

Precast's Versatility Makes the Grade

Universities, colleges take advantage of precast concrete benefits that include energy efficiency, sustainable design, aesthetics, economy, speed, and expandability

— Craig A. Shutt

College and university campuses in many ways resemble small towns. They require offices, classrooms, a variety of residential building types, laboratories, libraries, parking facilities, gymnasiums and even athletic stadiums. Providing all of these programmatic needs while retaining a consistent, high-quality appearance creates challenges, often with shrinking budgets. To balance all of these needs, designers frequently turn to precast concrete envelope and

structural systems.

The projects described below represent some of the ways that higher education administrators and designers are taking advantage of precast concrete's attributes to provide a wide range of benefits, including energy efficiency, aesthetic compatibility, economy of design, speed of construction and versatility for future expansion—all while helping to meet sustainable design goals.

Stanford's Y2E2 Building

The Yang & Yamazaki Environment & Energy Building (Y2E2) at Stanford University houses the schools' Environmental Studies program and supports interdisciplinary initiatives for the integrated study of natural systems. Meeting that variety of needs required faculty and graduate student offices, classrooms, multidisciplinary and event rooms, social spaces and laboratories with various functions.

In addition, the facility was the first



The Yang & Yamazaki Environment & Energy Building (Y2E2) at Stanford University, which achieved LEED Gold certification, features architectural precast concrete panels with embedded limestone tiles. The panels saved labor cost, sped up construction and eliminated trades from the site. Photo: Tim Griffith



Panels were cast without full-sized stones joint overlaps to avoid creating noticeable vertical joints. Once the panels were erected, crews handset the missing stones to cover the joints.

Fact Sheet

Project: Stanford University Yang & Yamazaki Environment & Energy Building

Location: Stanford, Calif.

Project Type: Environmental Studies building

Size: 166,500 square feet

Cost: \$70 million

Designer: Boora Architects Inc., Portland, Ore.

Owner: Stanford University, Stanford, Calif.

Contractor: Hathaway Dinwiddie Construction Co., Santa Clara, Calif.

PCI-Certified Precaster: Walters & Wolf Precast, Fremont, Calif.

Precast Components: 612 precast concrete panels

The architectural precast concrete panels helped the project pay off the incremental cost from its high-performance design in approximately 6.5 years.



of four buildings to be designed that would complete a science and engineering quad. The complex, comprising 500,000 square feet, was planned to be the most sustainable on campus and set benchmarks for future buildings while also fitting into the established architectural context. To help reach these goals, and exceed LEED standards, designers specified architectural precast concrete panels with anchored limestone veneer.

"Precast concrete was selected for the façade for a variety of reasons," says Eric Hasenberg, associate principal at Boora Architects. "We gravitated to precast concrete early in the process." Key factors were the labor savings and site decongestion it could provide in reaching the aesthetic goals, as well as the energy efficiency provided by the concrete mass.

Campus buildings from the early 1900s traditionally featured a heavy block limestone exterior, which invoked the Mediterranean architecture of the California missions. Newer facilities maintained that, some more successfully than others. "Our goal was to ensure the façade appeared to have real stone, but do it economically," adds Hasenberg. Walters & Wolf Precast of Fremont, California fabricated and erected the panels.

'We gravitated to precast concrete early in the process.'

Techniques to Avoid the Look of Continuous Vertical Joints

The limestone veneer was imported from France and set into the panels using a formliner template. To avoid joints that would have made the panelized construction apparent, the panels were cast with stones that would be less than full length left off. This created a sawtooth pattern that left every other row of stones at the end of the panels off on each side of the panel joint. Once the panels were erected, crews handset the stones that were left off, covering the joints. The stones had stainless steel pins set into their back and were grouted into place at the site.

Precast concrete trim elements were also cast as part of the panels, eliminating the need for additional support and ensuring uniform color.

'A world-class LEED-Gold equivalent building can be delivered in half the expected time and for significantly reduced cost.'

Precast concrete arches, cast in two pieces to accommodate wide structural steel beams to which they were connected, were designed with an integrated seam detail to give the illusion of a seamless construction.

The precast design and erection sped up construction significantly, Hasenberg notes. "The design team organized team members to simultaneously focus on different areas and overlap the start of construction," he explains. That was possible due to the advance fabrication of the panels, which ensured they were ready to erect when the steel structure was completed.

The panels reduced construction duration by at least 40%, he estimates, taking only eight weeks compared to as much as 24 weeks for hand-set limestone. "This time savings allowed the team to avoid much of the costs associated with inflation for materials," he says. "Fewer workers and less equipment were also required, further reducing costs."

LEED Exceeded

The precast concrete panels helped exceed the LEED standard through their mass, use of recycled materials, local manufacture and other factors. Key elements were the reduction of energy and water use in all of the building systems.

"Integrated systems helped ensure 56% less energy is consumed and 90% less water is used compared to an equivalent building," Hasenberg says. "The design and installation of an efficient and tight building envelope, provided by the exacting precast concrete manufacturing specifications, were essential to realizing these savings. The precast concrete skin system creates thermal lag that reduces heating and cooling needs to reduce HVAC requirements." Payback from energy savings to pay off the incremental cost of the high-performance design is estimated at 6.5 years.

The project has proven a success, to the point that the remaining three buildings are following the same design, he notes. The School of Engineering and Nanotechnology build-

ings have both been completed, and the final structure is expected to be completed in 2014.

"With thoughtful planning, an innovative design process, a supportive client, and hard work, even a world-class LEED-standard building can be delivered in half the expected time and for significantly reduced cost."

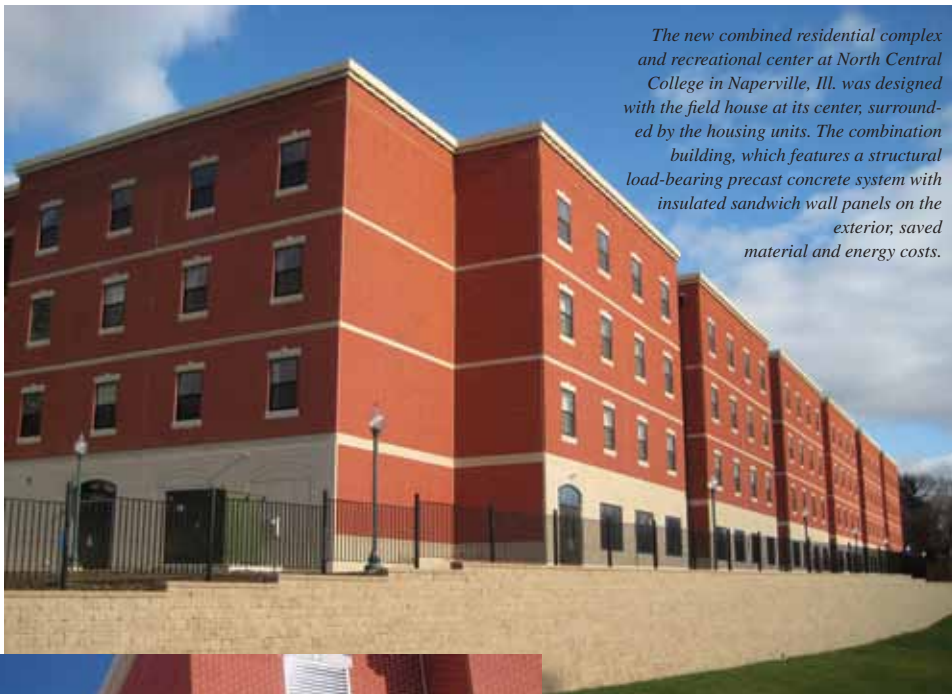
North Central College Complex

Saving energy, time and material were key benefits provided by the design created for a combination residential housing facility and recreational building for North Central College in Naperville, Illinois. The 198,000-square-foot complex, which earned LEED Silver certification, was designed with the recreational center at its core, surrounded by housing units. The design and sustainable features were enhanced by the use of a structural load-bearing precast concrete system with insulated sandwich wall panels.

"The college's challenge was that it required two new buildings, but the college lacked funding to build both, especially to the energy-efficient, sustainable, and aesthetically pleasing level desired," explains Tom Buchar, president of Thomas A. Buchar & Associates in Joliet, Illinois. "The precast concrete systems enabled the college to accomplish all of its goals."

The primary innovation came in wrapping the recreation center inside the residential component, creating one building from two and minimizing exterior cladding. "The total load-bearing precast system saved tremendous amounts of money, both on initial costs as well as future operating costs," he says. Dukane Precast Inc. in Naperville, Illinois fabricated the precast concrete components.

The residential portion consists of a four-story, 265-bed dormitory wrapped around a 62,000-square-foot field house like a 34-foot-wide rectangular doughnut. The total-precast concrete structure consists of double-wall, double-floor and conventional insulated sandwich wall panels, plus precast concrete columns, beams, stairs, landings, elevator shafts, and water-retention storage tanks.



The new combined residential complex and recreational center at North Central College in Naperville, Ill. was designed with the field house at its center, surrounded by the housing units. The combination building, which features a structural load-bearing precast concrete system with insulated sandwich wall panels on the exterior, saved material and energy costs.

Fact Sheet

Project: North Central College President Hall/Recreation Center

Location: Naperville, Ill.

Project Type: College dormitory and recreation facility

Size: 198,000 square feet

Cost: \$24 million

Designer: Thomas A. Buchar & Associates, Joliet, Ill.

Owner: North Central College, Naperville, Ill.

Contractor: Mustang Construction Co., Naperville, Ill.

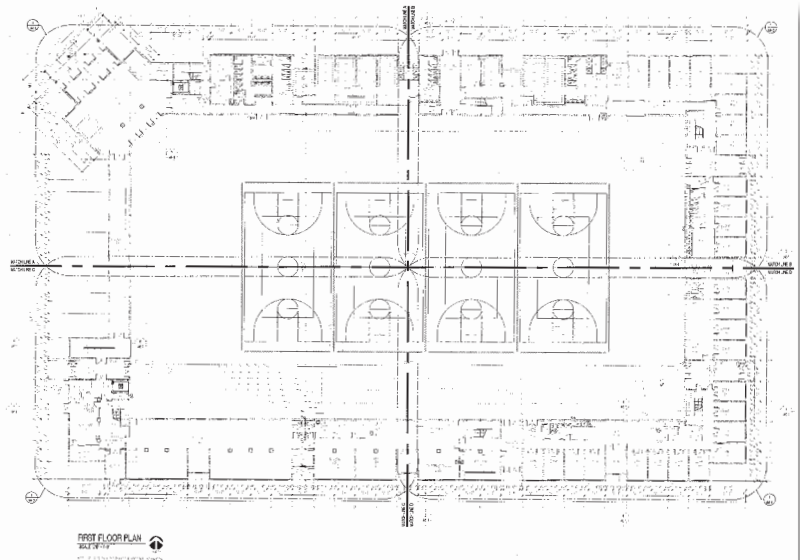
PCI-Certified Precaster: Dukane Precast Inc., Naperville, Ill.

Precast Components: 492 double-wall wall panels, 285 double-wall floor panels, 109 double-wall roof panels, 125 insulated sandwich wall panels, 192 structural beams and columns, and 60 stair/landing components



The panels' exterior appearance was achieved with formliners, each of which was used for 84 pours, cutting costs with the repetition.

By surrounding the recreational facilities with housing, the college saved material costs and energy needs, especially on the interior track, which doesn't require heating even in winter due to the insulated mass surrounding it.



The sandwich wall panels form dormitory walls, floors and ceilings. Interior wall faces and ceiling panels received a smooth finish that was painted so no drywall was required. For the field house, 50-foot-tall precast concrete wall panels and 180-foot-span steel roof trusses create an open-spaced, 200-meter indoor track, activity courts, and suspended walking track.

Dorm Insulates Field House

Enclosing the recreation center inside the dormitory facility meant only one exterior façade was needed, which not only minimized material costs but also reduced long-term maintenance needs. Likewise, the combined use of the HVAC system cut costs, which were further reduced by the mass surrounding the recreational areas. The interior track stays cooler in the summer and warmer in

winter, eliminating the need for any heating even in winter.

The double-wall panels feature three inches of bio-based polyisocyanurate insulating foam made from soybeans and castor oil. The insulation was sandwiched between two 2 1/2-inch wythes of concrete.

The exterior appearance of the panels, consisting of both stone and brick looks, was achieved using formliners that replicated the look of the two

'The total load-bearing precast system saved tremendous amounts of money.'

masonry textures. Four master panels were created using a liquid-rubber material, from which rubber molds were created for the form liners. Each was used for more than 84 pours. The distinctive patterns were achieved with multiple colors of elastomeric paints after they were pulled from the forms.

The precast concrete panels added other benefits, Buchar notes. "Five of the six surfaces in every dorm room were constructed with precast concrete components, ensuring excellent sound attenuation and fire resistance." The panels were smooth form-finished on both sides, eliminating the need for studs, insulation, and drywall, which saved significant construction time and cost. Electrical outlets and conduit for electronic cables also were embedded into the wall panels during casting, with extra conduit included to allow for various furniture placements and reconfigurations of rooms.

Withstands EF5 Tornado

The wall panels provide not only high energy efficiency rating of about R-19, but they also can withstand an EF5 tornado, which has winds of up to 250 mph. This allows the facility to serve as an above-ground tornado center at the center of the campus, a significant benefit for the students should it be needed. (For more on creating FEMA shelters, see the article on page 38.)

The precast structural system also provided sufficient support for a raised track in the recreational facility that is hung off the steel roof trusses and fastened to the precast concrete walls at the third level. Also included in the field house are an NCAA-regulation 200-meter track and four playing courts, along with training rooms and workout facilities.

Other sustainable-design elements helped the facility achieve LEED Silver certification. Radiant-heat tubing was cast into the precast panels at the factory to supply heating for the dormitory. The system is integrated into a geothermal system consisting of 60 650-foot-deep wells.

In addition, two underground storm-water retention tanks were built with hollow precast concrete wall panels. These structures served as stay-in-place forms using a hybrid approach, with the cores between the two wythes filled on-site with con-

crete to achieve water tightness. "The amount of site-cast concrete was significantly reduced, which saved time and money," Buchar explains.

In the first year of operation, evaluations indicate the facility achieved an energy-cost reduction of 21.3% over more typical designs. "The precast concrete structural system and wall panels on this job allowed the project team to maximize the energy efficiency and sustainable attributes of the building," says Buchar. "And it was accomplished at a cost the college could afford."

Catholic University Dormitory

A new seven-story, 400-bed suite-style residence for upperclassmen was created on the campus of Catholic University in Washington, D.C., to fit seamlessly onto the 80-year-old campus. The facility defines the edge of a new residential quadrangle, featuring a central tower that provides a focal point while serving as a central communal space on each floor. Precast concrete insulated wall panels helped to achieve these programmatic goals while providing increased energy efficiency that helped the building become LEED certified.

"The use of precast concrete panels in the construction of the hall became an essential part of the overall facility's success, both during the construction phase and now that the project is completed and occupied," says Beth Buffington, studio principal for community at Little Diversified Architectural Consulting, Inc., the architect of record.

In fact, the Opus Residence began the design process with traditional brick walls laid up on steel-stud backups, which would match other projects on campus. But the design-build process, in which the college administrators remained actively involved, opened the door to new cost-saving concepts. "The administrators wanted to use the design-build delivery method to bring everyone to the table and then maximize everyone's expertise," says Buffington.

The contractor suggested using precast panels on a cast-in-place, post-tensioned frame to speed the schedule and avoid setting brick through the winter, she explains. "Even in Washington, the winter climate can be difficult some years, and it was critical that this project come online on schedule. By using the pre-

cast concrete panels, we dodged that concern." The material calculated out at a higher cost, she notes, "but we saved so much time in the schedule that it easily made that up."

Campus Brick Matched

Initially, the designers were skeptical that the precasters bidding the project could match the existing campus brick. They wanted to ensure they could achieve the depth of dimension and lack of joint lines to truly replicate the stone on other buildings. Gate Precast Company of Oxford, North Carolina supplied the precast concrete components.

"Working closely with the precaster, we were able to create a precast concrete skin that effectively conceals the individual 30-foot panels of the façade," she says. The large size of the panels minimized the number of joints and increased the architectural similarity between the new facility and adjacent buildings. The panels were cast in a U-shape, which eliminated the panel joint that usually appears 8 inches back from the façade, she explains. Casting 3-foot return legs with thin brick on both sides of the punched window units provided a traditional running-bond appearance.

The design combines embedded thin brick with acid-etched accents to create a neo-Gothic look. "We also were able to create reveals and detail features that accentuate the verticality of the façade design," she says. The delicate precast fins that extend into the brick field at the building's base were easier to incorporate, she notes, and less costly than if traditional construction had been used.

The exterior panel faces were finished to provide the architectural look desired, while the interior sides received a smooth-troweled finish that sped up installation work by reducing drywall requirements.

The self-loading panels are 12 ft-4 in.-tall with lateral tiebacks to handle wind loads. They contain a layer of insulation between two wythes of concrete that uses nonconducting connectors to maintain continuous edge-to-edge insulation with no voids, improving energy efficiency.

Hidden Slab Connections

The architect also worked closely with the precaster to create a special connection at the slab edge to help conceal the panels' ties to the build-

Precast concrete insulated wall panels helped the Opus Residence at Catholic University in Washington, D.C., fit seamlessly onto the 80-year-old campus while achieving LEED certification. The seven-story, 400-bed suite-style residence defines the edge of a new residential quadrangle.



The large size of the panels minimized the number of joints, while casting 3-foot return legs with thin brick on both sides of the punched window units provided a traditional running-bond appearance.

Fact Sheet

Project: Opus Residence Hall at Catholic University of America

Location: Washington, D.C.

Project Type: Dormitory

Size: 120,950 square feet

Cost: \$27 million

Designer: Little Diversified Architectural Consulting, Inc., Arlington, Va.

Owner: The Catholic University of America, Washington, D.C.

Contractor: Opus East, Rockville, Md.

PCI-Certified Precaster: Gate Precast Co., Oxford, N.C.

Precast Components: 380 architectural panels



Special connections were created at the precast concrete slab edges to conceal ties so they wouldn't show on the slabs' underside, allowing the slab to serve as the finished ceiling without any disruptions.

ing structure so they would not show on the underside of the slabs. As a result, the slabs serve as the finished ceiling for the lower floor without any disruptions, increasing each room's volume.

Other sustainable-design concepts were incorporated into the project, including site engineering to maximize daylighting, low-VOC materials, eco-friendly paints, low-flow fixtures, Energy Star appliances, a significant recycling program on each floor, and low-energy, gearless elevators. "Many of the materials and products were basic ideas that can help achieve better energy consumption."

That includes the precast panels, which required close cooperation,

she notes. "This was the first time that the precaster had created such complex panels with so much variation and in such a large size," Buffington says. "We kept pushing them to do more and they kept producing for us. And the result is amazing. You can't tell that it's not hand-laid brick." That resulted in part from ensuring the rows of brick weren't too perfect, she notes, allowing some variation in the plane of the template.

"We learned that, by engaging with the precaster early in the process on a green project like this, we can develop solutions that are tailored to the architectural and user end-goals of the project," she says. That cooperation produced a satisfied owner, she

adds. "The owner was worried about the final look, but they're very happy with what was achieved. They love this building."

Ivy Tech Community College

Administrators at Ivy Tech Community College in Indianapolis needed a new facility in Valparaiso, Indiana, to consolidate operations of their two existing locations, and to meet the college's rapidly growing student population. The new facility needed to include areas of academics, student support, technology design, and technology labs, all in an environment that created a "sense of campus" and provided a "holistic experience." It also

wanted to project the high-tech look that the college tried to invoke with its course offerings while providing a true sense of community, which can be difficult with a community college.

To achieve those goals, designers chose a compartmentalized design that provided flexibility in handling long-term growth and allowed the project to be completed in phases to meet funding requirements. Helping with these factors was the construction of four simple, cost-effective rectangular modules featuring architectural precast concrete panels hung on a steel frame. These are connected by wedge-shaped enclosed spaces that serve as common areas.

"The goal was to create connecting spaces that created a 'wow' factor and a sense of identity for the technical and academic programs, in the way that individual colleges within a university are connected to the main commons," explains Peter Andreou, associate principal with Design Organization Inc. in Valparaiso.

Site integration allowed the architectural components to be oriented on an east-west axis to take advantage of natural light, solar orientation and natural ventilation, he adds. The common areas feature south-facing clerestories and exposed structure and mechanical systems to reflect the technical nature of the school's curriculum.

A key reason for using precast concrete panels was the need to construct the project in phases. "The second phase was highly probable but not guaranteed," Andreou says. "So Phase 1 needed to be perceived as a complete facility. At the same time, we did not want to use resources completing the first phase that would be wasted when Phase 2 began."

Panels Removed Used for Phase 2

As a result, the precast concrete panels on the end of two modules were designed so that they could be removed and added onto seamlessly. That proved significant when Phase 2 was approved and the expansion work began shortly after Phase 1 was completed.

The precast panels also aided the original three-modules design's schedule, he notes. "The schedule was critical to ensure the school opened as classes were planned to begin," he says. The 166 precast concrete panels, measuring 10 feet wide by 25 ft-6 in.- tall, and 10 feet wide by 33 feet,

Fact Sheet

Project: Ivy Tech Community College

Location: Valparaiso, Ind.

Project Type: Community college center (classrooms, student support, technology labs, computer labs, science and chemistry labs, nursing labs, surgical labs, library, auditorium)

Size: 184,820 square feet

Cost: \$38.6 million

Designer: Design Organization Inc., Valparaiso, Ind.

Owner: Ivy Tech Community College, Indianapolis, Ind.

Construction Manager: The Skillman Corp., Merrillville, Ind.

PCI-Certified Precaster (Phase 1): Coreslab Structures (Indianapolis) Inc., Indianapolis, Ind.

PCI-Certified Precaster (Phase 2): High Concrete Inc., Springboro, Ohio

Precast Components: 166 architectural panels in Phase 1, 143 vertical wall panels in Phase 2



Phase 1 of the Ivy Tech project consisted of constructing three rectangular buildings clad with architectural precast concrete panels. Phase 2 added onto two of the structures by removing some of the panels and adding length. It also included a fourth building.



Phase 2 of the project expanded two of the existing structures by adding space clad with architectural precast concrete panels that used the same mix design as the original panels used. A different precaster created the panels and provided a perfect match.

Architectural precast concrete panels form rectangular buildings connected by large glass-enclosed, wedge-shaped atriums to combine class facilities and communal areas at Ivy Tech Community College's Valparaiso campus. The project was completed in two phases by two different precasters.



tall were erected in two weeks, with another week spent detailing and completing the connections. The pre-cast erector averaged between 15–18 panels per day, equating to about 180 lineal feet of two-story building per day. This allowed the building to be “shelled in,” prior to inclement weather and gave opportunity for other trades to commence and work through the cold winter months, which saved tremendous amounts of time. Time also was saved by using insulated precast concrete panels which eliminated the need for installing metal studs, insulation, and drywall.

Two types of non-loadbearing precast concrete panels were used: insulated precast “sandwich panels” and non-insulated panels. The insulated panels (consisting of 2 in. rigid insulation with non-metallic connectors between the face mix and the back mix) were used in the HVAC Lab, the Welding Lab, Flexible Lab and the main Me-

chanical and Electrical spaces. These panels had a smooth finish back mix that after an epoxy coating was applied, gave a finished look with an extremely durable surface. The non-insulated panels required the installation of a metal stud wall with batt insulation behind them. This metal stud cavity allowed for concealed electrical requirements in offices and classrooms.

The quick approval of Phase 2 allowed design work and erection of more precast panels to begin shortly after Phase 1. The second phase of precast concrete panels was provided by a different precaster, but that created no difficulties, he notes. “We had the mix design available, which the second precaster could use in fabricating the later panels, and they came out looking just the same as the first ones.”

The Phase 2 panels had a typical size that was the same height and width as in Phase 1. The finish for both phases of work featured acid-

etched, exposed end and opening returns with steel-trowel finish. Core-slab Structures (Indianapolis) Inc. produced the first phase of architectural panels, while High Concrete Inc. in Springboro, Ohio fabricated components for the second phase.

The second phase added onto two of the three existing modules by removing some of the architectural panels on the ends and extending the structure. One module had 17,000 square feet of Flexible lab space added, while another had a 360-foot auditorium built onto it. An additional module also was created to house 80,000 square feet of classrooms.

All of the work progressed smoothly in both phases, although the initial erection process had to be completed through the winter months, he notes. High Concrete’s erection sequence took place later in the year when weather conditions were more amenable.

“The repetitive pattern design of

The new TCF Bank Stadium at the University of Minnesota in Minneapolis features a façade and colonnade columns clad with architectural precast concrete panels, as well as seating elements created with precast concrete components, including raker beams and seating units.



A specialized vacuum-clamp lifting device allowed the large structural seating components to more easily be transported and rotated as needed throughout the construction process. Photo: Steven Bergerson

Fact Sheet

Project: TCF Bank Stadium

Location: Minneapolis, Minn.

Project Type: Football stadium

Size: 50,805 seats

Cost: \$288.5 million

Designer: Populous, Kansas City, Mo.

Owner: University of Minnesota, Minneapolis, Minn.

Contractor: Mortenson Construction Co., Minneapolis, Minn.

PCI-Certified Precaster (architectural panels): Gage Brothers Concrete Products Inc., Sioux Falls, S.D.

PCI-Certified Precaster (seating components): Hanson Structural Precast Inc., Maple Grove, Minn.

Precast Components: 3,784 pieces of seating risers, 410 structural walls and more than 160 pieces of beams and columns, plus 1,690 architectural panels, columns covers, spandrels, cornices, trim and caps

Special forms had to be created for the precast concrete architectural panels cladding the stadium’s façade to achieve the proper radius to seamlessly cover the oval shape.



the precast concrete panels aided the budget and enhanced the construction completion time," Andreou says. "We compared a number of options, and taking in consideration the height of our building modules with approximately 3,200 lineal feet of footprint and dealing with winter construction, the precast concrete panel option provided the best economy and was able to achieve the construction schedule."

TCF Bank Stadium

Beyond the more traditional needs of classrooms, laboratories and housing, universities also have highly specialized needs for athletic facilities. None are more prominent than football stadiums, which often represent the university across the country. Setting that identity was a key part of the plan for TCF Bank Stadium at the University of Minnesota in Minneapolis.

The school had used an off-campus site for football games since 1981, so the new stadium brought college football back to campus. Administrators wanted to ensure it projected the proper image to set the stage for the experience. Architectural precast concrete panels on the façade helped project that image for the stadium, which also features seating elements and other structural components made of precast concrete.

The stadium architecture draws from the original stadium on the campus, which was used from 1924 to 1981, explains Jeffrey Spear, lead stadium architect for Populous, the architect of record. The horseshoe-shaped bowl is open to the west, allowing views of the campus and the city beyond. The precast concrete panels feature embedded thin brick, reflecting the original stadium's brick exterior and providing a look of permanence and history. Included is a colonnade, which provides a covered walkway around the stadium perimeter.

The original design called for full-depth, hand-laid brick, concrete block and some precast concrete trim, Spear says. However, working closely with the contractor and a local pre-caster, the plan was value-engineered to architectural precast panels after multiple reviews of samples and mockups. "Schedule, site congestion, safety and cost savings were the primary reasons we used precast concrete," he says.

Gage Brothers Concrete Products, Inc. in Sioux Falls, South Dakota provided the architectural precast con-

crete panels, while Hanson Structural Precast Midwest Inc. in Maple Grove, Minnesota, fabricated the structural precast concrete components.

Colonnades Create Challenges

Complicating the process was that the project was not redrawn to facilitate the new precast concrete façade design, so the precaster had to complete the drawings. The key challenge centered on the ninety-five 88-foot-tall colonnade and scoreboard columns and 175 radiused spandrels and wall panels needed to clad the curving, oval-shaped façade. In addition, no nonconcentric loading could be applied to the columns, so additional connections had to be created to tie each piece into the one below it.

To ensure a seamless 360-degree appearance for the columns and to speed erection, the precaster devised a plan that required stacking numerous components and completing erection of one column per day. The column stack consisted of an 11-foot-tall base column followed by two 30-foot C-shaped column components set face-to-face, two 12-foot-tall L-shaped column components at the spandrel level, two more 20-foot-tall C-shaped column components, and finally roof and fascia components.

Each of the architectural panels cladding the façade features a radius of some kind to seamlessly surround the stadium. The panels typically are 21 feet wide and 12 feet tall, with radiuses ranging from $\frac{3}{4}$ inch to 8 inches across the width. Special forms were created to cast the panels, with about 10 panels cast with the same radius with each form.

An architectural ring along the top of the stadium, originally designed as a GFRC piece, was value-engineered to precast concrete to save time and cost. However, the supporting structure had not been designed for the additional weight, so the accent ring was supported by a combination of the spandrels and built-up HSS sections to transfer the load into the columns and ultimately to the foundation.

The horseshoe-shaped stadium seats 50,805 but is designed for future expansion to seat 80,000 by adding seating levels above the current stands. The precast concrete structural components consisted of precast risers, columns, raker beams, vomitory walls and stairs.

The risers were fabricated as T-

shaped single units rather than doubles or triples to create tighter in-place tolerances. The risers were cast face-down in the forms with a broom-finished formliner used, which allowed a more durable finish along with a more consistent color and depth of broom.

Vacuum-Clamp Device Used

A specialized vacuum-clamp lifting device, more commonly used in Europe, allowed the large structural components to more easily be transported and rotated as needed throughout the construction process. This proved advantageous because complex architectural angles and limited perimeter access required installing pieces from within the stadium bowl.

The lifts use a large vacuum reservoir to create suction so the component can be stripped from the form, rotated 90 degrees and set down so the ends can be finished. The device then picks up the component on its form-liner face. The vacuum lifts then were used at the site to pick the risers and set them in place.

The technology reduced project costs by eliminating the need for hardware lifting inserts on each structural piece and the labor of patching over the inserts after installation. The 15-ton capacity vacuum device, which was attached to a special extension on a crane at the site, increased team productivity by 30%. Between 30 and 50 pieces were delivered and set daily versus approximately 18 prior to using this technology.

"The precast concrete solution met the key design challenges by reducing project risk, saving four months on the schedule and saving \$3.2 million while meeting the architectural design objectives," Spear says. "The stadium was exactly what the program coordinators at the university desired—a modern but traditional-looking stadium that fits into the campus as if it's always been there."

These projects show some of the range of design required to keep universities and colleges up to date and serving the needs of their users. In many cases, precast concrete structural and architectural components help meet those challenges and ensure the projects are aesthetically pleasing, efficiently constructed, and cost-effective throughout their service life. ■

For more information on these or other projects, visit www.pci.org/ascent.