

# Precast Provides High Performance—Efficiently

A wide range of projects can benefit from the speed, thermal performance, integration of systems, aesthetic versatility and other efficiencies offered by precast concrete

— Craig A. Shutt

**H**igh performance structures require integration and optimization of many attributes, adding challenges for designers and contractors. Precast concrete architectural and structural systems inherently provide efficiencies that integrate several components and systems, reduce complexity and risks, cut costs and time, improve performance, and provide an aesthetically pleasing design.

The efficiencies precast concrete offers arise from its high-performance capabilities, which derive from a variety of its inherent attributes and manufacturing processes.

Among these are:

- Offsite manufacturing under controlled conditions, minimizing the site area required for construction, while maximizing quality.
- Combination architectural/structural elements, which allow faster enclosure of the structure, reduced onsite activities, and focused responsibility in a single-source supplier.
- Multiple finishes cast in individual panels, reducing detailing, joints, flashing, onsite labor, and maintenance costs.
- Fast erection, requiring no staging area for just-in-time deliveries and no delays, or change order requests for harsh weather conditions.
- High thermal mass, which improves thermal efficiency and

reduces the amount of energy used to heat and cool a building.

- Reduced life-cycle costs due to excellent durability and lower costs for maintenance and utilities.
- Contributions to achieving sustainable-design goals through many inherent attributes such as use of recycled materials, nearby manufacturing, and improving an envelope's thermal performance.

The following projects are examples of how precast concrete can efficiently meet multiple-project requirements, in all regions and throughout all building types.

## Center for Performing Arts – Mansfield Independent School District

Architectural precast concrete high-performance wall panels opened up new possibilities for administrators at the Mansfield Independent School District when they considered ways to push the energy performance of their new Center for the Performing Arts in Mansfield, Texas. The thermally efficient, pre-insulated panels cut energy costs while providing a maintenance-free exterior envelope.

The \$40-million, 142,000-square-foot center, which is used for events ranging from graduation ceremonies to school plays, had to present an attractive, institutional look while meeting high-performance needs, explains

Doug Bensen, director of design for Huckabee, a Texas-based engineering and architecture firm. Designers considered several options of traditional exterior wall systems before deciding on load-bearing, insulated precast concrete panels.

"The high-performance precast concrete option was a little more expensive in initial costs than other systems, but the long-range planning and operational costs were much better, due to the reduced heating costs and low maintenance," he says.

A key factor was the height of the theater, which seats 6,000 people. To achieve the proper acoustics, a 90-foot-tall ceiling was required—but finishing and heating that space was going to be a waste of time and money, and continue to be a drain on resources through the building's life. "We didn't want to eat up the budget by having crews have to get up there to finish those spaces and then ineffectively heat and cool that space," he explains.

The height precluded a solid masonry wall, he notes. "We knew we couldn't take that approach, as it would be too expensive. When we looked at options, the precaster showed us the benefits of sandwich wall panels and how a continuous-insulation system could be created to efficiently control costs."

## Continuous Insulation Aids Efficiency

A key element was the continuous insulation that the precast concrete



*The Center for Performing Arts in Mansfield, Texas, features thermally efficient, pre-insulated precast concrete panels that cut energy costs while providing a maintenance-free exterior envelope. Photos courtesy of Gate Precast Co.*



## PROJECT SPOTLIGHT

### Mansfield ISD Center for the Performing Arts

**Location:** Mansfield, Texas

**Project Type:** Performing arts center

**Size:** 142,000 square feet

**Cost:** \$40.4 million

**Designer:** Huckabee, Fort Worth, Texas

**Owner:** Mansfield Independent School District, Mansfield, Texas

**Structural Engineer:** Jaster Quintanilla, Dallas, Texas

**Contractor:** Byrne Construction Services, Fort Worth, Texas

**PCI-Certified Precaster:** Gate Precast Co., Hillsboro, Texas

**Precast Components:** Insulated sandwich wall panels



panels could provide. "Other construction methods would have been really inefficient at insulating that high in the air, both initially and over the course of the building's life," he explains. The panels were designed with a 3-inch exterior wythe containing the concrete face mix and architectural features, 2 inches of continuous insulation, and a 5-inch interior wythe of structural concrete. The assembly minimizes wall thickness, providing a system several inches thinner than a traditional block and brick cavity wall construction.

The edge-to-edge insulation, combined with the nonconductive connectors between the interior and exterior concrete wythes, creates an

efficient thermal break that prevents heat and moisture from penetrating the building. "By specifying a high-performance system incorporating edge-to-edge insulation rather than the traditional 6 inches of solid concrete at the top and bottom of each panel, we completely eliminated thermal loss and vapor transmissions present in other wall assemblies," he says.

The insulated precast wall panels also met the ASHRAE 90.1 standard for a mass wall. That means the assembly can store heat energy and performs better than the sum of its parts. While the components of the wall individually added up to an 11.39 R-value, because of the mass wall,

it actually performs at an R-value greater than R-20. Conversely, in a non-mass wall, the sum of the parts is lower than the individual R-values, due to the thermal bridging that occurs with materials such as studs, masonry ties and discontinuous insulation.

"The continuous insulation was a significant benefit, especially as the panels butt against each other and maintain the thermal break," Bensen says. "With no thermal bridging between the interior and exterior panels, there is no heat loss, and that's worth a few percentage points in energy costs. That was what we were looking for and drove us to the precast concrete system."



*The load-bearing architectural panels used to clad the new 1,000-bed freshman dormitory at Northern Illinois University in Dekalb, Ill., feature Endicott Brick colors of Coppertone Velour and Desert Ironspot Light Wirecut along with exposed areas of white cement with an acid-etched finish. The panels are part of the total-precast concrete structural system, which includes shear walls, stair and elevator shafts, stair units, and hollowcore plank. Photos courtesy of Paul Grigonis.*

## PROJECT SPOTLIGHT

### First-Year Residence Halls

**Location:** Northern Illinois University, Dekalb, Ill.

**Project Type:** Dormitory

**Size:** 390,000 square feet

**Cost:** \$80 million

**Designer:** HKM Architects + Planners

**Owner:** Northern Illinois University, Dekalb, Ill.

**Structural Engineer:** SCA Consulting Engineers, Sugar Land, Tex.

**Contractor:** Pepper Construction, Barrington, Ill.

**PCI-Certified Precaster:** ATMI Precast, Aurora, Ill.

**Precast Specialty Engineer:** PEC Precast Engineering Company, Waukesha, Wis.

**Precast Components:** 1822 structural pieces, including exterior walls, bearing walls, shaft walls and stairs, plus 3178 hollow-core planks



Self-supporting stacked panels comprise the majority of the building's exterior shell. The panels bear on the foundation grade-beam footing, with multiple self-supporting panels stacked on top of each other, rising to the building's full height. The combination cast-in-place concrete and steel framing serve to handle the lateral wind loads. None of the weight of the panels is carried by the structure itself.

### Three Finishes Used

Many of the panels, most of which are 15 feet wide by 30 feet tall, feature radius profiles to follow the convex curve from the entry. Three complementary finishes were selected: a delicate acid-etch texture, a secondary brown pigment on some panels, and a proprietary finish that simulates large slabs of quarried stone. This custom feature was created with a retarder applied to the mold prior to pouring the concrete. Most of the panels also received a light sandblasting.

"Our goal was to create interest by using a lighter color to frame the glazing, creating an implied shadow line," Bensen explains. The third color highlights the entry and creates contrast with the radiused facade. Reveals also were used to help break up the mass of the building visually.

Samples and mockup panels were created for the desired choices, including full-size pieces. Those led to changes in the finish, with the goal of deepening the texturing. "Once we saw them at full size, we wanted to ensure we got a consistent finish across the panels and that the texture would 'read' from out at the street." Several cycles of samples were needed to achieve the long-range perspective that was desired.

The panels with radiused edges were cast in forms to create the required edging. These required no additional casting time and were erected smoothly. Corners were designed with a vertical 45-degree angle to create a mitered look. "The corners closed out nicely and provide a strong appearance at what can be a challenge." One crane was used to erect the entire project. "It was

amazing to watch the panels go up so rapidly. The large size of the panels enclosed the space very quickly."

The beauty, durability, and energy-saving performance of the high-performance precast concrete panels provide a strong first and last impression for visitors to the center. They also help acoustically during performances. The insulated panels provide sound-damping properties that prevent outside noise from disrupting activities, providing a comfortable and quiet environment, while providing sound attenuation to enhance performances.

### Dormitory – Northern Illinois University

When Northern Illinois University looked to expand its housing options for freshmen, it created a plan for a 1000-bed, 390,000 square-foot, two-building complex on a site at their campus in Dekalb, Illinois. To create an attractive, welcoming appearance that also met schedule and energy-performance goals, designers at HKM Architects + Planners specified an integrated precast concrete structural and architectural system (often referred to as total precast) embedded with thin brick.

The structural system consists of exterior load-bearing walls, interior demising walls, shear walls, stair and elevator shafts, stair units, and hollow-core plank. The exposed areas feature a mix of white cement with an acid-etch finish. All exterior walls were cast with embedded thin brick consisting of a blend of colors to create the mix desired by administrators.

The administrators' vision for the appearance of the new dormitory required it to aesthetically blend with other nearby buildings. A variety of styles are present on the campus, including brick buildings but also precast concrete structures with buff-colored finishes and even some buildings with embedded thin brick in precast concrete panels. This provided considerable leeway in creating the best system and aesthetic appeal.

The bricks were laid out to ensure separation between colors to create

a random appearance. A "frame" of white cement was created around the edges of the panels beyond the brick forms, creating thicker horizontal bands across the building with thinner vertical bands through the vertical joints.

The design featured a number of projections and setbacks, requiring many returns, some as wide as 3 feet, on the precast concrete panels to avoid joints at the corners. This aesthetic demand reduced some of the benefits provided by repetition in panels. But by creating such long returns, the precaster was able to minimize the number of pieces to be picked, which sped up construction even on the more complicated portions of the building.

Another key challenge involved erecting the gables along the roof line. These were cast as one-piece units and connected to the steel roof. A thermal break was provided at the roof line by providing insulation between the hollow-core ceiling and the exterior wall panels.

### Tight Schedule Drives Plan

The design was driven by a tight schedule that required the buildings to be ready for the new school semester 16 months away. Initially, administrators considered opening one of the buildings for the new term and phase the second to open later. To that end, one building was begun one month earlier than the other, with the team's efforts focused on completing it first. But the speed with which precast concrete panels were made and erected helped enclose both buildings quickly enough that interior tradespeople could complete their work faster than expected—enabling both buildings to be opened at the same time. "Precast concrete was the only option to meet the tight schedule," says Mark Hopkins, HKM.

Erection of the pieces began in June 2011 and ended for both buildings in November 2011. Production of the panels began four months earlier, in February, while other site-preparation work proceeded. This advanced production provided a significant inventory of panels on-hand when the site was ready, so 40 loads of pan-

els and structural components could be delivered to the site each day for erection. They were delivered to the site on flat-bed trucks with A-frames that protected the brick facing from damage.

Two cranes erected the complex, one on each building. The upfront time spent casting panels prior to the site being ready ensured the plant could feed enough pieces to the cranes to keep them busy once construction began. Only 90 erection days were required to complete both buildings, with two crews working on each building, one securing pan-

els and the other sealing 8-inch-thick hollow-core planks on each level. Installing precast concrete stairs between floors also sped construction and enhanced construction safety, as easy access was provided immediately between levels.

With both buildings ready for students when the new academic year began, the fast-track approach proved successful. The precast concrete structural and architectural systems provided the appearance demanded by Northern Illinois University while meeting the schedule and offering a durable, low-maintenance complex

for future classes of students.

## Operations Center – Sacramento Municipal Utility District

Administrators at the Sacramento Municipal Utility District (SMUD) set high goals for its new Operations Center to replace a variety of aging facilities spread around at various locations. A key goal was to ensure the buildings produced as much energy as they used, resulting in net-zero energy use. This required taking full advantage of highly efficient mechanical systems, photovoltaic panels, natural



*The design-build team on the new Operations Center for the Sacramento Municipal Utility District used a new type of lightweight precast concrete composite panel to help it achieve its goal of Net Zero Energy use. The three-layer panels feature a mesh-reinforced concrete skin, spray-foam insulation, and a tube-steel framing system. Photos courtesy of Clark Pacific.*

### PROJECT SPOTLIGHT

#### Operations Center–Sacramento Municipal Utility District

**Location:** Sacramento, Calif.

**Project Type:** Office building

**Size:** 203,000 square feet

**Cost:** \$110 million

**Design-Build Team:** Stantec and Turner Construction, both in Sacramento, Calif.

**Owner:** Sacramento Municipal Utility District, Sacramento, Calif.

**Structural Engineer:** Buehler & Buehler, Sacramento, Calif.

**PCI-Certified Precaster:** Clark Pacific, West Sacramento, Calif.

**Precast Components:** 153 Clark Pacific Architectural Precast Concrete Panels

lighting, and utilizing an aggressive energy-management system. A new type of lightweight precast concrete composite panel helped the District reach its goals.

"The East Campus Operations Center is a much-needed and important step that will allow us to better and more safely serve our customers, while also building a facility that is as environmentally friendly and cost-effective as possible," said Gary King, chief workforce officer at SMUD to Pacific Builder.

The \$110-million building includes spaces for distribution services, business technology, general services, and electrical-utility field support in a six-story, 203,000-square-foot office complex. Additional yard buildings contain shops, tool-distribution cleaning and storage, vehicle maintenance, warehouses, transformer shops, fueling, and a vehicle wash. Many unique shops were designed to handle specialized electrical and yard needs, including the storage of hazardous materials.

Stantec Architects and Turner Construction served as a design-build team to create the design plan for the campus. The team compiled an updated program and master plan to properly size the building and bring the variety of functions together into one location. "The new site provided many challenges to this effort, as it had grade changes of more than 60 feet in places, due to its former use as a gravel quarry," says a spokesman for the design-build team.

Although the grade change created obstacles, it also proved advantageous. Designers were able to place the office complex at the high point on the site and locate other buildings lower on the slope, hiding them from view. As a result, the building has a high profile that administrators wanted to ensure provided a contemporary, high-tech look that complimented the facility's energy goals.

A new type of composite precast concrete panel was chosen to clad the building to help meet the energy requirements while minimizing the steel and other material required for the structural framing. The system consists of lightweight, high-perfor-

mance precast concrete panels that consist of three layers: 3 inches of integrated three-color and multi-finished mesh-reinforced concrete skin; 2 inches of NCFI spray-foam insulation, comprising self-adhering polyurethane closed-cell foam insulation and a vapor barrier; and a 4-inch light-gauge and tube steel frame system. The framing contains galvanized pins to connect the skin to the frame.

SMUD represented the first use for the panels. Tests were conducted on performance mockups to determine their capabilities to handle air infiltration, structural wind loading, cyclic static and dynamic water penetration, elastic and inelastic in-plane seismic movement, and vertical live-load deflection. No structural damage to the mockups occurred during the testing, according to Construction Consulting Laboratory West, which conducted the tests.

The panels, most of which measured 15 by 30 feet, provided benefits to the project by offering a durable, attractive finish on the exterior while providing an R-value of 6.8, an air and vapor barrier, and high sound transmission coefficient (STC) rating all in one precast component. The panelized approach reduced construction time, with no scaffolding needed as with other systems. The panels were transported to the site and erected quickly, using one crane, with easy access provided to the site.

With a precast concrete finish on the exterior face, a variety of aesthetic designs were available to the design team. These include granite, red brick, simulated stone, and limestone options. SMUD features a buff-colored hue with a light sandblast finish. Interiors were framed out and drywalled, with the process sped up due to the continuous insulation already installed in the precast panel. The precast concrete panels also offer inherent protection against mold and fire, and can be cleaned with only a water wash.

The precast panels help to reduce energy needs, which are minimized by the use of displacement and evaporative-cooling techniques, external shading and light louvers for windows, geothermal energy stor-

age, radiant-slab heating and cooling, use of exhaust air to precondition incoming air, and a heat-recovery heat-pump system.

The project is aiming for LEED Platinum certification when it is completed later this year. "The project will serve as a nationwide model for customers and public-utility leadership peers in the ongoing sustainability movement," says SMUD's King.

## St. Jude Retirement Residences

It wasn't difficult for the precast manufacturer to determine what the owner of the Résidence Le Saint-Jude in Alma, Quebec, was looking for since they also own the building and served as the general contractor. They worked with architect Eric Painchaud Architect & Associates (EPA) to design the structure with a decorative exterior and a high level of safety, provided with the help of an insulated architectural precast concrete envelope and structural system.

The project consists of a six-story, 125-unit retirement residence along with commercial areas and a restaurant. It was designed to withstand cold Quebec winters and ensure the safety of residents by providing strong seismic and wind-force protection. The 115,175-square-foot building features precast concrete beams, columns, slabs, balconies, and stairs, and was clad with architectural precast concrete panels in three distinct finishes and multiple curving shapes.

"We wanted to innovate and show what precast concrete could accomplish in this area," explains Eric Painchaud. "Concrete has a cold and gray reputation here, so we took this opportunity to work with the owner, who builds buildings worldwide with creative precast concrete designs. The approach we took allowed the use of typical molds to create curves and colors that facilitated quick assembly on the site."

The project was brought to the owner by a developer looking for a partner, explains Guy Bouchard, vice president at the precast company. The firm owns other buildings in the





*The six-story Residence Le Saint-Jude retirement residence in Quebec in Alma, Quebec, features a striking exterior comprising architectural precast concrete panels in three finishes and multiple curving shapes. Its total-precast concrete structural system was designed to provide strong seismic and wind-force protection and features precast concrete beams, columns, slabs, balconies, and stairs. Photos courtesy of BPD.*



## PROJECT SPOTLIGHT

### Résidence Le Saint-Jude

**Location:** Alma, Quebec

**Project Type:** Retirement Center

**Size:** 115,175 square feet

**Cost:** CAD\$15 million

**Architect:** Eric Painchaud Architect & Associates, Chicoutimi, Quebec

**Owner/Contractor/PCI-Certified Precaster:** Bétons Préfabriqués du Lac, Alma, Quebec

**Mechanical Engineer:** Gémel Experts Conseils, Alma, Quebec

**Structural Engineer:** Axys Consultants Inc., Sainte-Marie de Beauce

**Precast Components:** 1770 insulated architectural panels, plus beams, columns, slabs, stairs, and balcony units

area but hadn't built one from scratch previously. "Since our plant was in the city and this project played to precast concrete's strengths with

its needs for aesthetics, speed, and safety, it was a natural for us to partner with the developer and to use this system."



## Precast Speeds Construction

The schedule benefitted from the total-precast concrete system, Bouchard says. The first floor was rapidly enclosed, allowing trades to begin interior work quickly. The L-shaped building was built in two phases, focusing on one leg of the "L" first and completing it in nine months. The second leg followed three months later, with the entire project being completed in one year.

Several techniques sped up the construction process, he notes. Windows were installed in the panels at the precaster's plant prior to shipping to the site, eliminating the need to have a window contractor on-site. "That provided a huge savings," Bouchard says. The use of full prestressed slabs for flooring units allowed electrical work and plumbing lines to be run quickly once the supporting walls were in place and the slabs were laid.

"If we had not used precast concrete on this project, we would have had to deliver it in a different way, as the construction techniques would not have been as advantageous with other materials," he says. The components were transported to the site using specially-outfitted trailers to protect the fenestration already installed. One tower crane on the

site erected the entire project, picking panels and other components directly from the trucks as they arrived.

The insulated panels provided thermal efficiency as well as sound attenuation, Painchaud notes. "The insulation ensures the concrete allows the interiors to retain heat in cold weather and stay cool during hot weather." The panels feature xx inches of interior insulation. "Fabricating the panels in the plant with insulation already installed allowed us to better control the quality of the parts, giving us maximum performance and energy savings."

The building meets regional seismic codes and provides strong wind resistance due to its precast concrete frame. "With a six-story building, the loads can be impressive, so we needed to pay close attention to the seismic design," Bouchard says. Grouted sleeves were used at the bottom of shear walls to help absorb loads. "We had to locate these perfectly at the foundation so the walls would fit exactly into them."

The precast concrete wall panels also aid fire safety, as their inorganic composition won't support combustion. The interior walls along the corridor were given a light sandblast finish, saving on time not needed to fur out and drywall these walls. Interior demising walls are also part of the precast concrete structure, providing good sound isolation between interior and exterior spaces as well as between units.

## Curved Balconies

Each unit features a curved balcony, either concave or convex, providing a wave pattern across the building's façade. These ensure access for all residents to fresh air every day. The balconies vary in depth between 5 and 12 feet and include flower boxes that encourage gardening.


The balconies were cast as single-unit pieces. "There were only a few molds for the periphery of the building, which repeated," Painchaud says. "We integrated as many curves, lines, and shapes as we wanted into those molds. By using them repeatedly, we created uniformity and saved costs."

The balcony units sit on the exterior wall and bears on a precast concrete column. This required the column to be erected first and then the balcony units to be grouted and bolted to the supports. "This was not a standard connection that we typically use, and it required some adjustments at the plant to support the balconies' weight," Bouchard explains.

To provide a creative look for the facility, the precaster used a variety of shapes, finishes, and colors. The precast concrete balcony units feature a red hammered finish, with a brick appearance created through the use of a formliner, while the units' main façades feature a buff, sandblasted finish. At ground level, a mosaic-like appearance was created by adding false joints and installing cast stone in random locations, with different abrasive treatments applied to achieve three contrasting looks.

"With all three treatments, the warm colors are guaranteed to retain their appearance in the precast concrete," says Painchaud. "Concrete is highly durable, and we wanted to take advantage of that with these colors. What is wonderful about the precast concrete finishes is that they are integrated in a uniform manner."

Special lighting was attached to the building exterior in strategic locations to highlight the building's curves and finishes at night, casting eye-catching shadows. "The lighting was designed in-house to wash the walls but not make them too bright, so we could keep the shadows and showcase the curving shapes," Bouchard says.

The project started construction in April 2011, and the first tenants moved into the facility in December. The second leg opened in March 2012, with no delays due to winter weather. The project not only provides a contemporary, attractive, comfortable, and safe facility for residents, but it stands as an example of the strong aesthetic values that high-performance precast concrete panels can provide. 

**For more information on these or other projects, visit [www.pci.org/ascent](http://www.pci.org/ascent).**