The Transfer Solution

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Steel saves valuable space and time in accommodating high-rise column setbacks.

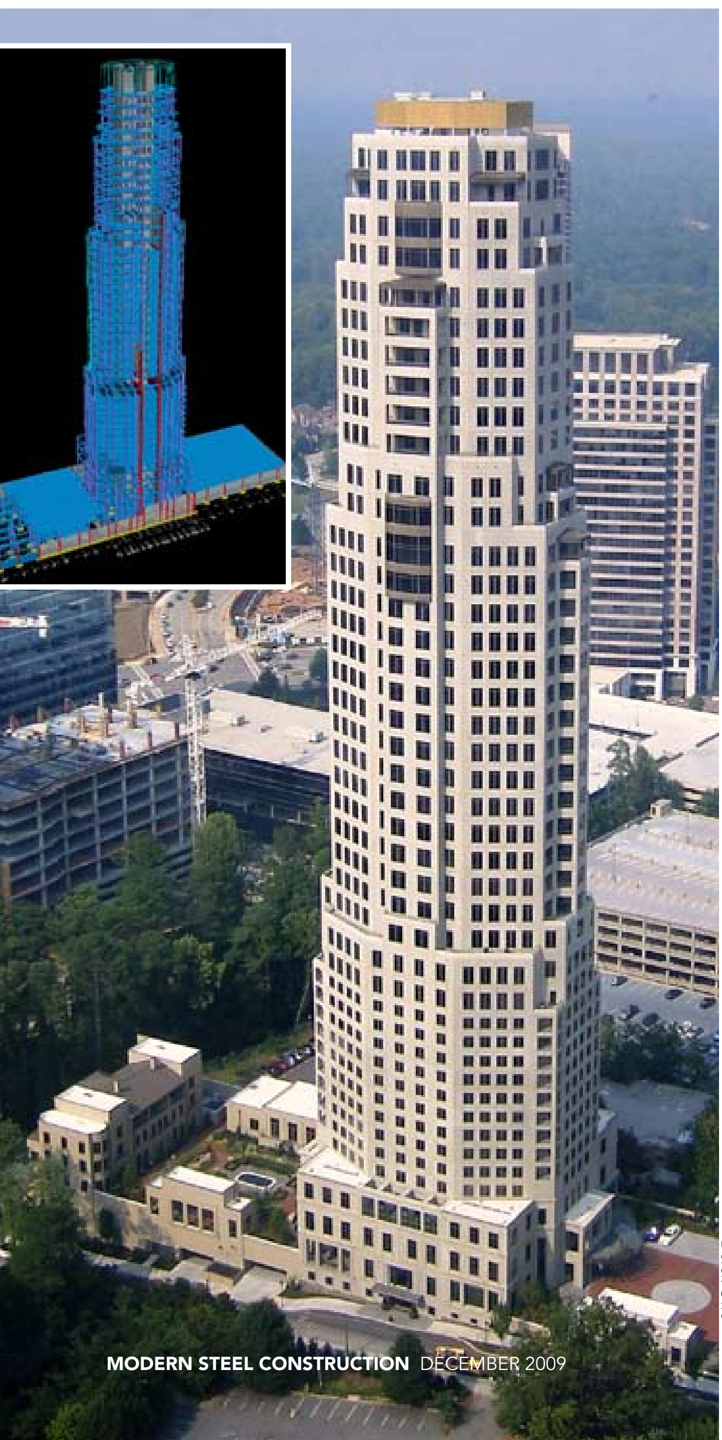
THE MANSION ON PEACHTREE contains many of the complicating elements of typical mixed-use buildings using a stacked configuration. The project includes a parking garage, elevated motor court and garden, 142-key hotel, 15,000 gross sq. ft spa, 8,000 gross sq. ft banquet and meeting space, two restaurants, a bar, three residential villas, and 41 high-rise luxury residential units.

The building is approximately 620 ft tall with a total of 46 occupied levels. It uses a "wedding cake" scheme with steps in the floor plan and column transfers at seven different floors. The design stacks a 27-story residential building on top of a 15-story hotel above a three-story parking deck. Only two of the columns from the residential tower extend to the foundation, while 26 of the 38 tower columns transfer at the top of the hotel floors.

The project presented many design and construction challenges, three of which had a significant impact on the transfer design.

1. Remove all interior columns from the hotel floors.
2. Maximize the number of saleable floors within the height limitation while maintaining 12 ft, 3 in. clear height on the residential floors.
3. Support a fast-tracked delivery process.

The combination of these requirements led to the use of structural steel transfer trusses at two of the seven transfer floors. At these two levels, the transfers span more than 36 ft, support more than 27 levels, and need to accommodate openings for utilities and personnel. The use of traditional concrete beams was considered for these conditions but was found to be unacceptable because the resulting designs either increased the building height, limited utilities and personnel movement, or could not accommodate the fast track schedule.



Derek Owe

Stepping in the top 27 floors of this mixed-use high-rise required transferring the column loads from the top portion using 18 floor-depth structural steel trusses and W40 beams.

Structural Steel Provides the Solution

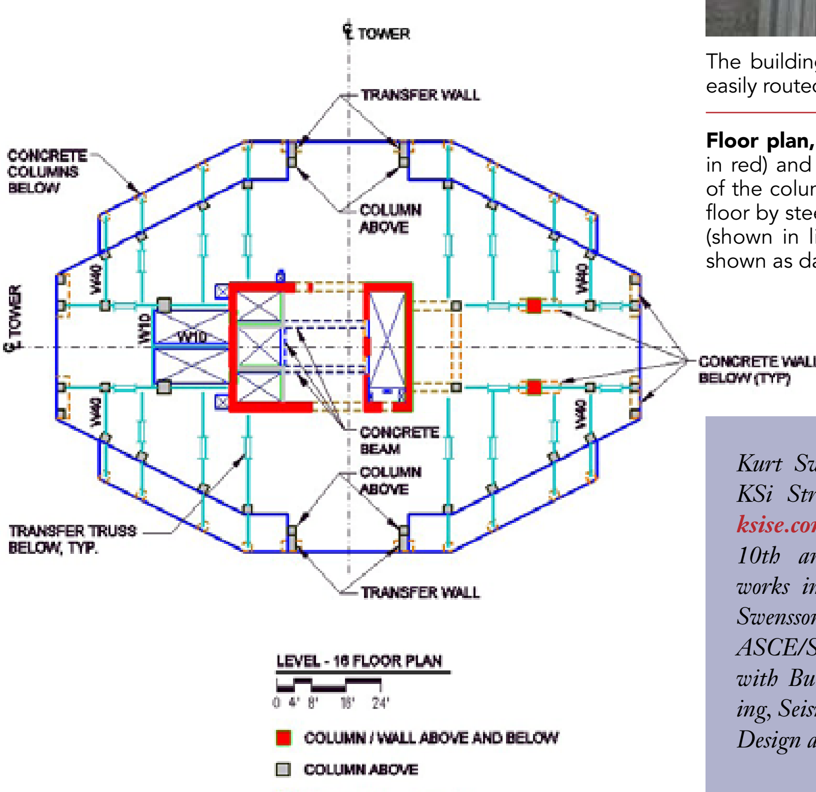
As the design of the transfer elements developed, it became obvious that structural steel was the only realistic option. The requirement to provide openings for egress and access by personnel severely limited the efficiency of any concrete option. The fast track delivery required detailed design before the final location of utilities, which also made the use of structural steel trusses advantageous. The multiple opportunities for penetrations through openings in the truss web allowed the design to proceed with minimal coordination. Further, the open web truss configuration provided flexibility for future replacement, relocation, or addition of utilities. The use of large concrete transfer beams would have made movement of existing or placement of new utilities very difficult.

In the final design, 18 floor-depth structural steel trusses and four wide-flange beam sections transfer 22 columns at the transfer level. Fourteen of the trusses use a composite top chord configuration. Two trusses transfer columns above the ballroom just below the hotel floors.

Through the use of structural steel the column transfers were accommodated without adding height or square footage to the building. Space on the transfer floor was used to transfer the stairs and the elevators, support air handling equipment, as well as data and fire pump rooms. This integrated use of floor space allowed an additional level to become saleable residential space with a value, at the time of design, of approximately $4 million to $6 million.

Project Challenges

Once the decision was made to use structural steel, the challenge was to determine the most efficient way to execute the plan. The integral teamwork of the design team, owner, contractor, fabricator, connection designer, and erector was the key to the success of the plan. The following considerations were significant in the analysis, design, and construction of the trusses—minimizing transfer loads, controlling deflections, and minimizing impact on the construction schedule.



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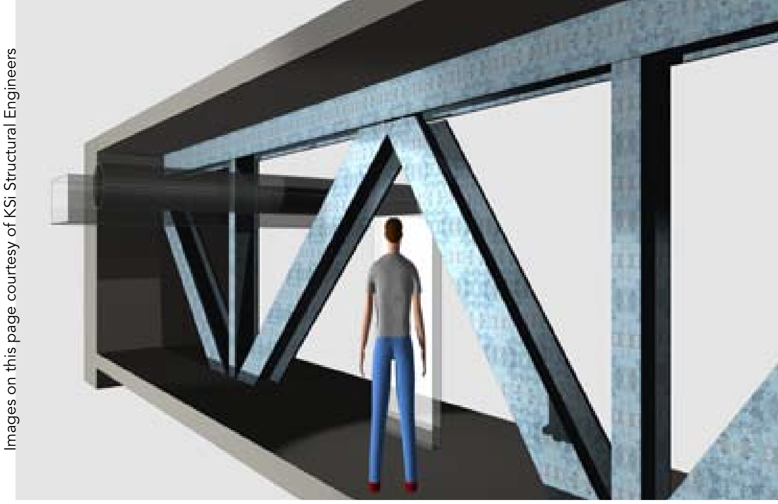

The structural steel transfer trusses used on this project are the full height of the level. Their open web configuration allows people and building systems to pass through easily without extra coordination concerns.

The building's mechanical, electrical and plumbing components were easily routed through the structural steel transfer trusses.

Floor plan, left: Only two columns from the residential tower (shown in red) and the concrete core extend to the foundation. All other 22 of the column loads from the top 27 floors are supported at the 16th floor by steel transfer trusses and the four W40 sections at the corners (shown in light blue). The supporting columns and walls below are shown as dashed brown.

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Connector plates were provided on level 16, atop the transfer truss upper chord, to receive loads for each of the concrete columns.

Aerial Innovations of Georgia

The slab is being formed on the south side of the tower as truss erection continues on the north side. Integrated steel truss erection with slab placement minimized the schedule impact of on-site truss erection. The only way to transfer the column loads resulting from stepping the building in was to use structural steel transfer trusses that are the full depth of the floor.

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To keep from having to use a larger crane, the transfer trusses were lifted into place in pieces each weighing 22,000 lb or less, which were then bolted together using 14,200 high-strength bolts (in addition to the 5,700 used in the shop).

Minimizing Transfer Loads

An effective way to reduce the size of any structural element is to reduce the force it must resist. To this end, the structural engineer worked with the project team to reduce loads on the transfer girders early in the design process. A review of the tower geometry revealed that transferring particular columns on multiple levels provided significant advantage. This plan took advantage of building steps existing in the architectural plan on floors where transfers already were planned. The final geometry allowed the use of more traditional transfer beams with smaller spans reducing cost and schedule impact without increasing the building height. The changes made reduced the load on several trusses at lower levels by up to 60%. Without these adjustments, the transfers at lower levels would not have been economically or technically feasible.

In early computer analysis, it became evident that the transfer trusses attracted significant forces from lateral loading. Therefore, the trusses are de-coupled from the lateral load resisting system. One set of outrigger walls was located just above the transfer level thus transferring overturning loads directly to the columns. This measure isolated the trusses from significant overturning forces. Next, the slab was isolated from the bottom chords and the bottom chords were not extended to the supporting columns. These two measures interrupted the load path for lateral loads through the truss webs.

Controlling Deflections

Deflection criteria were developed accounting for the three-dimensional behavior of the floor, the relative distance between transferred columns, distance between transferred columns and the core, and the allowance for tile on the floors above. The resulting target deflection values varied from 0.25 in. to 0.5 in. for spans up to 38 ft, 6 in. Analysis indicated that shortening in the compression chord was a significant contributor to the truss deflection. To reduce the shortening the compression chords were designed to act compositely with the 10-in. slab placed at that level. The resulting design reduced the weight of the top chord of the trusses by between 60 to 70 lb per lineal ft.

Constructability

Two major challenges shaped the construction of the transfer system. The first was crane capacity, which was based on the requirements of the project's concrete slab and precast panel placement. The tight urban site would not allow the use of additional mobile cranes. Increasing the tower crane capacity for the several weeks needed to erect the trusses would have added $500,000 to the project cost. So the trusses were erected in pieces each weighing less than 22,000 lb.

The second challenge was to minimize the truss erection time. To accomplish this, steel truss erection was woven into a cast-in-place concrete flat slab building schedule. This required coordination of concrete shoring, placement and finishing around the in-place structural steel erection and assembly of the trusses.

Planning for the installation process began four months prior to truss installation, while design was still in progress. The coordination sessions included the general contractor, steel fabricator, steel erector, and the formwork subcontractor as well as the structural engineer. The result was the following process.

1. Place columns/walls to bottom chord level.
2. Set bottom chord with connection plates and independent shoring system.
3. Build slab formwork and shore.
4. Place slab at bottom chord level.

5. Place columns/walls to top chord bearing.
6. Set web elements/top chord.
7. Begin final bolting/welding of web members while forming top chord slab.
8. Place top chord concrete slab.
9. Complete bolting/welding while placing shoring/formwork for next level slab.
10. Remove shoring after bolting/welding completed.

Erection of the 18 transfer level trusses took six weeks during which three floor slabs were placed. When compared to a standard floor construction schedule, the truss erection added four weeks to the project schedule. However, when compared to the alternative—construction of large concrete transfer girders and the additional area that would have been required for a separate mechanical level—the impact of the trusses on the schedule was minimal.

In the final design the weight of the typical truss, without connection material, is approximately 600 lb per lineal ft. The largest truss spans approximately 39 ft, is approximately 15 ft deep, and weighs 1,343 lb per lineal ft. The truss supports two columns as well as reactions from three other transfer trusses. The total calculated load transferred by this truss is approximately 4,700 kips. In total, the structural steel system used to transfer columns included 165 structural steel pieces weighing 410 tons. The system utilized 19,900 high-strength bolts. Of those, 5,700 were shop bolted and 14,200 were field bolted. The approximate cost of the steel transfer system was $2 million, which resulted in an increase of saleable residential area with an estimated value of $4 million to $6 million. Not only was there a solution in steel, it also was a good investment. MSC

Architect of Record
Milton Pate Architects, Inc., Atlanta, Ga.

Structural Engineer of Record
KSi Structural Engineers, Atlanta, Ga.

Steel Fabricator
Steel LLC, Scottdale, Ga. (AISC Member)

Steel Detailer
Engle & Associates Detailing, Inc., Birmingham, Ala. (AISC and NISD Member)

Connection Designer
Ferrell Engineering, Inc., Birmingham Ala. (AISC Member)

Steel Erector
Williams Erection Company, Inc., Smyrna, Ga. (AISC, TAUC and IMPACT Member)

Software Used
RAM Advance