Speeding Mass Transit Projects

Precast concrete aids mass transit projects and their specific logistical challenges by offering benefits in construction speed, durability, design and aesthetic versatility

— Craig A. Shutt

Projects that support transportation services—including rail lines, buses, and airline terminals—offer distinct logistical challenges that add to traditional design and construction requirements. Foremost, they usually must be constructed around active services that place restrictions on when and where construction can take place. The benefits provided by precast concrete often are called upon to bring these projects in on budget and on schedule.

In many cases, no matter what type of construction has been used on the service buildings themselves, precast concrete is specified for accompanying parking structures that will provide support services for the main transportation hubs. Some of the key benefits include providing complementary aesthetic appearances to existing or new buildings, plant-based fabrication that minimizes site congestion and impact, quick erection and reduced weather delays that accelerate construction and help ensure on-time completion, and sustainable-design attributes.

The following projects show ways in which designers have used precast concrete on mass transit projects to meet the owner's goals while overcoming the distinct logistical challenges that these designs present.

Denver Airport Expansion

A number of key challenges faced designers when officials at the Denver International Airport needed to expand their terminal space by adding five gates onto one of their concourses. The construction had to be done quickly to allow the airport to add needed flights and to reduce disruptions to the airfield. And logistics would have to be closely considered, as some of the work would take place within only a few feet of the working terminal and taxiing airplanes, service vehicles, and passengers.

Designers chose a precast concrete structure and enclosure system to meet these goals. Approximately 565 pieces, covering 72,232 square feet, were required to construct the terminal expansion. Included in those pieces were nine-piece monolithic moment frames that were cast at the plant and then fit together onsite like jigsaw pieces.

"There was an exhaustive study done to determine the fastest and most effective way to build the new gates," explains Kevin Sullivan, president of Wong Strauch, the architect of record. To meet the airport's commitments to airlines, the project had to be designed and built in a 24-month window. "We found that precast concrete would provide the best option to meet our goals."

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Using precast concrete for the terminals was a new approach, Sullivan notes. "We've been involved with the airport on other projects, where precast concrete typically is used for the parking structures. But this application offered the best solution for the terminal."

This was a much different type of application of the material for us, agrees Morgan Lysohir, construction executive and project manager at Milender White, the general contractor. "In this case the structural framing that had to be integrated with interior storefronts and interior finishes with a large, open area at its center. It was a great decision to use precast concrete."

Casting components off-site at the plant eliminated a lot of congestion and logistics from the airfield, she explains. "It let us get away from all the traffic with much of the construction. The number of concrete trucks we would have had to drive across the working airfield would have been significant and had a major cost and time factor to it. Precast concrete worked quickly and efficiently by doing so much of the work off-site."

"The speed of construction was a hot item for the airport, because they wanted the terminal gates opened on a very fast schedule," says Gerald Shook, project coordinator at Stresscon Corp., the precaster. "The entire project was fast-tracked: the shop-drawing schedule was condensed, with limited time to set up everything and cast it, and then the erection in the field had a tight schedule to completion."

Site Challenges

Adding to the challenges was the winter weather through which the construction had to continue. "Some days, temperatures were in single digits or negative numbers, so it was definitely a challenge," says Lysohir. Adds Stuart Karp, field superintendent, "A significant amount of protection and tenting had to be provided, including heat wagons. We had to use a lot of hoses to heat and maintain the pieces for post-tension grouting and dry packing." In some cases, the hoses had to be coiled over two levels to reach the required areas of the splice sleeves to ensure the grout set.

Congestion at the site required close communication and detailed logistics to avoid any conflicts. The new precast framing was erected up to the edge of the existing structure, with only a 3-inch joint between them, which was filled with an expansion

Photo: Milender White Construction Co.

joint. The floor system had to cantilever to this point from supports 5 feet away. "The general public was on the other side of that 3-inch gap when we began construction, so we had to be very careful with the process," says Karp. "As we moved further away, we had a little more leeway."

The work was complicated by the foundations being laid as work progressed out from the terminal, causing trucks to have to drive over existing grade beams, and a 150-foot boom crane being maneuvered so as to protect the grade beams. "It became a very critical process that had to be designed to protect the active airfield and existing foundations," says Sullivan.

Contractors also were concerned about safety due to the possibility of high winds arising while working near active areas, notes Lysohir. Coordination also was required working with the cranes with planes taxiing by. "The planes sometimes were within 100 feet of where we were working. Everything had to be monitored very closely."

Photo: Milender White Construction Co.

Photo: Wong Strauch Architects.

A preliminary study showed designers that using precast concrete to add five gates onto the Southwest Airlines terminal at the Denver International Airport would provide the most economical approach with a tight sight and a short deadline.

PROJECT SPOTLIGHT

Denver International Airport Terminal
Location: Denver, Colo.
Project Type: Terminal expansion
Size: 80,000 square feet
Designer: Wong Strauch Architects, Denver, Colo.
Owner: Denver International Airport
Structural Engineer: Weingart Structural & Civil Engineering Consultants, Denver, Colo.
Contractor: Milender White Construction Co., Arvada, Colo.
PCI-Certified Precaster: Stresscon Corp., Denver, Colo.
Precast Components: 565 precast concrete components including straight columns, H-columns, U-columns, spandrels and 672 splice sleeves

Moment Frames Constructed

The work moved quicker thanks to the use of moment frames that connected major segments. These frames were needed to supply a large, open area in the center of the terminal where people gather before moving to their gate. "The precast concrete design could achieve that goal easily using the moment frames," says Shook. "It allowed us to posttension the pieces together onsite rather than have to use shear walls."

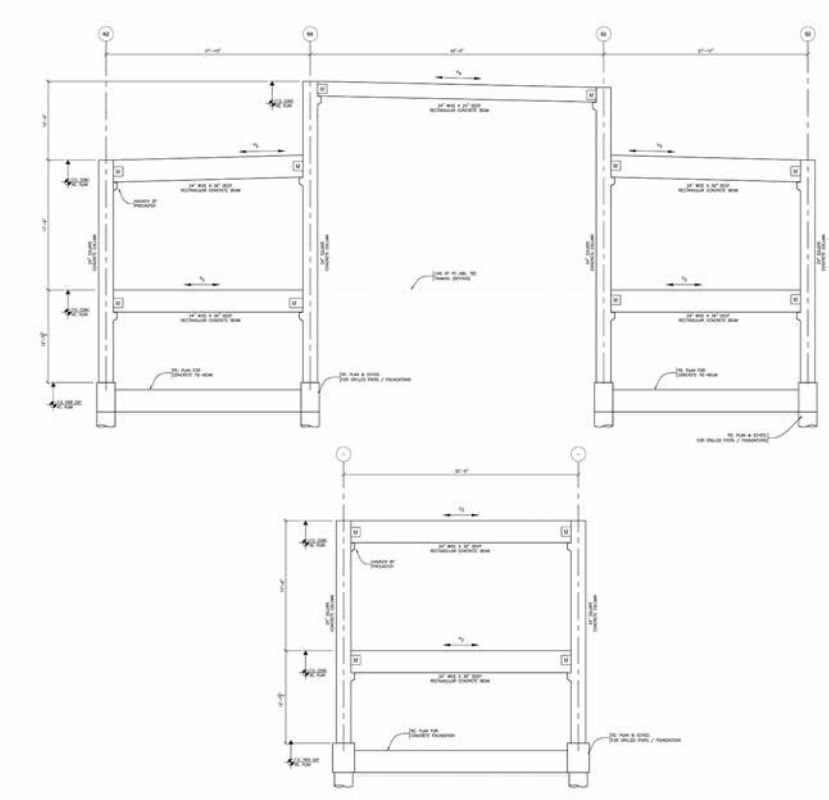
The moment frames were used to "keep the interiors as open as possible, not only in the center section but in the hold rooms and retail areas," says Sullivan. "The airport wanted everything as open as possible. They wanted to invoke an airy feeling to the entire addition."

Each frame comprised nine precast concrete pieces, consisting of straight column sections, H-shaped sections, and U-shaped sections. The frames were tied together using splice sleeve-type connections. Each receiving piece had four sleeves, with three strands per sleeve, cast into its edges that fit into dowels cast into the other pieces, with a 1/8-inch tolerance. In all, 672 splice sleeves were used, along with 288 pieces of 0.6 strand totally 9,800 linear feet.

"We had to fit them together from a 50-foot height, so we had to hold to very tight tolerances to make it work," says Karp. "There were some field adjustments needed, as would be expected, but it really went very smoothly." In one place, the design called for back-to-back moment frames that created "a means and methods challenge" for threading the posttensioned strand and dogging off the ends to tension it," he notes. "That was the biggest challenge, but we were prepared for what was needed."

"We did a painstaking review with the architect and airport to ensure the details were precise before any fabrication was done," Lysohir says. "When we got to the site with all the pieces and fit them all together, it was very smooth, just like building blocks coming together."

The moment-frame pieces were erected into place before the main structure was tied in due to the finish work that was needed. "It was really a two-function erection, with the first part finishing before we could work out from there," says Karp. "We erected the moment-frames by themselves and did dry-packing and posttensioning before beginning any finishing. Then we tied the main structure and flooring into those structures."



Lower Level Left Open

Additional connection embeds were cast into some spandrels to allow expandable walkways to planes to be secured. The lower level of the building remained open to provide for vehicle access and delivery locations for the retail spaces above. Masonry infill was used to fill in locations on this level.

Working at the airport also required close attention to security needs for all personnel. "It was an active airport, and we had to meet security requirements like anyone using the airport," Shook notes. "Everything and everyone had to be badged through security every day."

Finishes were specified to complement or match those on the existing building, which were primarily precast concrete panels produced by another precaster. Most of the panels had an acid-etched finish to meet this requirement. Standard strip windows in 400-foot lengths, were installed between the spandrels, with standard door openings for the terminals.

The project moved smoothly and efficiently, so much so that when it was

Moment frames were cast at the plant and then fit together onsite, with the goal of keeping interiors as open as possible. They were erected before the main structure was tied in due to the finish work that was needed. Diagram: Stresscon.

Photo: Clarke Caton Hintz.

completed, the airport and Milender White presented Stresscon with an award for safety excellence. "Throughout a very risky operation, they had no incidents or injuries and nothing that disrupted the schedule," Lysohir reports. "They ran a very safe and efficient operation." In fact, the project was completed 1 day ahead of schedule.

"We had done other airport projects, but nothing as extensive as this one," says Shook. "We'd created posttensioned moment frames, but this was the first where the entire structure required monolithic and posttensioned frames. Product tolerances were critical to be successful, but we achieved them." The erection took only 33 days to complete.

The design offers potential for the future, he notes. "The moment-frame design provides a viable solution for open structures at airports, as well as other structures that need a completely open design. It can emulate a cast-in-place design while eliminating all of the activity and congestion that it would produce at the site."

For this project, it was the right concept, says Lysohir. "Stresscon did a fantastic job and helped make this a very successful project." Sullivan agrees. "Precast concrete not only gave us the fastest construction time possible, it also was a very economical solution."

The 186,000-square-foot, five-story, 500-car parking structure built for the MTA Metro-North Railroad line in White Plains, N.Y., features a total-precast concrete structure and architectural panels. A key logistical challenge came in building a new utility facility inside the garage so those services could be shifted over, then building the rest of the parking around it.

Photos: Metropolitan Transportation Authority of the State of New York / Patrick Cashin.

PROJECT SPOTLIGHT

Metro-North Parking Structure

Location: White Plains, N.Y.
Project Type: Railroad station parking structure
Size: 186,000 square feet
Cost: $41.8 million
Preliminary Design: Gannett Fleming Engineers and Architects, Camp Hill, Pa., in association with Sowinski Sullivan Architects P.C., Sparta, N.J.
Architect: Clarke Caton Hintz, Trenton, N.J.
Design-Builder: Prismastic Development, Fairfield, N.J.
Owner: MTA Metro-North Railroad, White Plains, N.Y.
Structural Engineer: Stantec Consulting Services Inc. (formerly FST), New York, N.Y.
Site/Civil & Geotechnical Engineer: Langan Engineering, New York, N.Y.
MEPFP Engineer: Kelter & Gilligo Consulting Engineers, Princeton Junction, N.J.
PCI-Certified Precaster: Dailey Precast, Shaftsbury, Vt.
Precast Components: Total-precast concrete structural system consisting of double tees, columns, beams, spandrels, wall panels and stair/elevator core components

Metro North Parking Structure

As reliance on public transit grows in cities, the need for support structures also intensifies. Ensuring passengers have places to safely and easily park or drop off travelers are critical to encouraging more use. That was the dilemma facing officials at MTA Metro-North Railroad in White Plains, N.Y. A new parking structure was needed to replace the existing, smaller one as the rail line's passenger total reached 2,200 customers per day.

The new 186,000-square-foot, five-story structure contains 500 parking spaces, a net gain of 391. It includes three lower floors of permit parking and two higher floors of metered parking. Spaces on the first two floors were provided to meet ADA requirements.

The tight site, durability needs, fast schedule, and other factors led the designers to specify a total-precast concrete structural system and architectural spandrels. The components included double tees, columns, beams, spandrels, flat panels, and stair/elevator core pieces. Dailey Precast fabricated the components.

Design-Build Method Used

The project used the design-build delivery method of construction. The preliminary design was performed by Gannett Fleming Engineers and Architects in association with Sowinski Sullivan Architects. Prismatic Development served as the design-build lead, with URS Corp. providing construction management, inspection and supervision. The team of firms included architectural firm Clarke Caton Hintz (CCH), Langan Engineering, Kelter & Gilligo Consulting Engineers, and Stantec Consulting Services Inc. (formerly FST Engineers Inc.).

"The fairly tight schedule drove the decision to use a design-build format," says Jim Branch, senior principal at Stantec. "Design-build excels under a tight schedule." So too does precast concrete, as it can begin casting as site-preparation work gets underway. And this site had a lot of prep to be done. It included demolishing the existing 109-car parking structure, maintenance building, a surface lot, and several utility sheds.

"We evaluated several options, and the precast concrete system proved to be the most efficient," says Michael Nelson, senior associate and project manager with CCH. "It also offered the benefit of durability and speed of construction while maintaining the design aspirations of the project."

Precast concrete often is the choice when working on a design-build project, notes Branch. "We often choose precast concrete, if only because it's usually the most economical. The cost can vary with demand, but even when precasters are busy, it's usually very competitive and offers other advantages over a steel-frame design in our climate."

"We were involved from the early design process," says Erik Subik, project manager at Dailey Precast. "We worked very closely with the other members of the team to ensure all of the logistics were worked through for the challenges that had to be addressed."

Utility Service Moved

The biggest challenge came from the existing utility services that were housed in a small storage building adjacent to the new structure's site. The services, consisting of three generators, fuel-oil storage, and mechanical systems, needed to remain operational to service the adjacent Metro headquarters building until the new services were constructed in the lowest level of the new parking structure.

"The proximity of the new structure relative to the adjacent headquarters required us to be fairly surgical in how we brought openings to the building envelope to meet code required ventilation while providing necessary fire protection to the nearby structure," says Nelson. "There were many site constraints and logistics challenges to address. The structure is constrained on all sides with the headquarters to the east, a neighboring structure several feet from the southern property line, and overhead power lines immediately to the west."

The work was completed in two phases, with the structures to house the utility services erected and the systems put into place first. Once they were operational, the original utility structure could be removed and work could proceed on the rest of the building.

The station and track alignment were across the street and did not pose site restrictions, but power lines were located on several sides of the project and had to be coordinated to work around them while doing glazing on the stair towers, Branch says.

A taller ceiling height was needed on the first level to accommodate backup generators and associated fuel-oil storage for the adjacent building, Nelson notes. That allowed ample space for retail storefronts, which were placed along the main street elevation near the elevator core along the primary access path used by commuters.

The precast concrete structure also achieved the very stringent fire-rated assembly requirements associated with the building's backup systems. "We could follow the requirements for mixed-use structures without any additional needs," says Branch. A waterproofing membrane was added to the double tees on the second floor above retail spaces to prevent any moisture seeping through from cars arriving during inclement weather, says Subik.

Decorative Façades Created

A series of stainless-steel mesh screens were installed on the infill panels of the first floor level exterior. Designed to be decorative, they secure the parking structure if needed, with concealed rollover doors at the entries. The screens feature die-cut, stainless-steel artwork by Situ Studio titled Percolate. The pieces, commissioned by MTA Arts & Design, features various forms of vaporizing droplets, referencing the role water has played in the city's history. It consists of approximately 125 panels in ever-changing forms of water bubbles attached to the metal mesh in random patterns.

"The designers did a good job of setting up the embed locations and clearances needed, so we could cast the pieces and have the mesh installed quickly," says Subik. Some required special inserts to secure them in place. A larger stainless-steel screen was used to front the entrance to the roof. Onto it was placed a stainless-steel, die-cut logo and signage directing users to the entry and providing a signature design.

The aesthetic design was planned to relate the parking structure to the adjacent headquarters building, with the precast concrete color and embedded thin brick providing a traditional look. "Several colors of brick were selected and randomized to create a

blend that reflects and complements the older brick palette found at the headquarters," Nelson explains.

Horizontal spandrels feature a buff-finished limestone look that offers a contrast in color and texture. An imported sand and aggregate mix was used for the spandrels that posed unusual challenges, according to Timothy Breen, sales manager at Daily Precast. "The mix that was selected had a high lime content, which caused it to set up quickly, making it harder to work with."

It also showed any minor handling scuffs or mars, requiring careful handling. "We spent considerable time after the fact doing a final detailing of all the pieces. "This was a signature focal point for the company, so we paid a lot of attention to detail and washing the pieces clean after the erection." The precaster also spent time minimizing dust and soot from the mechanical equipment during the erection to ensure no additional marks on the panels.

Sustainable-Design Concepts

The team also added sustainable-design concepts wherever possible. The structure was designed to meet code requirements for an open parking structure, which minimized the need for mechanical ventilation. Building systems, equipment, and lighting were designed to achieve a 35% improvement over state energy-code requirements. The structure also offers bicycle-storage and scooter parking along with charging stations and dedicated parking for fuel-efficient vehicles.

One of the biggest additions was the use of bright-white double tees to construct the roof, generating a high albedo. This mix consisted of local aggregate and sand with white cement. All of the upper tier double tees were cast with this mix. "It was a challenging mix to create, but reducing heat island effect on the roof was a key goal for the owner," says Nelson.

In addition, the owners feared it would raise costs to have to remove snow from the roof after heavy snowfalls, so the design team created a designated area on the roof where snow can be stored after plowing. That required boosting the load requirements in that area and ensuring the potential added load could be directed into the columns and to the ground, Branch says.

Native and drought-tolerant landscaping was installed, as were new crosswalks and traffic signals. New decorative lighting includes architectural light poles at the structure's perimeter and an LED linear grazer that dramatically illuminates the stainless steel fabric over the drive entry.

The result of the close attention to detail by the design team and successful tackling of logistics by the construction team created an aesthetically pleasing structure that provides all of the functional benefits required of such a demanding building use while achieving sustainable-design features. "Precast's modular construction is a big benefit to construction in the Northeast," says Branch. "It gives us a lot of bang for the buck."

City officials agreed. "I am so proud to cut the ribbon on a facility that will serve the needs of our commuters," said Joseph Giulietti, Metro-North Railroad president at the ribbon-cutting ceremony. "The fact that it was completed in a timely, cost-effective way confirms our continued commitment to our customers."

Cherry Street Parking

In some situations, parking and transportation functions can be combined into the same facility. That was the design approach taken for the Cherry Street Transit Facility in Terre Haute, Ind., near the campus of Indiana State University. Lack of parking in the downtown area led the city and Indiana's Department of Redevelopment to create a 216,000-square-foot, five-story parking structure that also provides office space for the transit authority and amenities for the bus-transfer point.

The project features a total-precast concrete structural system consisting of double tees, inverted tees, L-beams, columns, beams, shear walls, litewalls, slabs, structural columns, architectural spandrels, and other components. Coreslab Structures (Indianapolis) Inc. provided the structural components, while Gate Precast Co.'s Ashland City, Tenn., plant fabricated the architectural panels and the structural columns that support the panels and double tees.

"The facility was designed to provide much-needed improvements to the bus-transfer system and public parking for area businesses," explains Matt Jobin, project manager for Rich & Associates, which served as architect and engineer on the project in association with Sanders & Associates. (For more on Rich & Associates' work, see the Architect's Profile in this issue.)

In addition to 626 parking spaces, the L-shaped facility includes an inner

The total-precast concrete structural system provided a quick and easy erection. Many panels feature several finishes, including two colors of thin-set brick and accents. Photos: Rich & Associates.

PROJECT SPOTLIGHT

Cherry Street Transit Facility

Location: Terre Haute, Ind.
Project Type: Parking structure with bus-transfer station and office space
Size: 216,000 square feet
Cost: $14 million
Designer/Engineer: Rich & Associates Inc., Southfield, Mich., in association with Sanders & Associates, Terre Haute, Ind.
Owner: City of Terre Haute/Indiana State University, Terre Haute, Ind.
Contractor: Hanning Construction Co., Terre Haute, Ind.
PCI-Certified Precaster (structural): Coreslab Structures (Indianapolis) Inc., Indianapolis, Ind.
PCI-Certified Precaster (architectural panels and structural columns): Gate Precast Co., Ashland City, Tenn.
Precast Components: Double tees, inverted tee beams, L-beams, columns, beams, shear walls, litewalls, wall slabs, structural columns, and architectural panels

Photo: Sanders and Associates.

Photo: Sanders and Associates.

Photo: Coreslab Structures (Indianapolis) Inc.

The precast concrete design for the Cherry Street Transit Facility in Terre Haute, Ind., allowed for a variety of finish treatments. The first floor features floor-to-floor heights 3 feet taller than upper floors, to provide clearance for buses and create a more open feel.

covered bus lane along the long side of the L, plus public and driver restrooms, a waiting area with spaced benches during waits for bus transfers, and office space.

The first floor features floor-to-floor heights 3 feet taller than upper floors, to provide clearance for buses and provide a more open feel, explains Mike Owings, engineering manager at Coreslab. To retain the openness needed for the bus lane and provide lateral stability, a "healthy-sized" shear wall about 20 inches wide and 36 feet long was placed along the long side of the L. On upper floors, litewalls were used to provide more visibility and allow daylight to reach further into the interiors.

Pretopped Double Tees

The double-tee floor members provided were pretopped, allowing the surface of the 6,000-psi components to serve as the driving surface, saving time and material. "It provides excellent durability and lower maintenance costs, as well as a shorter construction time-frame," says Jobin. The double tees also provide a two-hour fire rating, which was required due to the facility's multiple uses.

The long side of the L features 60-foot-long double tees, while the shorter side had a slight offset and needed 63.5-foot-long spans. The longest component provided was the closure spandrel over the ramp at the top level, where a 64'11 ¼" long, 6'9 ¼" tall member was needed. This piece was cast and delivered as one piece, reducing pick time and transportation costs, according to Bill Henderson, vice president of operations at Gate.

Ramps are located in the 90-degree corner of the L, allowing large, flat floors. An express ramp provides quick access to the upper floors to reduce congestion on the first level near the bus-transfer station.

Multiple Finishes Used

The architectural spandrels feature a complex finish consisting of two colors of thin brick embedded in most of the panels. The brick covers the first level and creates a frame around three-story arches above, with tan-colored horizontal spans through the center of the arches at each level. The horizontal portions are set behind the brick surrounding sections, creating a dimensional appearance emphasized by reveals and the difference in finish and color, explains Chris Winfield, project manager at Gate Precast.

The arched top-level panels consist of four pieces: A double-arched piece, a horizontal tan segment, a V-shaped portion of the arch at the center, and two half-V shapes on either side. To these were added rollup bricks with a ¾-inch chamfer that was cut in half at the kerf to create two pieces that could create the infilled-arch design of the cornice.

Columns supporting the entry points in the parking structure feature an Ashlar-stone texture, created with a custom formliner on the precast concrete pieces. The texture provides a dominant base while adding texture and contrast. One-inch brick was used to provide projections, creating a dimensional feel, on the stair towers as well, Winfield notes.

The spandrels, columns, and wall panels were designed as load-bearing pieces for the structural double tees. Pockets were cast into the spandrels to support the double tees, with through-sleeves provided in the columns so the spandrels could be fit in from behind and bolted into place, explains Winfield.

"This approach greatly reduced the material that would have been

A bus lane was incorporated into the 216,000-square-foot, five-story Cherry Street Transit Facility structure in Terre Haute, Ind., providing weather protection and gathering points for patrons to transfer buses. Two precasters, one for structural components and one for architectural panels, collaborated on the project. Photo: Sanders and Associates.

required to construct a façade after the structure was erected," says Jobin. "This resulted in overall savings in construction costs, due to the material savings and the shorter construction time frame."

Smooth Erection Process

Delivery and erection went smoothly, although the backside of the L in the corner was "pretty snug," says Winfield. "We were tight to the street and had to maneuver carefully in that area." An historic church adjacent to the parking structure also created an obstacle, as it had to be preserved and remain in operation during construction.

The project moved smoothly with close communication between the precasters. "It definitely added a level of complexity to the project with two precasters providing components," says Owings. "We coordinated it closely to ensure everything arrived on time and went together quickly."

Jobin agrees that everything moved smoothly. "The project was a success for the city. The facility blends in seamlessly with its neighboring, downtown surroundings and provides the public with a convenient place to park in the heart of Terre Haute."