Staggered Truss SOLUTION

Beth S. Pollak

A luxury apartment building in White Plains, NY features staggered truss framing for flexibility and economy.

The Clayton Park Apartments complex in White Plains, NY, was designed to be a modern, double-loaded-corridor, luxury-rental apartment building. The owner required a framing system that could be built economically—and chose the staggered truss. "A staggered truss system was selected because it is so economical in its usage of steel," said Project Architect Peter Kastl, of Perkins Eastman Architects.

The building is eight stories high, with a three-floor parking structure below-grade. The building contains 260 apartments, 360 parking spaces, 272,000 sq. ft of residential space, and a 93,000-sq.-ft garage. The building in plan is a U shape. The area inside of the U is an extensively landscaped plaza entrance that includes a pool. A total of about 1,500 tons of steel was used for the project. Fabrication of structural steel began in June 2001 and was complete by December 2001. Erection began in July 2001 and was completed in May 2002.

FOUNDATION

In order to make room for the extensive parking garage, a significant amount of rock was evacuated from the site. The building was designed to hug the grade, and was constructed into the slope with a concrete foundation. "A cost-saving feature included eliminating concrete buttresses in the exterior walls and replacing them with steel columns," said structural engineer Neil Wexler, P.E., Ph.D., of Wexler and Associates. "This feature resulted in significant cost and time savings. We were able to pour the foundation walls without interrupting the forms at each buttress, as would have been required if you had to form concrete buttresses."

Wexler says that significant time savings were accomplished in the construction of the foundation. "The architect had to increase the dimension that existed between the center line of the column and the outside face of the exterior walls to allow for construction," he said. "This worked well architecturally, because the architect could create an architectural reveal at the location where the parking garage met the apartment structure above."

STEEL PARKING SOLUTION

The parking garage consists of post and beam construction in steel. The structural steel was designed to be composite with a concrete floor by

By concealing the trusses within permanent partitions, staggered-truss framing provides large, flexible open spaces.

using concrete studs. "The steel frame for the residential portion of the building just drops through to the garage levels," Kastl said. "It was the most economical way to frame out both the tower floors and the garage."

In the parking garage, 2" metal deck was used. Connections were bolted double-angle web connections. Lateral-force resistance was provided by concrete walls, which also consisted of foundation walls.

For fire protection to meet a two-hour fire rating, beams, columns and girders were sprayed with a cementitious fire-protection coating. The metal deck did not need to be coated. Reinforcement rods were placed over beams and girders.

Concrete had to be poured in the parking garage before the erection of steel could begin for the apartment above. "The first three floors had to be poured so they could backfill against the retaining wall," said Mike Fasciano, president of fabricator/erector Luzerne Iron Works. "Then we remobilized to erect the tower of the apartment building."

A special admixture was specified to create a concrete mix that would be impervious to moisture. "This was ac-

Specially formed concrete plank sections provide support for bay windows.

complished by using micro-silica additives that lower the water-cement ratio in the concrete about three gallons per cubic yard," Wexler said. "The result was a concrete mix that became watertight, and provided protection from potential corrosion for the metal deck and the steel beams."

STAGGERED TRUSS

The framing of the apartment tower above the parking structure was staggered steel trusses supporting hollowcore concrete plank. The owner chose this system in order to eliminate interior columns. "With this option, the columns are located on the outside of the building," Wexler said. "This works well with parking garages—the garage layout is different from the apartments above. The requirement for transfer girders that exists with post and beam construction is eliminated by the staggered trusses."

The lateral load-resisting system consisted of 60′ staggered trusses in both directions. In some areas, the lateral system was supplemented with small braces. Building corners were handled as regular post and beam construction. Concrete plank was 10″ thick and spanned 27′ or 36′ between the trusses, as did the supplementary spandrel beams.

Engineering drawings specified 82 trusses that all differed slightly from each other, but Fasciano says that Luzerne was able to save on time and labor by fabricating near-identical, standard trusses that satisfied the load requirement. "We made them all basically the same," he said. "Once we made one truss, the other 81 went faster. By the end of fabrication, we had sped our production by four times, producing about two trusses per day. The standardization didn't cause any later erection problems."

One fabrication adjustment that had to be made later was a beam penetration detail that would accommodate lines for the building's sprinkler system. "When we began work on the tower, I looked at one of the fire-protection drawings by chance, and it specifically showed a sprinkler line going through a center line of bottom- or top-chord of a truss," Fasciano said. "At that point, many of the trusses were already fabricated and some had even been erected. So we went back and re-submitted the drawings, this time showing the details for the beam penetration. We fixed as many as possible—about 75%—in the shop. We had to fix and detail the other 25% in the field."

The solutions was to reinforce the openings by using a pipe chase through the web, controlled at locations of minimum stress.

Various types of connections were included in the structural frame. The truss connections were gusset plates welded to beams, columns, and diagonals. Gusset plates ranged from ½″- ¾″ thick. The welded connections were done in the shop: Trusses were fabricated in one piece, then transported to the site and erected into place.

Trusses were then bolted in the field to the columns using ASTM A490 bolts. Column splices were bolted in the field, as well as beam-to-girder and beam-to-column connections.

Fire protection for the apartment tower consisted of a three-hour gypsum-wall board enclosures for the trusses and for the truss chords. Columns and spandrel beams were coated with spray-on fire protection, and sprinklers were located throughout the building.

One interesting aspect of the project was the use of light-gage wall panels on the outside of the building. "It's a new technology, where walls are pre-fabricated in a shop, complete with brick facing," Wexler said. "They are transported to the site, and then erected in wide panels. The benefit of this is that there is no need to scaffold the building, and it's very fast to erect."

The connections of the wall to the structural system are light-gage clip angles, fastened to the top of the concrete plank and then welded to the stud walls. "The wall is fabricated under quality control in a shop, and it is easy to verify quality control in the field by walking the plank around it," Wexler said. "They are fully adjustable in the field, with simple connections and no special structural steel preparations. This allows tremendous flexibility in the field during construction. The walls simplify the coordination that is required between the various trades, and the wall-sandwich thickness is reduced from the traditional masonry wall. Also, with these walls you don't get slowed down during winter, when temperatures can be cold."

ERECTION

Kastl says that the coordination between steel, plank, and utilities in the construction phases presented a challenge. "Using this structural system demands rigorous coordination at the architectural and engineering design phase, and by the general contractor's project engineer. You have to pay attention to stair cutouts, gusset plates at corridors, getting horizontal utility runs past the trusses and fire protection coordination. The fact that the plan changes in this project from floor to floor makes it a challenge to everybody."

Erectors had to maintain the staggered trusses straight and plumb while erecting plank at the same time. The contractor initially used the plank itself to keep the trusses straight, which caused some difficulty. "If a contractor is able to erect plank in a certain sequence, trusses can be kept straight, but that's a sequence that has to carefully controlled," Wexler said. "It's inconceivable that a truss will remain vertical when planks are erected on only one side. That load creates torsion that is inadequately resisted during erection. Alternately, you can erect planks on each side of the truss—but that is very complicated for the erector."

Fasciano says that the best method to erect the plank while maintaining vertical trusses was learned through a process of trial and error. "When we erected the steel for the building, our crane was situated in the center of the U," he said. "We went counterclockwise from the right. By the time we got to left side, the right side was all bolted and plumb. But problems started when we began to erect the plank, which was big, heavy and hard to handle in the confined space. It was very hard to keep the plank equally loaded, and it became difficult to keep the trusses plumb. We developed a checkerboard pattern of erecting the plank, to keep everything equally loaded. It worked, but it was an inefficient way of going around the building."

The erectors found a simple solution by using cables as temporary bracing between the top of one truss and the bottom of a column on a certain floor. "We used a horizontal line of cable and passed it through the sprinkler penetrations to stabilize the trusses," Fasciano said.

Another challenge was that the building had to be erected in a limited area. "The site was a metropolitan site, and we were limited in the areas that we could shake out the steel and receive the plank," Fasciano said. "We were surrounded by Main Street and two other cross streets on three sides. The fourth side was an existing building. There was also an elementary school across the street, which brought a lot of activity and constant traffic. It was hard to get to the job transportation-wise and logistically. Sometimes we ran out of room to lay out the steel and plank."

STEEL CHOICE

"The steel was a very good choice, the natural choice for a residential building with a garage component," Wexler said. "The point needs to be made that the alternatives to steel would have been cumbersome and expensive, with significant weights and materials. Steel created a light building. It's easy to purchase steel and to work with steel. You can purchase steel locally or bring it in from other towns. In contrast, you can't bring concrete into town if its not available. Concrete doesn't have the flexibility of geography that steel does."

Fasciano says that he recommends the staggered truss system, despite its challenges. "It was a tough start, and we didn't know what it would entail," he said. "But once we got through the learning curve, it was fine." ★

General Contractor
Worth Construction, Bethel, CT

Architect
Perkins Eastman Architects, New York

Structural Engineer
Wexler and Associates, New York

Fabricator/Erector
Luzerne Iron Works, Luzerne, PA, (AISC member)

Engineering Software
RISA 2D, RISA 3D

Absolutely Staggering

Unless you've been hiding under a rock, you've likely heard about the staggered truss steel framing system. The fact is, bell-bottoms, shag carpet and the staggered truss, all born in the 1960s, are enjoying a comeback. We can't comment of the bell-bottoms and the shag carpet, but the renaissance of the staggered truss is an easy one: This cost efficient steel-and-precast-plank system can provide up to 60' by 100' of clear space—an architect's dream. In addition, it offers floor-to-floor heights as low as 8'-8".

Improved fabricator efficiencies, low mill prices and increased steel availability are combining to make this system the winning choice for multi-story residential construction.

As interest in the system rapidly increases, AISC has responded with a number of resources to help engineers understand and design the system, including AISC's *Design Guide 14: Staggered Truss Framing Systems*, in-house technical seminars, and the Steel Solutions Center. What's more, many hollow-core plank manufacturers offer practical details and design information on combining plank with structural steel framing.

To visually answer your questions about the system, the "Anatomy of the Staggered Truss" drawing was presented in the September 2002 issue of *Modern Steel Construction*. The drawing also includes a wealth of typical information that can help you better understand what the staggered truss system is and how it works.

If you would like additional copies of the drawing, or would like to discuss how a staggered truss system could benefit your project, please contact the Steel Solutions Center at 866.ASK.AISC or solutions@aisc.org.