Three precast concrete parking structures serve the new 1.35 million sq ft (125,000 m²) Shops at Willow Bend, a shopping mall in Plano, Texas. The all-precast structures, featuring spandrels and field-topped double tees, have space for 4400 cars and include one C-shaped facility that wraps around one anchor store on three sides, providing access to a number of mall shops. The structures’ upper spandrel features a unique detail in its cast-in, high-relief willow-leaf pattern, which also was included in a metal grille attached to the exterior precast shear walls. Two precasters supplied the components, and the design team made full use of their skills and insight by bringing them into the project planning early. This facilitated a dramatic change to the design when zoning ordinances forced the project, after fabrication had begun, to include cast-in thin brick as a major part of the structures’ exterior. This article presents the design considerations and construction highlights of the project.

Designing and producing the high volume of parking facilities required for new, large shopping malls calls for close communication and coordination among the members of the design and construction team. This proved especially true on a recent massive project for the Shops at Willow Bend, a new shopping mall in Plano, Texas, which features 570,000 sq ft (53,000 m²) of mall retail stores and 780,000 sq ft (72,000 m²) of department stores.

These facilities required vast amounts of parking support, which had to be built concurrently with the store construction itself. By bringing in all project team members early to gather input and foster communication, the program met its budget and deadline goals despite several key hurdles, including a last-minute requirement that thin-set brick be provided as the primary facing material (see Fig. 1).

The mall is located adjacent to the Dallas North Toll-
way, which offers a high-profile highway from which to entice shoppers with signage and logos—if the parking facilities did not block site lines. The chosen locations for the structures offered the best way to balance those needs while concentrating vehicle needs so that they best served the various tenants in the development as well as patrons coming to shop (see Fig. 2).

The size of the shopping mall, coupled with the requirements of the department-store anchors, zoning requirements, and site logistics, drove the considerations for locating the parking facilities. It was decided ultimately to break up the required 4400 vehicle spaces among three structures. These consisted of two rectangular structures containing 939 and 1317 spaces placed at the far corners of the mall, plus a 2161-space, C-shaped structure that wraps around three sides of the anchor department store at the mall’s center (see Fig. 3).

The two smaller structures each have two supported levels, while the third structure has both one and two supported levels in different sections. In all, the three facilities contain about 1 million sq ft (93,000 m²) of deck surface area.

The parking design was especially

Fig. 1. The all-precast parking structures for the Shops at Willow Bend in Plano, Texas, provide space for 4400 cars and feature thin-brick insets and a decorative willow-leaf pattern.

Fig. 2. Panoramic view of the Shops at Willow Bend. The three parking structures were located to take best advantage of the site and its location adjacent to a high-volume highway.
developed to feed shoppers onto the upper level of the two-story mall and three-story anchor stores. Often, drawing shoppers to above-ground retail levels can be difficult, and the parking structures were created with this need in mind. To facilitate that goal, speed ramps were provided to give drivers fast access to upper levels, where precast concrete walkways funnel shoppers to the upper levels of the stores.

This approach typically requires only a few months to overcome the shopper’s natural tendency to park at grade level, as they realize they can park closer to entrances if they drive higher. This in turn brings them to the upper levels of the shops, ensuring uniform traffic flow in the stores and making effective use of all of the parking space (see Fig. 4).

This article presents the design considerations and construction highlights of the project with particular emphasis on the architectural precast aspects of the job.

**STRUCTURAL OPTIONS**

The design team examined a variety of structural schemes before deciding on the precast concrete system. Options included steel beams with post-tensioned slabs and a cast-in-place system. Several factors led to the selection of precast concrete. The key rationale centered on the vast quantity of construction under way at the site, with essentially six construction projects—four anchor stores, the mall, and the parking structures—all being built simultaneously. The design team realized that construction would move much smoother if components were cast off site, aiding the schedule and logistics.

Another significant factor was the speed of precast concrete construction,
both in being able to start fabrication while site work was being completed and its speed of erection once the pieces arrived at the site. The selected parking structure design features precast architectural spandrels, columns, beams, and field-topped double tees (see Fig. 5).

Two precast concrete manufacturers were used on the project, with one providing structural components and the other the architectural spandrels. This reduced costs and spread out the amount of work to be accomplished on this massive project. Because the two precasters are friendly competitors, they are familiar with each other’s capabilities and operations, and in this case the situation worked to the project team’s advantage. The two producers shared information readily and communicated well on this major project.

The owner created a quasi design-build approach that took full advantage of the expertise offered by everyone involved, including the precasters. The owner’s in-house team, headed by Jarrell DeBrohun, worked closely with the architect and general contractor to put together a basic plan for the project. Thus, the construction documents were approximately 70 percent complete when the precasters were brought in. This gave the precasters some basic design parameters to work with and allowed them to apply value-engineering concepts to the proposals to enhance the effectiveness of their own fabrication methods.

To aid this process, bids on the project included a section for “preconstruction services” that estimated costs for attending 16 meetings at various locales. In fact, the process was completed in only 10 meetings. This approach allowed shop drawings to be eased along with discussion and consideration before piece drawings were completed. The shop-drawing process was broken into a preliminary phase and a final phase.

The owner has found from previous projects that if specific design approaches are imposed on the precasters, it can create unnecessary hardships and hamper creative efforts to reduce costs. This obviously adds cost to the project up front, but it ultimately saves money by taking full advantage of the precaster’s expertise. The end result is that it creates a better project both technically and aesthetically.

This planning paid off significantly, notably in the designs for drainage. The structural precaster was required to review and make recommendations for the drainage system as designed, so the company used its SmartCAD software to establish better drain locations and floor-surface contours that eliminated ponding. The software allowed the engineers to examine the theoretical elevation of the deck surface at any point from the input control points.

The designers could see the theoretical camber of the double tees and the effect any allowable warping would have on water flow. As a result, the precaster could create drainage drawings that showed where ponding could occur and what warping could be done to various double tees to keep them within acceptable limits while still meeting the drainage needs.

The precaster also made recommendations on changes to the external speed ramps to ensure a smooth
and efficient transition from the ramp to the parking area (see Fig. 6). This transition offered a challenging design element, as the ramps entered the deck at an acute angle, requiring careful attention to the curvature to ensure ease of vehicle travel between the two elements and balance with water flow for drainage at these critical portions of the deck.

The precasters provided a complete schedule of values for all precast components in the structures, to establish individual costs and to allow the construction team to understand the monetary effect of any adjustments during evaluations while the design plans were being completed. The schedule of values and unit prices carried through the project’s duration, eliminating the need for the contractor and precaster to analyze cost adjustments. This attention to detail and ability to adapt with all of the ramifications spelled out ensured the project retained its cost effectiveness through to the end.

The all-precast structure, including columns, beams, field-topped double tees, and spandrels, provided floor-to-floor heights of 17 ft 6 in. (5.3 m), taller than typically is provided (see Fig. 7). This was done to match parking levels with retail levels and avoid ramped walkways, thus making the flow from parking to retail more user-friendly. Raising the floors on the supported parking levels is cost effective, as it only requires the columns and speed ramps to be lengthened without raising spandrel costs. The advantages gained from the retail and marketing aspects make this adjustment well worth the cost.

The higher floor levels also aided passive security by providing a more open, airy feeling. This was enhanced by painting the ceilings white to reflect light and provide more illumination (see Fig. 8). Because of the added ceiling heights, double (or scissors) stairs could be provided in the stair towers. This doubling up in the towers helped minimize the number of towers needed. The towers include windows but retain enough structural concrete so the tall stair elements also serve as shear walls for primary lateral loads. Load resistance was supplemented by interior shear walls.

The exterior shear walls feature a...
lightly sandblasted finish with thin-set, clay-fired brick cast into them. On the two smaller structures, the typical shear wall measures 24 ft wide by 44 ft tall (7.3 x 13.4 m), whereas on the larger C-shaped structure, it measures 24 ft wide by 38 ft 6 in. tall (7.3 x 11.7 m). Each shear wall consists of five precast concrete pieces, with field-applied stone cladding at the base and thin-set brick on some of the upper portions.

**ARCHITECTURAL DETAILS**

The aesthetic design for the parking structures also began from the preliminary stages of the project. The architects and owner visited the site and discussed plans for the mall’s design to find an appropriate architectural style that could be used throughout the project.

As a result, elements derived from the Prairie-style of architecture for the retail buildings were applied to the exterior design of the parking structures. These included the use of thin-set...
brick and warm precast tones, along with a willow-leaf pattern cast in high relief that was applied on the upper-level spandrel panels.

The sculptural details in the panels project from the background by at least one-half their depth. Similar patterns were used in several locations in the retail shops, including carpet and tile patterns. These motifs join to create an architectural statement for the parking structures that supports the overall project design.

The aesthetic design was given top priority due to the prominence of the parking structures in the site layout. Essentially, they served as the center’s front door, projecting the mall’s image while offering the first impression most visitors would receive of the facility as a whole. Thus, the structures needed to project a strong look both from a distance and from closer in to complement the retail image. The goal was to create a coordinating fabric that worked with the retail portions but also had its own identity. The designers wanted to make the best possible use of natural materials, such as stone, and tie that ingredient into a palette of earth colors.

A key element of this program can be seen in the upper spandrels’ willow-leaf band. This band serves as a “frieze” that wraps around the structures at their tops and ties into a similar design used at some of the retail entrances. It aids the image of the structures as a crafted piece of garden wall that joins with landscaping to help break down the scale of the spandrels and the structures overall (see Fig. 9).

The band was devised by the architects and translated into the concrete design by the architectural precaster, Meridian Precast, with several iterations developed prior to the final offering. The design was cast with a form liner produced from a high-density foam positive coated with a pourable elastomeric liner. The spandrels were poured monolithically and vibrated to ensure no voids appeared, with all pieces fabricated from the same form. They were cast to be raised on a bullnose radius from the rest of the panel. Two other finishes also were used on the panels, an ultra-light sandblast and an acid etch (see Fig. 10).

A typical upper spandrel measures 6 ft 9 in. (2.1 m) tall, with the willow-leaf pattern providing an 18 in. (460 mm) band across the top half. Below this is another band featuring thin cast-in brick that measures 2 ft 7 in. (0.8 m) wide. The panels were tinted a light beige or buff color. Spandrel panels below the top level are dominated by a band of thin cast-in brick without the willow-leaf pattern. Panels range in length from 20 to 63 ft (6.1 to 19.2 m) long and are 9 in. (230 mm) thick.

The willow-leaf motif also was picked up in the 19 exterior shear walls on the structure’s perimeters, where it was incorporated into decorative metal grilles attached to a cast-in V-shape running the full height of the walls (see Fig. 11). Typically, these pieces are about 3 ft (0.9 m) wide and extend to within 3 ft (0.9 m) of the top of the parking structure. The grilles

Fig. 10. Precast concrete spandrels on the upper level of all three structures feature horizontal bands that include an embossed willow-leaf pattern and thin inset brick in the same piece.

Fig. 11. Decorative metal grilles, with dramatic backlighting for night viewing, were incorporated into the exterior shear walls.
were outfitted with backlighting, so at night they provide a dramatic effect that projects the willow-leaf design prominently. Nine internally located stair towers also provide some of the shear-resisting elements (see Fig. 12).

**DESIGN CHANGES**

The close cooperation and early planning among the design team paid off when a dramatic change was required during the construction process. The original design for the parking structures featured two tones and finishes of precast concrete: a darker, exposed-aggregate style for the body, and the lighter, willow-leaf-embossed design for an accent. However, local zoning codes required the exterior of the structures to contain a specific percentage of masonry in its design. The owner had hoped the parking structures’ complementary look would fulfill the spirit of this requirement, but the commission held the project to its letter.

Meeting this requirement from a design standpoint was not difficult, as the existing precast specification for the main spandrel finish could be changed to brick and retain the original intent. But accomplishing it from the precaster’s end required shutting down the fabrication process, making adjustments to the casting design and waiting for thin-set brick to be delivered.

The requirement arose after 22 spandrels featuring the original exposed-aggregate finish had already been cast. Four of these had to be disposed of, but the other 18 were reused. The design team worked together to devise a plan by which the smallest parking structure was fitted with a mechanically fastened system that could be added to the front of the already cast precast panels to allow field-set brick to be applied.

The remaining panels on this structure were cast with a recess to receive the mechanical system and brick. This gave the team the breathing room to allow for the thin-set brick to be delivered, after which it was factory-applied to the spandrels for the other two parking structures.

By creating a new sequencing plan and adapting this design to the project, no actual erection time was lost due to the change. In fact, although the need to order thin brick produced a six-week delay in casting the components, the erection still was finished two weeks ahead of schedule. The structural precaster, Coreslab Structures (OKLA) Inc., erected the components.

**ERECTION HIGHLIGHTS**

Several techniques speeded the erection process. First, the contractor ensured early on that all staging areas and roads were paved or filled with gravel, avoiding problems with mud that could have caused significant delays. In addition, a specially rated sling was used to lift the spandrels, stretching like a rubber band to provide the most advantageous location for balancing the weight.

Note that with some spandrels as long as 63 ft (19 m), using pick points with cables would have made it difficult to balance the spandrels while they were lifted into place. Using the slings let the crew calculate the required third points and balance the load more easily and quickly, making...
the handling easier in the field.

The 76 acre (31 ha) site had enough room for maneuvering and staging, but coordinating the variety of construction projects with different contractors proved logistically difficult. The site crew stayed in radio contact with both precasters so they would know when trucks were departing the plant and when they would be arriving. Oversized loads also were brought in the night before they were needed, alleviating morning traffic and giving crews a head start on the erection.

One 200 ton (180 Mg) crane was used on the erection, which took only 10 months to complete, starting in mid-February 2000. The first structure, the smallest one, was completed in May, with work on the C-shaped structure starting next. It was erected from both ends working toward the center, and then work stopped while the anchor store that connected to it was completed (see Figs. 13 and 14).

The center portion of the structure was finished next, with the entire process taking from May until August. During this interim period, the third structure was erected, with all three
erected by December 2000. In all, some 3600 precast pieces were used on the project, with the total cost for the precast concrete set at $15.5 million.

The parking structures connect to the mall and anchor stores at the second level through precast concrete walkways. These feature the same decorative spandrel design used on the upper levels. The precaster had significant input on the walkways, as only their general location was spelled out in the initial drawings, with decisions on specific bay location, materials, and dimensions made once the precaster was on board. This approach was necessitated by the time required to receive input from each anchor store about the best location and construction methods.

This element again showed the advantages of the early input from the precaster. A shorter, stubbier double tee was used to connect these spaces to strengthen the span and avoid extending a longer tee into the department stores. Rather than a 28 in. (710 mm) depth with a 2 in. (51 mm) flange, the precaster used a 8 in. (203 mm) flange with a 8 in. (203 mm) thick leg.

**CONCLUDING REMARKS**

The project moved rapidly, with initial design meetings held in August 1999 and erection completed ahead of schedule in December 2000. The mall held its grand opening on August 3, 2001, with all parking structures ready to receive the multitude of shoppers expected to arrive (see Figs. 15 and 16).

The project won an award for “Best All-Precast Structure for 2001” in the recent PCI Design Awards Program. The jury citation was as follows:

"In making the award, the judges said, “This total precast parking structure exploits all of the advantages of precast concrete and shows a very high quality of workmanship, which produced an elegant facade. The structure also overcame the aesthetic problems associated with exterior shear walls by adding an architectural feature that blended them with the spandrels. The detail of the exterior spandrels, particularly the upper spandrel with its beautiful form-liner finish, creates a dramatic structure with impressive attention to detailing. Those details, in conjunction with the exterior shear walls, create a very attractive use of a total precast, prestressed concrete structure.”"

**CREDITS**

Owner: The Taubman Co., Bloomfield Hills, Michigan
Engineer/Architect: Walker Parking Consultants, Boston, Massachusetts
General Contractor: Sordoni Skanska Construction Co., Parsippany, New Jersey
Structural Precast/Prestressed Concrete Manufacturer: Coreslab Structures (OKLA) Inc., Oklahoma City,