 new beds. The two new connector towers will connect Stradley and Park Halls and Smith and Steeb Halls, effectively creating two buildings from four.

But the goal of the renovation and expansion goes beyond just adding beds; it seeks to create a better sense of community among students, a modernized campus appearance and a LEED-Certified structure. The dormitory renovation and expansion was designed to meet the university's Interim Green Build and Energy Policy, which involves reducing energy consumption and attaining at least LEED Silver status.

Stephen Metz, P.E., is vice president of Shelley Metz Baumann Hawk, Inc., Columbus, Ohio.

Classes and Construction: In Session

Building at universities while classes are in session always presents challenges. Occupancy had to be maintained for residents in adjacent buildings throughout construction, which could not interfere with service deliveries to adjacent buildings. The laydown and staging areas were near the site to avoid disruption elsewhere.

Additional challenges included matching the existing floor-to-floor height of 9 ft, 4 in. while also accommodating an 18-in. difference in the elevation of the floors of Park and Stradley Halls.

The design team ended up choosing a staggered steel truss system because of its fast erection. This system also saves space with smaller columns and permits a relatively shallow floor, similar in thickness to the existing construction. Additionally, fewer columns are used with staggered truss construction, allowing the interior lower levels to be column-free. The system also worked well with low floor-to-floor requirements of the project. And, it allowed for the innovative aesthetic desired by the project's architects.

The final layout of the building has plan dimensions of 81 ft between the existing buildings by 40 ft 6 in. Both additions are 11 stories tall, and floor-to-floor heights match and align with existing geometry at the Smith/Steeb addition. At the Stradley/Park addition, where the existing floors were misaligned 18 in., the new floor elevations were placed between the existing elevations, resulting in ramps at each end of the addition to transition to the existing floor elevations. The Stradley/Park addition is built over a basement that houses the chillers and electrical equipment; the cooling towers are on the roof of this addition. The exterior facades of both additions are a combination of precast concrete, metal panel and curtain wall.

In addition, there were three main challenges that made this particular staggered truss application (we refer to as a hybrid staggered truss system) special: the two-story space at the first floor lobby, the transfer level at floor three, and the cantilevered student lounges at floors three through nine (all in both new towers).

For the lobby, the architect wanted the first-floor entry to be a two-story space to provide a well-lit, welcoming entry space. The typical configuration of a staggered truss system would have the trusses terminate at the second floor with bracing at the first floor. However, a two-story-high, open space would not allow this. That meant the lateral load resisting system at the lower two levels had to become a moment frame. In order to make this happen, trusses from floors three to four were placed at every column line, and the bottom chord of the trusses became part of the moment frame. Additionally, a 42-in.-deep upturned plate girder was used as the bottom chord. The depth of the plate girders would not have allowed proper clearance at the second floor walkway if they had been placed so that the top flange was flush with the precast concrete floor, due to the low floor-to-floor height. To allow for headroom, the girders were upturned, so that the bottom flange is just below the bottom of the precast. The plate girder had to be notched to allow for the third-floor corridor to pass through the truss. The result is that the bottom chord of all four of the trusses at floors three and four is a 42-in.-deep plate girder with 2½-in. by 10-in. flanges. These trusses are supported by W14×398 columns. The combination of trusses and columns form the moment frame that is the base of the lateral load resisting system in the north-south direction (see Figure 1).

For the transfer level at the third floor, the columns at floors one and two needed to be offset 2 ft, 2½ in. toward the interior from the upper level columns. This was done to allow the lower level columns to be inset from the exterior curtain wall system while the upper columns are within the exterior wall system. This presented a loading challenge: both the gravity and lateral loads had to be transferred

Shelley Metz Baumann Hawk, Inc.

▲ Exterior elevation of the addition. The cantilevered study lounges are on the right.

▼ Notch in upturned girder at the corridor.

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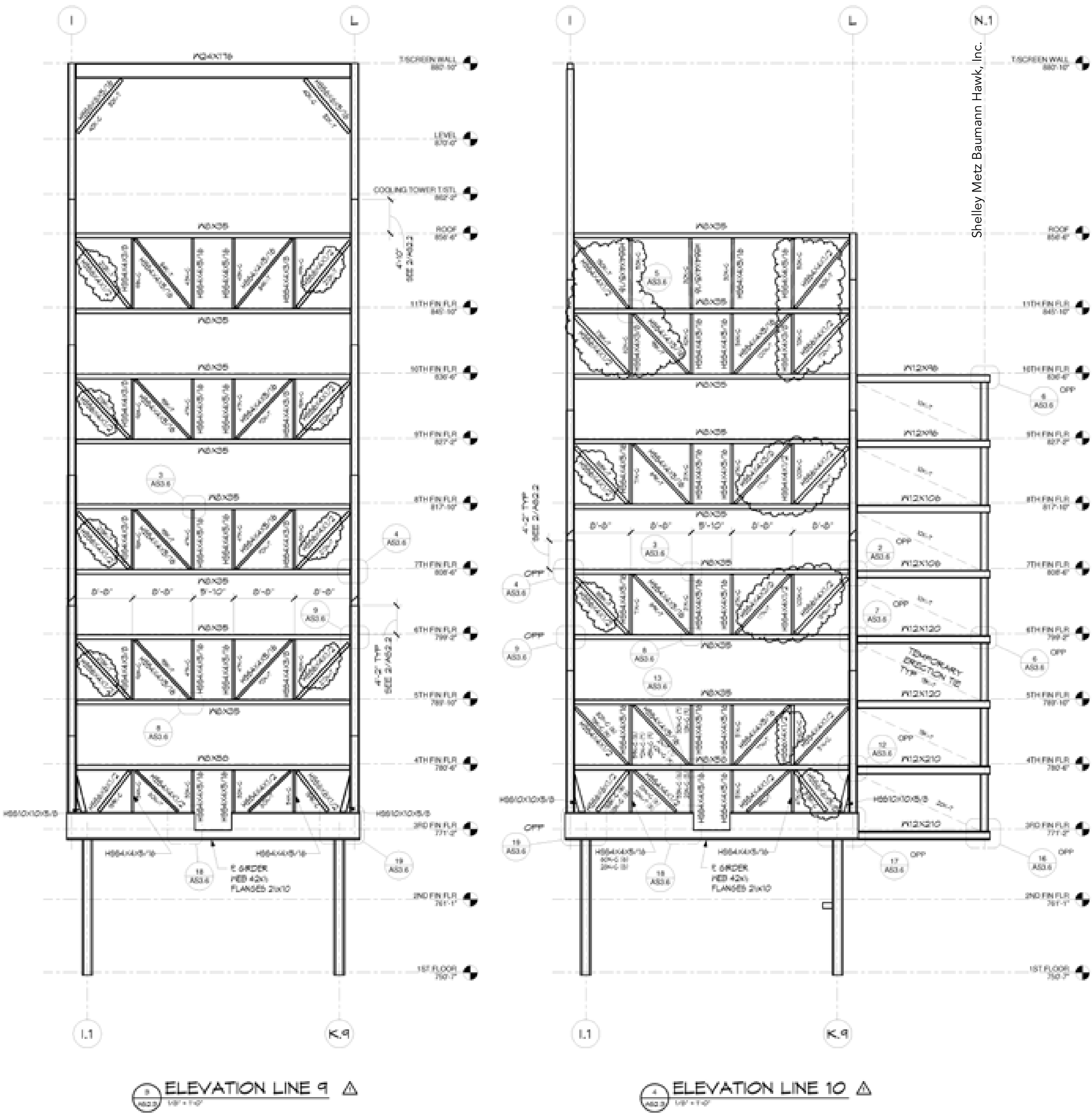

Figure 1: Typical truss elevations. There are two of each elevation.

from the upper columns back to the lower level columns. The gravity loads were transferred by using the trusses at floors three to four, and the plate girders that were used in the moment frame were also used as transfer girders for the gravity loads from the upper level columns.

To transfer the lateral loads, a horizontal truss system was used at the third floor. This truss system was designed to transfer the lateral reaction from the base of the upper level columns back to the top of the lower level columns. This resulted in the W14×398 lower level columns serving double duty as moment frame columns in both the east-west and north-south directions.

There are two student lounges at opposing corners of the addition at floors three through nine. The lounges extend 19 ft from the face of the main building and are approximately 15 ft wide. Because of aesthetic desires and site issues, the lounge extensions could not be supported by columns that extend to the ground. Interior space constraints also would not allow for the trusses to cantilever through the space. To provide support, a single steel girder cantilevers from the column as an extension of the truss chord on the other side of the column. This girder supports the entire floor framing in the lounges. To keep the depth and weight of the girder reasonable, a vertical member is moment connected to the end of the girder for stiffness. To counter the eccentricity of the unbalanced loading on the floor, the framing connects to the existing building columns for uplift support.

From the multi-phase schedule to the framing system, all

▲ The two new connector towers will increase OSU's South High-Rise Residential District's occupancy by 360.

◄ Floors 3 and 4 of the cantilevered study lounge.

components comprised a new and innovative design process. Providing a design that would allow the new additions to fit between the existing buildings was also challenging, and organization among all parties onsite has been a key to its success thus far. At a project size of 487,000 sq. ft in renovation and 96,000 sq. ft in new construction, the estimated construction cost is $120 million. With an anticipated opening date of May 2012 for Stradley/Park and May 2013 for Smith/Steeb Halls, this renovation and addition defines the long-term direction of the school's South High-Rise Residential District. MSC

Owner
The Ohio State University, Columbus, Ohio

Design Architect
Sasaki, Watertown, Mass.

Architect of Record
Schooley Caldwell Associates, Columbus, Ohio

Structural Engineer (Additions)
Shelley Metz Baumann Hawk, Inc., Columbus, Ohio

Construction Manager
Smoot Construction, Columbus, Ohio

Steel Team

Steel Fabricator
Marysville Steel, Marysville, Ohio (AISC Member/AISC Certified Fabricator)

AISC Lends a Hand

Engineers can take advantage of AISC resources to explore, select and promote innovative systems on their projects. For the OSU South Residence Halls, Monica Shripka, AISC's Upper Midwest regional engineer, supported the engineer in the system selection phase. Through the engineer's invitation, she presented an overview of the benefits, challenges and case studies of the staggered truss system to the entire project team, including OSU representatives.

As the project progressed into the construction phase, AISC organized a presentation and site tour to highlight this innovative application of the staggered truss system. Local engineers, architects and construction professionals learned about the project's system selection process, design aspects, best practices and lessons learned during a breakfast presentation. Then, everyone had the chance to see the staggered truss system firsthand while walking through the construction site. More info can be found at **www.aisc.org/osu**.

Contact your local AISC regional engineer at **www.aisc.org/MyRegion** to engage AISC support. They're happy to provide support "in your corner" at your next project meeting, and can help you promote your successful steel projects to the local AEC community.