Bookmen Stacks, Cobalt Condos Use ER-POST for Column-Free Space

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When a structural challenge on a difficult project presents itself and conventional solutions seem inadequate, the design ingenuity in the precast concrete industry responds by creating innovative new systems. This scenario is exemplified in the case of an owner of a proposed mid-rise condominium tower in downtown Minneapolis, Minn., who wanted column-free parking levels to accommodate sufficient vehicle space for planned condominium units. But were column-free parking levels even possible? This article presents the results of the entrepreneurial work of an innovative structural engineer in the precast concrete industry and the conception of the new Prestressed Open Space Truss (POST) system, a solution wherein precast concrete trusses span between exterior columns to produce column-free interiors for owners and residents. The Bookmen Stacks condominium project in Minneapolis was the first application of the new ER-POST, and this article discusses this project as well as a subsequent application of the new truss design in the Cobalt condominiums, also in Minneapolis.

With its exposed brick buildings, trendy bars, and popular loft apartments, the Warehouse District of downtown Minneapolis, Minn., may not be the first place one would look for the latest trends in architectural and structural design. The recently built Bookmen Stacks condominiums in the heart of this old neighborhood, however, is the first project to implement a new precast concrete truss system that could change the look, size, and cost of multifunction mid- to high-rise buildings (**Fig. 1**).

Nestled amid the bustling freeways entering downtown Minneapolis, the Bookmen Stacks is a 9-story, 45-unit contemporary residential development in the popular Minneapolis Warehouse District. Viewed by thousands of drivers on a daily basis, Bookmen Stacks' prime location gives the structure high visibility, which generated many passerby double takes during the rapid construction of its unique structural system (**Fig. 2**). Although, like most of the warehouses in the district, this condominium project used concrete as the primary structural element, Bookmen Stacks stands in stark contrast to its brick-clad neighbors. While architecture is typically the defining measure of a structure's creativity, for this development, it is the innovative precast concrete structural system that sets Bookmen Stacks apart.

Courtesy of James Dayton Design and Angela Rugg Images.

Fig. 1. Located next to the Bookmen Lofts (left) in the trendy Minneapolis, Minn., Warehouse District, the Stacks (right) is built on an underground parking structure that is shared with the Lofts. Surrounding the Bookmen Stacks base is a folded zinc panel system with large, punched window openings. The zinc cladding continues on the west elevation and leans out toward the Bookmen Lofts as it rises up on the north side of the building.

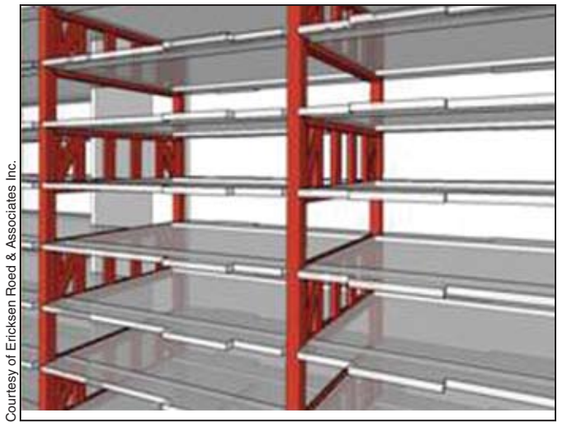
Courtesy of Ericksen Roed & Associates Inc.

Fig. 2. Next to a busy freeway in downtown Minneapolis, Minn., the Bookmen Stacks condominium is the first application of the new ER-POST developed by Mike DeSutter, partner with Ericksen Roed & Associates Inc. of St. Paul, Minn.

Knowing that concrete construction offers the most economical and beneficial solution for multifamily residential living, the Bookmen Stacks design team faced a daunting challenge posed by the owner's project requirements. The hurdle was to find a structural system that maintains the shallow floor-to-floor heights synonymous with flat plate construction while achieving clear spans of up to 70 ft (21 m). The Stacks employs a new exposed structural precast concrete truss system that allows alternating floors to remain completely free of interior columns (**Fig. 3**).

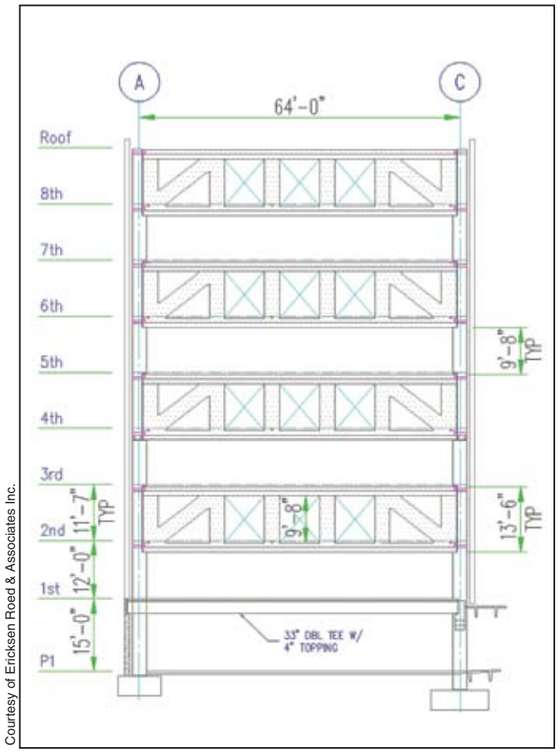
THE OWNER'S NEED: COLUMN-FREE SPACE

For this particular project, the driving force behind developing a system that afforded column-free space was the owner's need to maximize the number of parking stalls in the underground structure. Any columns penetrating the parking level to reduce the open-span length would result in a reduction in the number of parking stalls, which is directly related to the number of planned condominium units. To optimize usable space in the Bookmen Stacks condominium project, the interior columns in the parking space needed to be eliminated. This open-space requirement was a high hurdle to clear, but through problem solving, creativity, and teamwork, a new in-



Courtesy of Ericksen Roed & Associates Inc.

Fig. 3. This rendering of a 3-D schematic reveals column-free alternating floors provided by the new ER-POST system. The building industry needed alternatives to the conventional post-tensioned and precast concrete beams and columns so that owners could have the flexibility and openness necessary for a multiuse design.



Courtesy of Ericksen Roed & Associates Inc.

Fig. 4. This Bookmen Stacks elevation drawing provides dimensions for the new truss system and illustrates the column-free underground parking garage and first level. In multifunction buildings that accommodate first-floor retail, upper-floor residential units, and underground parking, support members (columns) create logistical problems for owners. Note: " = in.; ' = ft; 1 in. = 25.4 mm; 1 ft = 0.3048 m.

novation for precast concrete construction was born.

Mike DeSutter, partner with Ericksen Roed & Associates Inc. of St. Paul, Minn., took on the challenge of finding a system to achieve the desired clear spans for the condominium project. Formerly an engineer in the precast concrete industry, DeSutter's background helped him conceive the new innovative Ericksen Roed prestressed open space truss (ER-POST) system.[1] DeSutter drew upon the concept of the structural steel staggered-truss system created in the 1960s when developing the full-story precast concrete trusses (see Interview with the Inventor, p. 69). DeSutter's idea was to invent a system to bridge the gap between the maximum allowable height of a 4-story wood building and the economical height of a 10-story, post-tensioned, cast-in-place concrete system while improving clearances and providing maximum space utilization for owners.

PRECAST CONCRETE'S SOLUTION: AN OPEN-SPACE TRUSS

Diverging from the conventional staggered truss design, the patented ER-POST[1] system utilizes prestressed, precast concrete trusses that support two floors simultaneously. The trusses span between the exterior walls and are located at each column line with bottom and top chords supporting floors. The trusses are on every other floor (for example, between levels 2 and 3 and levels 4 and 5), allowing the odd-numbered floor levels to be completely free of structure. This alternating-level truss pattern creates column-free spaces on an entire level, resulting in the ultimate flexibility in interior wall layouts to accommodate a multitude of space functions.

Most importantly, the ground level of Bookmen Stacks is completely open, which allowed complete design freedom in the column-free space (Fig. 3). This open-space configuration is not only advantageous to condominium construction. Owners of hotels, senior housing, assisted living residences, and other buildings with high occupancy desire this column-free arrangement for open lobbies, large banquet halls, meeting rooms, and other group facilities. Mixed-use projects that incorporate retail shops at the ground level with residential housing above also benefit from a column-free main floor (**Fig. 4**).

Advantages of the ER-POST System

The ER-POST system has a significant number of important structural and sustainability advantages for residential and commercial construction projects:

- Innovative high-performance structural solution: the ER-POST system is a comprehensive structural system designed to reduce the amount of structural building materials used for the entire building;
- Column-free interior: trusses span from exterior column to exterior column, allowing the structure to be column-free at alternating floors;
- Open space at ground level and alternating floors: this is an important requirement for many residential and commercial structures (**Fig. 5**); on the floors with trusses, the trusses are approximately 40 ft (12 m) apart;
- No interior bearing walls: the system delivers maximum flexibility in renovation and remodeling;
- Flexibility with parking layout: clear spans and the absence of interior columns and bearing walls in parking structures translate into flexibility in parking planning and layout;
- Sound performance and fire resistance: the concrete structure has sound attenuation and fire resistance attributes that enhance the architectural benefits over other alternative construction materials;
- Accelerated construction schedule: large modular structural members with minimum structural pieces allow for speed in early stages of construction, a rapidly enclosed building shell, and accelerated occupancy (**Table 1**);
- Restrictive site solution: the ER-POST system allows construction on a restrictive building site because there is minimal on-site manufacturing, laydown area requirements, and piece erection (see Cobalt Condominium Project Capitalizes on Advantages of New Truss System, p. 70);
- Cold-weather solution: the fast early construction stage leads to enclosure and heating of the building in a very short time, which is especially beneficial in cold-weather climates;
- Exterior wall system flexibility: exterior walls are nonloadbearing, establishing greater flexibility in fenestration and cladding design; and
- Economy: compared with either concrete or structural steel alternatives for the same building, the ER-POST system provides a durable structure at a low cost.

Courtesy of Hanson Structural Precast Midwest Inc.

Fig. 5. The column-free space on the first-floor retail level of the Bookmen Stacks condominiums ensures that the owner has maximum flexibility and space for layout of shops and large open areas, a critical advantage in the real estate market.

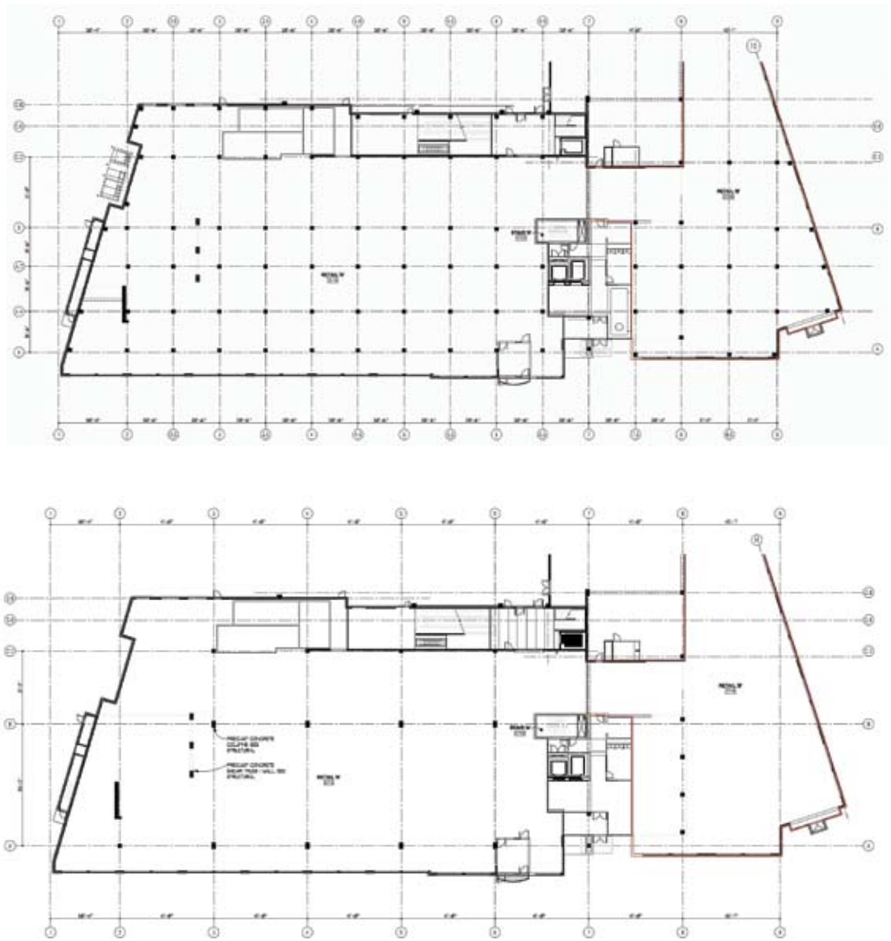
Sustainability is an important parameter for any construction project in today's world of shrinking resources and concerns for environmental conservation and thoughtful recycling initiatives. With regard to sustainability, the ER-POST system has more notable advantages:

- Reduced materials: the ER-POST system utilizes efficient geometry and structural element assembly, thus minimizing raw materials and eliminating unnecessary structure (**Fig. 6**);
- Recycled material content: the ER-POST system is a structural precast concrete system that uses recycled steel for reinforcement and other recycled materials, including fly ash, to replace some of the cement content;
- Local/regional materials: the ER-POST system typi-

Table 1. Components and Details for the ER-POST System for Bookmen Stacks and Cobalt Projects

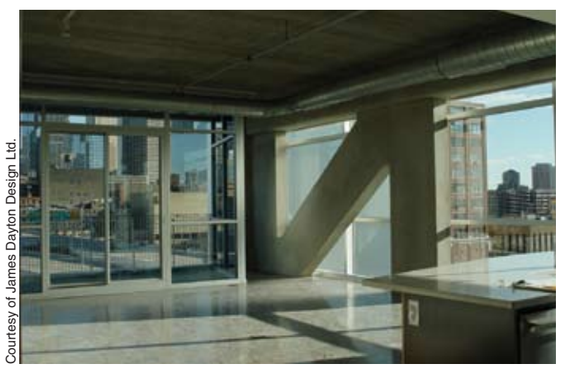
Bookmen Stacks Condominiums	No. of Pieces	Dimensions	Weight, lb
33-in.-deep double tees	124	10 ft × 52 ft	45,000
Open-space truss	20	13.5 ft × 62.7 ft	75,000
Inverted T-beams	31	34 in. × 36 in. × 30 ft	32,000
Truss columns	20	20 in. × 34 in. × 52 ft	37,000
Plank	677	–	–
Solid slabs	18	–	–
Spandrel	20	–	–
Insulated walls	156	–	–
Cobalt Condominiums			
25 in. double tees	122	10 ft × 58 ft	43,000
33 in. insulated double tees	26	10 ft × 58 ft	48,000
Open-space truss	20	12.4 ft × 59.4 ft	69,000
Architectural walls	250	–	–
Inverted T-beams	123	34 in. × 36 in. × 41 ft	44,000
Truss columns	16	20 in. × 34 in. × 67 ft	48,000
Plank	1341	–	–
Solid slabs	172	–	–
Spandrel	28	–	–
Insulated walls	136	–	–

Note: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 lb = 0.4536 kg.



Courtesy of Ericksen Roed & Associates Inc.

Fig. 6. Reduction in building materials and resource conservation are evident in the comparison of these two building plan views depicting the column placement in a conventionally built concrete structure and the remarkable reduction in columns and increased open space in the same structure built with the new ER-OST system.

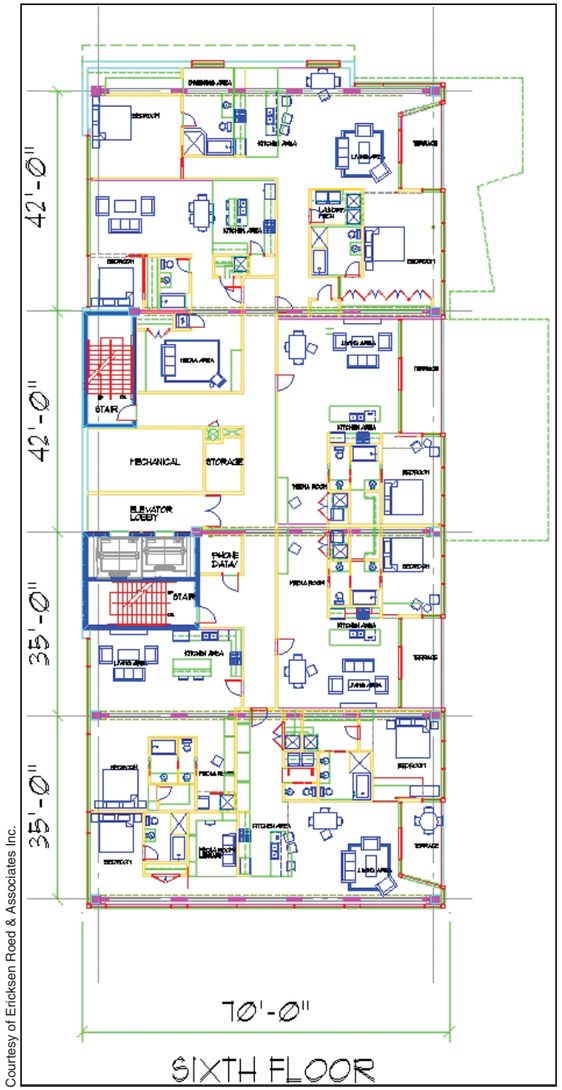


Courtesy of James Dayton Design Ltd.

Fig. 7. This interior photo of a typically spacious level in the Stacks shows the marvelous open views of the Minneapolis, Minn., skyline afforded by column-free construction.

Courtesy of James Dayton Design Ltd.

Fig. 8. The furnished living room space in Bookmen Stacks presents the airy, unobstructed, and spectacular downtown Minneapolis, Minn., views afforded to residents.



Courtesy of Ericksen Roed & Associates Inc.

Fig. 9. The sixth-level floor plan illustrates the layout of residential units and the location of the elevator bank. Note: " = in.; ' = ft; 1 in. = 25.4 mm; 1 ft = 0.3048 m.

cally uses local precast concrete facilities to manufacture the structural elements, which provides a reduction in expended energy required to transport the building materials;

- Enhanced thermal performance: the ER-POST system contributes thermal mass to help control indoor temperatures by contributing to a system that dampens indoor temperature swings;
- Daylight and views: the ER-POST system design eliminates the need for interior columns and perimeter spandrel beams, thus allowing for maximum availability for solar illumination and unobstructed views through exterior walls (**Fig. 7, 8**);
- Modularity and erectability: the ER-POST system uses large modular structural members with optimized piece layout, manufacturing processes are conducted in a controlled precast concrete plant environment that offers minimal waste and efficient use of resources, and minimized field manufacturing allows for fast installation and a reduction in expended energy required for the production and erection of the structure; and
- Reusable structure: the ER-POST system provides tenants and future tenants with a durable structural solution that allows flexibility for use in tenant spaces by eliminating interior column requirements.

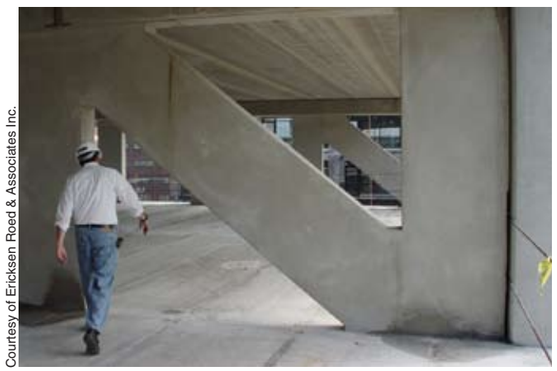
THE STRUCTURAL DESIGN

Bookmen Stacks is a 112,000 ft^2 (10,400 m^2) structure comprising eight stories of condominiums over one level of underground parking. The typical floorplate is 67.33 ft × 159.0 ft (20.5 m × 48.5 m), with trusses at each column line spanning the full 67.33 ft (**Fig. 9**). To complete the floor system, 12-in.-thick (300 mm) precast concrete hollow-core spans the truss intervals ranging from 35.0 ft to 42.0 ft (10.7 m to 12.8 m). The longer hollow-core spans allowed for a reduced number of trusses to additionally economize the system.

To obtain an open first-level lobby along with one parking level below grade, the trusses start on the second level. The first floor (grade level) is framed with 33-in.-deep (840 mm) precast concrete double tees that span the long distance over the subgrade parking (Fig. 3, 4). By eliminating the columns in the parking area, the parking capacity increased approximately 15%. This additional space alleviated many of the problems in parking planning and layout and provided sheltered parking for 100 vehicles.

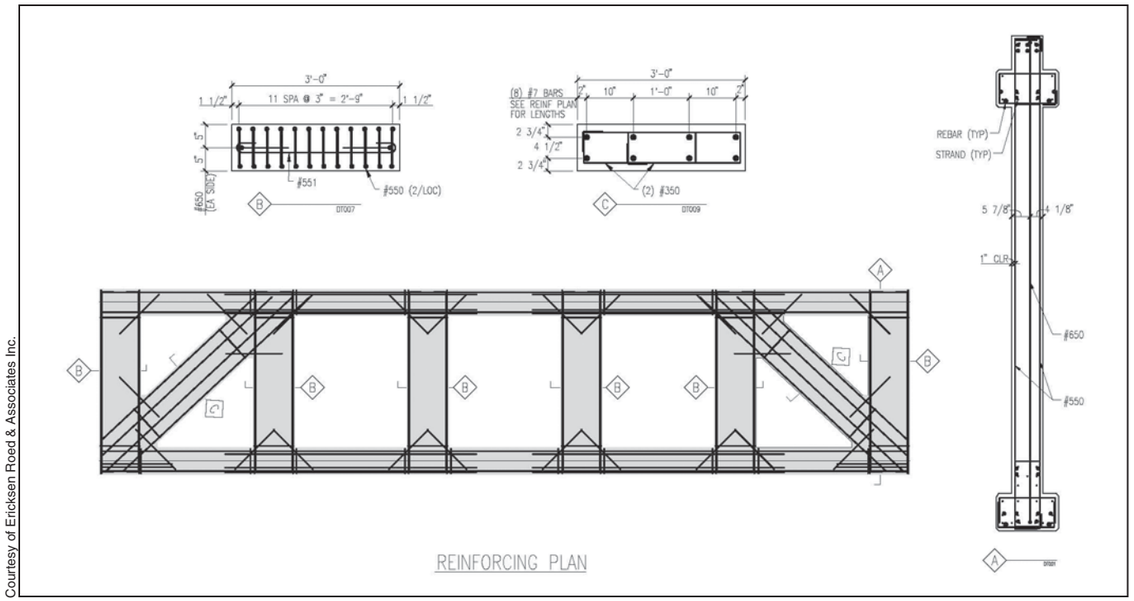
Design Based on Vierendeel Truss

Designed as a hybrid bowstring Vierendeel truss, the ER-POST system marries economics and functionality. The



Courtesy of Ericksen Roed & Associates Inc.

Fig. 10. Flag Builders' construction superintendent, Tom Casey, walks through a vertical element of new prestressed truss system. Vertical components of the truss system are eventually incorporated into the interior walls of the condominium units.



Courtesy of Ericksen Roed & Associates Inc.

Fig. 11. This graphic identifies reinforcing and prestressing tendon placement in the open-space truss. Note: " = in.; ' = ft.; 1 in. = 25.4 mm; 1 ft = 0.3048 m.

trusses are 64.0 ft × 13.5 ft (19.5 m × 4.1 m) and weigh 75,000 lb (34,000 kg). The overall layout of the vertical and diagonal truss members has enough flexibility to align with architectural openings. Passage locations for doors (and for corridors in residential units) are not obstacles for this framing system because the diagonal members can be eliminated in predetermined sections. With the generous column spacing, the trusses often enclose an entire unit layout and generally do not interfere with future tenant modifications.

The precast concrete hollow-core floors are supported by prestressed top and bottom chord inverted T-beams with 20 in. × 12 in. (510 mm × 300 mm) flanges and 10 in. × 23 in. (255 mm × 660 mm) webs. A 4-in.-thick (100 mm) lightweight concrete topping overlays the entire floor system, yielding a shallow floor depth of 16 in. (410 mm) for the long-span, column-free space that is difficult to match.

The top and bottom chords extend slightly into the open living space with minimal soffit protrusion (Fig. 7, 8). The vertical components are generally contained within the walls that separate the living units (**Fig. 10**). A typical wall width comprises the thickness of the vertical concrete truss members and the room finish. Because the typical member width is 10 in. (250 mm), the overall wall width is less than 12 in. (300 mm). This wall width is over 25% thinner than the 16 in. (410 mm) equivalent steel staggered truss width, which requires additional width for the necessary fireproofing requirements.

Fire Rating, Sound Transfer, and Strut-and-Tie Model

The truss system yields a two- to three-hour fire rating, which lowers insurance costs. Without the need for fireproofing material, there was no additional schedule allowance required for another subcontractor to perform this work.

Sound attenuation is excellent, with a sound transmission class (STC) of greater than 50 inherent in the material. The impact insulation class (IIC) ratings for the truss system are above 50 when using a sound mat.

The top chord of each truss is designed primarily as a column because the design loads place this component in compression. In the bottom chord, the prestressing strand is designed to resist all of the design tensile forces and mild reinforcing steel is used for local stress reversals (**Fig. 11**). The trusses generally have an open-web configuration, but depending on structural capacity requirements, some truss segments may require a solid web section or additional diagonal struts.

Casting a solid web panel is not difficult, but the overall truss weight may be contingent on the capacity of the crane used for erection. Thus, using the open-web truss layout is more economical despite the increased congestion at the connection regions. The truss connections are designed using the strut-and-tie model (STM) approach. The STM approach provides a more realistic load path for the safe transfer of load throughout the truss and to the supporting vertical members and allows for easier visualization by the designer. The use of self-consolidating concrete and the high level of quality control at the Hanson Structural Precast–Midwest Inc. facility in Maple Grove, Minn., virtually eliminate any problems associated with the highly congested reinforcement areas in the trusses.

Lateral loads are transferred at each level through the precast concrete plank diaphragm to a concrete shear core. The core for Bookmen Stacks is located at the bank of elevators near the building center, and the connections use standard

Fig. 12. The truss is aligned and welded to the columns. It awaits the top and bottom chord precast concrete plank to complete the floor system.

Fig. 13. Delivered to the construction site on a flatbed truck from the Hanson Structural Precast concrete facility 20 miles (32 km) away, the 64-ft-long (19.5 m) × 13.5-foot-tall (4.1 m) truss weighing 75,000 lb (34,000 kg) is being lifted from its transport.

Fig. 14. The truss is lifted off the truck's flatbed and is starting its swing into position.

Fig. 15. Crane operator and erection signal crew members carefully prepare to slide the massive truss into the precast concrete column brackets.

Fig. 16. This photo perspective is an overall view of the ER-POST system. All but the two final trusses are in place, and precast concrete plank (12 in. [300-mm] thick) will soon establish the top two floors. The parking is clear-spanned with precast, prestressed concrete double tees. The truss bottom chord supports the second floor, and the truss top chord supports the third floor, leaving the first floor completely open. The erection is fast and simple, and with all precast concrete elements—columns, trusses, and plank—the onsite work is minimized. With this building elevation, one can visualize the amount of open space on all floors, allowing for large flexible space planning.


Fig. 12.


Fig. 13.

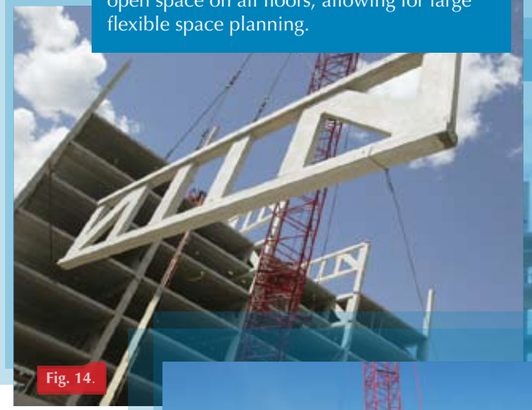


Fig. 14.


Fig. 15.


Fig. 16.

Courtesy of Ericksen Roed & Associates Inc.

Table 2. Construction Sequence for Bookmen Stacks

Activity	Date
Start of design	January 5, 2004
Start of production	March 8, 2004
Start of precast concrete erection	April 5, 2004
Complete precast concrete erection	June 15, 2004

precast concrete details (Fig. 9). For areas where the governing lateral force is the minimum 90 mph (145 km/h) wind load, the lateral design generally does not control the system design for structures up to 12 stories. This building system is practical for structures up to 25 stories in areas of low seismicity.

Precast concrete also provides a stiffened structure, which significantly reduces the vibration and deflection issues that plague structural steel structures and the shrinkage/movement issues associated with wood construction (racking of doors and windows). With concrete as the material of choice, the tenants of the Bookmen Stacks will experience high-end loft living in this durable and low-maintenance structure.

THE APPLICATION: BOOKMEN STACKS CONDOMINIUMS

Precaster's First Open-Truss Project

Fortunately, the contractor for the Bookmen Stacks project had heard of the truss design through a contact at Hanson, which manufactures the trusses in its 250,000 ft^2 (23,000 m^2), fully enclosed plant in Maple Grove. Because the project was over budget as originally planned, the initial motivating need of the owner was to reduce the structure costs. The precaster contacted Ericksen Roed to explore the idea of using the new precast concrete truss system. Hanson believed that the new truss design would solve the parking issues and bring the project back in line with budgetary goals. Because the truss system would reduce costs up to one-third of those of a cast-in-place concrete solution, the owner was pleased.

All of the key players on the Bookmen Stacks project agreed that while saving money was the initial reason for choosing the truss, the system ended up delivering a tremendous design advantage. The trusses were placed on alternating floors, creating completely open floor plans with spacious 3000 ft^2 and 5000 ft^2 (280 m^2 and 460 m^2) levels that required no other internal supports. There are no beams or posts scattered throughout the units, which enables designers to create desirable open-air condominiums with maximum flexibility in placement of walls and doors.

Concrete was placed in the forms for two of the giant precast components at a time at Hanson's Maple Grove facility and then placed flat on truck beds to transport to the site, 20 miles (32 km) away. Once at the building site, a crane picked up one end of the truss from the truck bed, rolled the truss onto a set of large concrete blocks next to the trucks, and swung the truss up and into place on the structure (**Fig. 12–16**). While the forms were being manufactured at Hanson's precast concrete facility, workers on the jobsite were able to excavate and place the foundation for the building. With typical cast-in-place concrete construction, none of the superstructure component work could be done until the site excavation and foundation work were complete.

The in-house production of the truss pieces gave Hanson a quality edge, keeping tolerances tighter than those possible for field-placed concrete and creating optimum drying and curing conditions—a real bonus considering how the alternative, traditional structural materials would have done when production began in the rainiest April on record in Minnesota. Even though Bookmen Stacks was Hanson's first project using the new truss system, there were few production problems beyond working out edge details and fit-up details for the facade.

The resulting structure was an elegant and flexible design, as well as a cost-effective solution. The resulting open, airy spaces are appealing. To make the new building fit into the old neighborhood, some of the concrete components were left exposed to give the Stacks the same aesthetic look and ambience that typifies the adjacent Bookmen Lofts and many of the other surrounding structures in the Minneapolis Warehouse District.

The Bookmen Stacks tower utilized a variety of precast concrete products, including hollow-core, long-span truss beams supported by exterior columns, wall panels at two stair/elevator shafts, and insulated panels for the foundation walls. The parking structure was constructed with two levels of double-tee beam deck, interior beams and columns, below-grade insulated foundation walls, and precast concrete grade beams (Table 1).

Fig. 17. This production photo was taken at Hanson Structural Precast–Midwest facility during manufacture of open-space truss.

Courtesy of James Dayton Design and Angela Rugg Images Inc.

Fig. 18. The Bookmen Stacks condominium's (Lofts at far right) landscaped courtyard serves as a gathering space for the entire Bookmen campus. The concrete structure is visible from the outside through a transparent glazing system that wraps the exterior.

The Builder's Point of View

For the builder, the Bookmen Stacks project started out as an inefficient, underground two-story parking structure—an extension of a warehouse (the Lofts) conversion project (Fig. 1). The initial plan called for a parking ramp to provide access to the lower level of the existing warehouse. From an owner's perspective, support members (columns) create logistical nightmares in a multifunctional building that must be flexible enough to accommodate retail, residential, and parking spaces. Column location may be acceptable for the housing sections of the building but not for the retail sections and never in the parking area. In the case of parking structures, owners see every support column as taking up valuable real estate, and column elimination can dramatically change the size and potential profit of a project.

The elimination of columns in the parking structure solved the initial dilemma that drew the Bookmen Stacks design team and owner to consider the new truss system. The first phase of the Bookmen project involved renovating an existing 50-unit structure, the Bookmen Lofts (Fig. 1). As part of the renovation, the owner promised condominium buyers that they would have underground parking in the soon-to-be-built Bookmen Stacks building. It turned out that the original plans, using a post-tensioned concrete design, were too expensive.

Because of the many columns in the original design, the builder would have had to excavate two levels to provide sufficient parking spaces for the units, making the parking structure twice as expensive to build—adding roughly $5/ft^2 ($54/m^2) to the cost of the precast concrete package. The expensive prospect of excavating two levels for parking in soils that were suspect (potential contamination) meant that the $2 million project was spiraling well over budget.

Because the owner wanted the maximum space for parking and fewer columns than would be delivered through a typical precast concrete construction, Flag Builders went to Bob Geil at Hanson and was introduced to the possibilities of the newly developed precast, prestressed concrete truss system. DeSutter provided design and engineering that gave the contractor the benefit of footage pricing that was easily tracked in terms of additional building space and in providing quotes to the owner (see Interview with the Inventor, p. 69). Once the builder decided to erect Bookmen Stacks with the new prestressed open-space truss system, the subsequent erection process was surprisingly fast and fluid.

By selecting the ER-POST system, the contractor could offer the owner a mid- to high-rise building without the constraints posed by internal columns and erect the number of floors desired. Because the truss is a single piece that can be customized in height, length, and number of openings to meet the needs of any structure with open spaces and optional placement of doors and windows, the contractor was able to eliminate cumbersome structural elements that hinder most multiuse building designs.

Attaching the curtain wall to the precast concrete system was not difficult, as all the engineering and details had been worked out ahead of time by the project architect. A deflection tolerance of 0.75 in. to 0.88 in. (19 mm to 22 mm) was allowed for vertical rise on the curtain wall. The erection went so fast that in only four weeks, the precast concrete structure,

from level 1 to level 8, was completed before the other building trades were organized to work at the site.

One issue that had the potential to delay for the construction crew was obtaining permission for any field penetrations of the precast concrete trusses. Because the trusses contained prestressed strand and reinforcing for structural integrity, it was critically important to identify panel locations for proposed penetrations and obtain clearance from engineering before proceeding with cutting openings. The contractor credits the thorough preplanning done by the precaster for supplying accurate truss grid lines that made field-cut openings proceed without a hitch.

The only other concern that the erector had with the truss system was the capacity of the hoisting crane and the weight of the precast concrete trusses. Because the precast concrete trusses are heavy, up to 75,000 lb (34,000 kg), selection of an adequate crane for weight and reach was critical to installing the system. Hanson used a 2250 Series 3 Manitowac crane (300 ton [270 tonne] capacity) equipped with 220 ft (67 m) of main boom for lifting the massive trusses.

The sizes and weights of the precast concrete components were manageable by a smaller mobile crane because the hoisting equipment was dictated by the restrictive building site (Table 1). The eight-story, above-grade portion of the Bookmen Stacks project was erected in four weeks (Fig. 12–16). The ER-POST system required no shoring, which significantly reduced the construction schedule. This construction schedule reduction translated into an earlier date for tenant occupancy, greatly satisfying the owner (**Table 2**). Bookmen Stacks required only 20 trusses for erection of its eight stories.

Additional schedule reduction was generated by the material selection.

This kind of open layout used to be unheard of in mid- to high-rise construction. By using concrete strengths of 8500 psi (59 MPa), the precast concrete trusses can support the weight of several stories without the need for interior columns. Except for plumbing walls, the system affords clean, wide-open space. The project precaster and builder credit the strength and flexibility of the truss system for enabling the Bookmen Stacks project to be erected in record time and for a much lower cost than many traditional structural options.

CONCLUSION

Bookmen Stacks is one of the newest condominium developments to hit the trendy Minneapolis Warehouse District. These condominium units are not like the rest. They boast plenty of open interior spaces and some of best views of the downtown skyline (Fig. 7, 8) and have the distinct advantage, with respect to Minnesota's frigid winters, of tenant parking in an enclosed and heated precast concrete parking structure. Using a precast, prestressed concrete truss system cut 20% off the structure's original package costs, shaved two months off the construction schedule, and eliminated all of the interior columns on alternating floors.

The original goal was not to find an inexpensive building material; it was to find a solution to the challenges of building mid- to high-rise multiuse housing that meets owners' needs. The Bookmen Stacks design team discovered that not only did the truss system work, it saved considerable money over conventional designs, gave builders and designers more freedom in construction, and created open spaces to accommodate any need.

"The precast concrete option breathed life back into the project. The tower was erected in just six weeks, and the parking garage only took two weeks to complete," said Tom Casey, senior jobsite superintendent for Flag Builders. "We are quite pleased with the end result (**Fig. 17, 18**)," said Bookmen Stacks owner Steve Frenz of Rex II Development Inc., "and the speed of construction was quite impressive. As a repetitive design, the system would be quite efficient. Our residents love the open spans that the system provides." This project is a great example of how teamwork and ingenuity evolve into an innovative solution.

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CREDITS

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Interview with the Inventor

PCI Journal recently interviewed Mike DeSutter, partner and vice president with Ericksen Roed & Associates Inc., the structural engineer who invented the patented ER-POST system.

PCI: What first sparked your idea for the new prestressed truss system?

MD: Kent Larson from Weiss Builders asked us to come up with an affordable structural system in the 6- to 12-story range for housing projects.

PCI: How did you come up with the new open-space truss design?

MD: In our review of housing structural systems, the staggered steel truss system had some very positive features. A few engineers in our office used this system with good success in the late 1970s. However, it has shortcomings that limited its utilization. After some analysis it became apparent that most of those shortcomings would be eliminated by simply using a precast, prestressed truss instead of steel.

PCI: What was your biggest challenge in designing the truss?

MD: The final configuration of the truss, arrived at after several iterations of analysis, in the end seemed fairly obvious. In the component design process, the biggest challenge is locating and sizing the correct amount of prestressing and mild reinforcing to resist the interaction of stresses between overall flexural behavior and the localized beam stresses, which reverse signs rapidly.

PCI: Contractors for the Bookmen Stacks and Cobalt projects felt that the rapid erection and enclosure of the buildings during Minnesota's winter conditions were the design's greatest benefits. What do you consider the number one advantage and disadvantage?

MD: Column layouts that work for housing rarely fit in well for retail levels, and [columns] always cause problems in parking. We're always wrestling with where to put the columns. The truss system solves this dilemma. The major disadvantage is the large size of these elements, which will always be a challenge for shipping and erecting.

PCI: What is the future for this system?

MD: As another tool that designers should consider to solve structural problems. We need to encourage owners and architects to consider function interaction with structure, economics, and constructability.

PCI: What do you see as the most exciting potential development in materials and designs in the precast concrete industry?

MD: SCC [self-consolidating concrete], carbon reinforcing for slender elements, and flange connections with seismic capacities, structural solutions that can provide architectural forms and finishes—[while these designs] may not be new, the potential, however, is largely untapped.

Photo of the finished Cobalt condominiums.

Cobalt Condominium Project Capitalizes on Advantages of New Truss System

Steven R. Doughty, AIA, Pope Associates

Adjacent to the Mississippi River and within the St. Anthony Falls neighborhood near downtown Minneapolis, Minn., the Cobalt condominium project has become an architectural landmark. With its contemporary and transparent design, the new building offers trendsetting, upscale living spaces above active street-level retail.

Cobalt is a mixed-use development that features 92 condos with additional retail space. Hanson Structural Precast–Midwest was responsible for the production, delivery, and installation of precast/prestressed concrete structural and architectural building components.

The precast concrete truss system provides the necessary column-free areas required for the below-grade condominium parking and the large retail spaces at street level. The condominium floor plates above the retail level also benefit from the open floor areas that are made possible with the unique structural system. The plan layouts of the condominiums can be customized to the individual resident's needs due to the absence of space-defining structural components typically found in a residential tower of this scale.

The project team requested that Hanson be involved very early in the preliminary design phase. Hanson representatives Gary Pooley, sales, and Bill Witbeck, estimating, worked together for several weeks to assist in multiple design and budget phases for the project. Working closely with Pooley and Witbeck was engineering manager Mike Wagner. Pooley eventually proposed and sold the complete precast concrete system being used for this project based on three main advantages that it has over other building systems.

Flexible Design

Working with McGough Construction and Exeter Realty Co., Pope Associates created a contemporary structure that combines retail, housing, and structured parking in an efficient and flexible design. Lund's Neighborhood Market anchors the retail space and subleases smaller spaces for restaurants, coffee shops, and similar service providers. Residential units are accessible via private lobbies and elevators and connect to lower-level parking via a separate access. While the building's design is intended to stand out, the design team took great care to listen to and incorporate the feedback of the surrounding neighborhood.

Column-Free Interiors

The Cobalt project allowed Pope Associates to collaborate with two distinct types of clientele, retail and housing, in interesting and innovative ways. In collaboration with Lund's, the retail space was designed to enhance the visibility to the street and pedestrian traffic and provide convenient loading-dock areas. The adjacent multi-tenant retail spaces allow for flexible layouts and optimize access and visibility. The residents of the housing units were able to choose (and customize) from a variety of unique floor-plan options. The sales, design, and construction teams worked closely together to consistently provide a unique living environment for each individual buyer.

Restrictive Site Solution

The construction site area was very limited. In fact, once the project was completed, 100% of the site area was infilled with new construction. Due to these site constraints, which are typical of an urban site, material staging, erection, site safety, and minimizing disruption to normal street activity were of the utmost concern to the Cobalt project team. The successful integration of the four major building components (exterior curtain wall, precast concrete structure, mechanical systems, and electrical systems) required strict adherence to material and construction tolerances when necessary and, at times, required flexible adaptation of installation procedures.

Located at the busy intersection of University and Central Avenues near downtown Minneapolis, the Cobalt jobsite covers a full city block, and the city of Minneapolis required access, during construction, to the streets that surround the site. Because of these tight site conditions, the weight and overall size of the precast concrete structural members, and the reach requirements for this project, Hanson used a 300 ton (270 tonne) Manitowoc 2250 crane that was brought in from Montana to do the job. The heaviest members (the trusses) weigh as much as 69,000 lb (31,000 kg) and are over 59 ft (18 m) long (**Table 1**). Over a period of 12 weeks, this massive crane set precast concrete columns, beams, trusses, and plank components for the structural frame of the 10-story tower.

This precast concrete erection photo illustrates the modular stacking method of assembly during construction of Cobalt condominiums.

Cold-Weather Solution

From the general contractor's point of view, as Cobalt's construction began in the frigid month of December, one outstanding advantage of the precast, prestressed concrete truss system was its early building enclosure. A cast-in-place concrete system would have required considerable resources and planning to provide climate control for workers and materials during the cold winter months.

One aspect of the project that took considerable planning and coordination was approval to cut openings in the precast, prestressed concrete trusses. Openings had to be carefully located to avoid prestressing tendons or mild reinforcing steel in the trusses. Excellent early coordination between McGough Construction, Tim Morey and Gary Peterson of Ericksen Roed, and the layout staff at Hanson made fitting up relatively problem free. Another concern on the Cobalt project was ensuring worker safety. Because the open-space truss is a new system and the trusses are heavy, great care had to be taken to make sure workers in the building were always safe and not placed in potentially dangerous situations during truss erection. Consequently, no building trades were allowed to work in the structure during hoisting operations.

Lower Cost, Open Space, Accelerated Construction

The first advantage of the open-space truss system was the lower overall cost of construction compared with other material systems, such as cast-in-place concrete and structural steel. The second advantage was availability of large areas of open floor space because fewer columns were needed with the precast concrete system. Open space provided more design flexibility for the architect. The third advantage was the speed of construction provided by using precast concrete. While site excavation, utility work, permitting, footings, and all other related work was being done on-site, Hanson produced the precast concrete components in its 250,000 ft^2 (23,000 m^2) indoor production facility in Maple Grove, Minn., less than 20 miles (32 km) from the Cobalt site.

The Cobalt precast concrete structure was completed in June 2006, and the entire project was scheduled for completion in February 2007. Installation took place in five months, using over 2375 pieces of structural and architectural precast concrete produced by Hanson. According to Gary Pooley, Hanson sales representative, this short construction schedule was possible because, from the early stages of this project, the owner required all project members to attend weekly meetings and stressed a dynamic team atmosphere.

Owner's Assessment

"The precast concrete truss system was a good solution for our 10-story Cobalt condominium project," said the owner, James A. Stolpestad of Exeter Realty Company, "because of its cost and timing advantages over conventional post-tensioned concrete construction. We were also pleased with the finishes of the precast pieces that were brought to the job site. We would certainly consider using this system again for any new building of approximately 6 to 12 stories in height."