Complex Apartments

By Beth S. Pollak and Michael Gustafson

An innovative staggered truss system and a design-build effort sped the completion of an apartment complex in Ames, IA.

"Everyone thought that the staggered truss was a good concept, considering cost, schedule and simplicity," said Gene Arnold, P.E. structural engineer for the new Legacy Tower apartment complex in Ames, IA. It was Arnold's first staggered truss project, but he was familiar with the system through AISC's educational efforts from years past.

"We started designing the job about the time that *Modern Steel Construction* published its "Anatomy of a Staggered Truss" insert (Sept. 2002), and the sample set of plans helped," he said. "We drew up some models of what the building might look like and presented them to the owner during the preliminary design stages. The architect came up with a floor plan, and everybody liked the layout of the system. The owner had experience with structures made out of steel and precast concrete before, and since we have good fabricators and good precasters locally, the staggered truss would use both materials quite well."

Fifty-six staggered trusses frame the 96-room luxury apartment complex, located near Iowa State University. The structure consists of four levels (each with a main and mezzanine level) of residential space and three levels of pre-cast concrete parking structure below.

At each grid line, two 57'-6"-long staggered trusses span each side of a 7'-0" wide corridor. Due to limited site access and crane-lift capacities, designers split the building width by using two trusses instead of one. The use of two trusses allowed a stiffer truss section, which enabled easier fit-up of the structure.

An accelerated schedule and design-build project delivery helped complete the building in less than two years. "The whole team worked together exceptionally well," said Project Manager Lee Welch. "Design-build facilitates communication between members. It's definitely the way to go. If you get your team put together early on, everyone has good input and works out problems in advance."

Robert Pyle and Michael Gustafson,

Having the fabricator, erector, precaster and general contractor on-board from the beginning helped reduce project cost and shorten the schedule. We worked with all of the main trades including electrical and mechanical in schematic design to determine the schedule so as to meet the short time frame available to build the project. Having everyone involved from day-one worked very well for the owner and the project.

In contrast, with the design-bid-build method of delivery design professionals can overlook the realities of construction methods and schedules. I don't profess to know everything there is about building a building, that is what the construction team is about. By working with the expertise of the entire team of designers and major subcontractors the finer details could be looked at more closely resulting in faster delivery and lower cost.

—Mike Sloter
Senior Project Manager
Stott & Associates Architects, P.C.

regional engineers with AISC Marketing, worked with the design and construction team early in the project. They hosted pre-design and pre-erection meetings with team members to educate them on the lessons learned from previous staggered-truss construction projects.

"The major design requirement for this project was to fit as large of a building with as many apartment units as possible on the given site and to erect the building as quickly as possible," said Architect Michael J. Sloter, AIA. "The staggered truss system seemed to meet the needs of the short construction time by providing a repetitive template for the fabricator. Other benefits included repetitive components, column-free spaces, speed of erection and flexibility."

Due to height restrictions on high-rise construction in Ames, the owner maximized floor-plan size while minimizing the overall height of the structure to approximately 111'. The floor plan is a double-loaded layout, where two units are accessed on each side of the central corridor. The building stories consist of alternating main and mezzanine floors.

The mezzanine floor layout permits a creative, two-level, loft approach that is probably the first of its kind for staggered truss construction. At each mezzanine floor, the precast concrete floor plank is removed within the interior of the floor plan. This allows each apartment to have a two-level occupancy, where tenants access the mezzanine from their main floor via staircases. The mezzanine level hosts a balcony at the exterior of the building.

Typically, a great strength of staggered-truss construction is low floor-to-floor heights. However, in this case, the staggered truss system was flexible enough to allow an 18' ceiling height in some areas while maintaining a low frame floor-to-floor height of 9'-0".

"Steel, for this project, was the best in terms of schedule, cost, ease of assembly, and large open spaces," Arnold said. "With the column spacing, you couldn't have built this out of all concrete. Trusses allowed us to eliminate the floor beams and use the precast planks for the ceilings."

The building required Type 1–Fire Resistance (1997 UBC), a three-hour rating, on all structural components. As such, the trusses were enclosed in three layers of $^5/_8$" gypsum board.

The Legacy Towers' mezzanine loft approach is probably the first of its kind for staggered-truss construction. At each mezzanine floor, the pre-cast concrete floor planks are removed within the interior of the floor plan. This allows each apartment to have a two-level occupancy, where tenants access the mezzanine from their main floor via staircases.

Some benefits of the early-involvement were:

- A good relationship with the structural engineer meant we could see the designs up-front and talk about the efficiencies of the steel sections. We knew what sections were being rolled, what was in stock, and what could be applied in the field, so there was good communication with engineering, detailing and purchasing.
- Because we had that information up front, we had a good comfort level that our take-off list was the correct material. We could order material early knowing we had the right stock coming.
- Ordering materials early allowed us to take advantage of mill pricing and receive stock with less costly rail delivery, reducing overall cost for the owner.
- With steel arriving early, even though it took some of our space, we had it all in stock, nothing was missing, and we were not waiting for odd members when we got started.
- We only run one shift, so it is important for us to manage our workload. By starting early on this project, we were able to manage shop-fabrication hours well and stage fabricated material before it was needed at the job site. The early start allowed us to get ahead, so we didn't have to worry about delaying the schedule. It also allowed us some flexibility in production planning.

—Doug Kollbaum
President, Mid-States Steel

Teamwork

Early involvement of all steel specialty contractors was essential to the success of the project. All key construction and design team members had a direct contract with the owner, including the steel fabricator. This true design-build approach provided many benefits for the project.

"Before they even broke ground, there were several meetings early on with the fabricator, detailer, precast supplier/erector, construction manager, engineer and architect," said detailer Jeff Drake, of Mid-States Steel. "We had worked with the structural engineer on other projects. We knew the basic design and gave ideas to each other. When there were design changes, communication between parties was very quick."

The steel fabricator and detailer worked with the structural engineer to minimize the overall frame costs of the structure. The number of different trusses, connection details, truss-member sizes and types, and temporary erection systems were all discussed and resolved in the project's design phase. Early on, the steel fabricator suggested making design changes to the trusses based on three-member-bundle quantity orders. Recognizing the benefits of economies of

The footprint of Legacy Towers takes up about 97% of the site, making construction challenging.

scale helped minimize the overall cost impact of changes to the project.

"We had several meetings trying to get the material sizes nailed down, so we could get it ordered from mill sources and delivered by rail—the most economical way to transport the material," Drake said. "The trusses are almost 60′ long. Originally the design called for the trusses to be three-chord, 18′-high trusses—that would be too deep and expensive to ship. So the designers scaled it back, and went with 9′-high trusses."

Also during planning stages, the steel erector and the precast supplier (Iowa Prestresed Concrete, Inc.) discussed what size crane to use, so that the precast members could be designed around the capacity of the proposed crane. The team chose a PECCO SK400 Tower Crane with a 162′ radius and maximum capacity of 40,000 lb. For this project, the erector selected a 20,000-lb maximum capacity, and the precast members were sized accordingly.

Another benefit of the early involvement of the steel fabricator with the design team was the ability to place a mill order at 75% design completion with minimal risk to the owner. Typical design-bid-build models that conduct such early mill orders impose additional risk to the owner because of the potential steel frame changes that occur during the remainder of the design. For this project, the early steel order saved money for the fabricator, who could purchase steel according to mill schedules, ship steel by rail rather than pay trucking costs, and fabricate the steel with time to spare.

"I can't emphasize enough how important early involvement was for us in terms of material handling and costs, rail delivery, giving us the ability to work in our schedule, and other savings," said Doug Kollbaum, president of Mid-States Steel. "This really worked well from the fabricator's standpoint. I wish I had 10 more jobs like that right now."

Erection

The owner believed that structural steel would simplify the construction process, especially with the proposed mezzanine loft floor plan. Although precast concrete was used for the parking structure, it could not offer the low floor-to-floor heights of the staggered-truss frame.

"The structural engineer really convinced us that we ought to try the staggered truss system," Welch said. "From an erection standpoint, the building went up very fast, even faster than if we had a conventional steel frame and poured concrete floors, especially because we were building during the winter months. It saved us a lot of time. The staggered truss system allowed us flexibility as far as the spans between the trusses, and in how we could lay out the interior walls of the building."

Fabrication began in August 2003. "Because of the staggered truss system, there was a lot of steel, but not a lot of pieces, so it was very easy to manage the actual piece-mark numbers, compared to conventional column framing," Kollbaum said. "There were 56 trusses, 72 columns, and approximately 600 beams. The structure erected quickly, like an erector set."

Erection began Dec. 15, 2003 and ended April 1, 2004. It took 14 weeks as planned, even with some days lost during the coldest winter months. The erector was able to make up lost time, partially due to the ease of erection of the staggered trusses and precast plank. The steel and precast un-topped system minimized the risk of tripping and other hazards on site, especially during winter. Temporary bracing of the staggered truss was provided through coordination between the structural engineer and erector.

The limited staging area created a construction challenge, with 97% of the site used for the building footprint. Truss

I think communication with a design-build team is always better [than with a design-bid-build team].

From connections to piece sizes, and to the sequence of putting it together, everyone can sit down and share their perspective of the project. That's what happened here.

Also, with design-build, you have a ballpark figure of what materials and services will cost. You have to have a high level of trust by picking team members, bringing them on board and assuming you'll be able to negotiate a price that is fair. All of us have worked together on several projects and all the players knew each other quite well.

We have a great deal of trust with Project Manager Lee Welch and Superintendent Dennis Oppedal. They ask great questions and can work with every discipline. From beginning to end, they kept everyone working together.

—Gene Arnold, P.E.
Arnold Engineering

and precast concrete deliveries were coordinated to establish a quick-flowing erection process.

"Lee Welch and his staff, with the direction of the erector, handled the sequencing well," Kollbaum said. "We broke down the sequences and staged them. They handled changes in the field. We are only 15 miles to the site, so they would call us if there were any construction delays. Since we're close to the site, we were able to use our own tractor, and we didn't have to spend money on a separate carrier."

There are different ways to erect the staggered truss on site: either connecting the columns to the trusses on the ground and then erecting, or erecting the columns first and then sliding in the trusses. The latter was done in this case. However, due to rotation of the trusses after installation and therefore rotation of the columns, the erection of additional trusses above required additional fit-up requirements. Using one-story column splices instead of two-story column splices would minimize the amount of rotational effect on the extension of the columns, thereby minimizing fit-up issues.

"One thing we discovered in hindsight was that it would have been helpful to assemble more of the frames in the shop," Arnold said. "Some small x-braced frames and horizontal frames would have been better assembled in the shop. The more assembly you can do in the shop, the better, and this system lends itself to that."

Welch said that the staggered truss system met the project requirements on time, giving Ames an attractive new residential complex. "There was no other method or material that could have been used on this building that would have worked in our schedule." ★

Owner/Contractor
Ev Cochrane & Associates, Ames, IA

Architect
Stott & Associates Architects, P.C., Ames, IA

Structural Engineer
Arnold Engineering, Waukee, IA

Steel Fabricator/Detailer
Mid-States Steel Corp., Boone, IA (AISC-member)

Structural Software
RISA

Detailing Software
SDS/2, PowerCAD

Plank/Precast Supplier
Iowa Prestressed Concrete, Inc., Des Moines, IA