SUMMER 2011

ASCENT®

DESIGNING WITH PRECAST

CONTINUING EDUCATION

AIA

AIA Education Program Inside

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Education Redesigned

- IEQ - Key to Better Learning Environments
- Continuing Education
- School Safe Rooms

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MID CENTRAL EDITION

Photo courtesy of Gate Precast Co.

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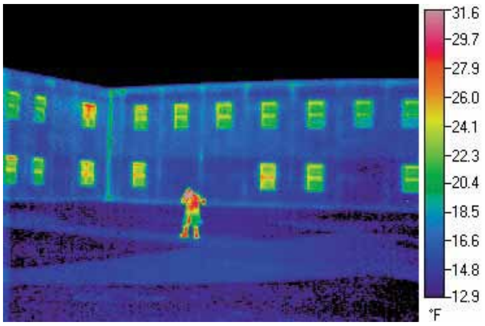

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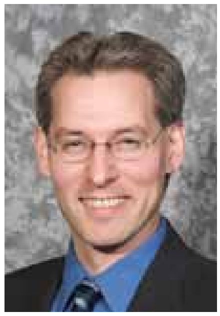
Learning Never Stops



Brian Miller,
P.E., LEED AP
Executive Editor
bmiller@pci.org

It is a fast-paced, interesting world we live in today. Just when you think you have things figured out, and maybe even under control, it seems like you have to adapt and learn something new to keep up. I can remember when I used to pick up a device called a telephone, and using a rotary dial, actually had to remember a person's phone number in order to call him or her. Today, I just need to know that number 1 calls my wife.

The reality is that learning never stops. We must continue to learn, adapt and evolve with the world around us. There is always something new to learn and an improved way of doing things.

This proves very true when we think about education. That is why this issue of *Ascent* is focused on learning facilities. The students, the learning environment, and the approach to learning have changed. Today kids have computers, the internet, Facebook, and X-box 360s, and they communicate via text message rather than face-to-face. Sometimes I wonder as my son sits in the same room as his friend and they are texting each other; is the art of conversation going to be lost?

The learning environment must adapt as well in order to keep pace—and this includes construction. As an industry, we are learning about sustainable design and construction practices and have placed more emphasis on indoor environmental quality (IEQ), energy efficiency, water efficiency, acoustics, and even functional resilience. This means that we cannot build schools and higher education structures as we have in the past. Along with the students, our designs, materials and systems must also change.

How do these changes impact the structures we design and build? Architect Patrick Glenn discusses some of these challenges in the Perspective section on page 26 of this issue of *Ascent*.

Precast concrete has a lot to contribute to building schools and higher education structures that meet these newer requirements and goals. For example, high performance precast concrete insulated sandwich wall panels have evolved. Today these great envelope systems can provide edge-to-edge insulation and use a variety of new wythe connectors that essentially eliminate thermal bridging. Hence, this is very important in developing an energy-efficient building envelope. When you add in the thermal mass capability, along with all of the other benefits of precast concrete, this becomes an optimal system to build with. And you still can have the real brick and stone facade that many schools and universities desire, or require. You can learn about these systems in the *High Performance Precast Insulated Sandwich Wall Panel* Designers Notebook on page 51 in this issue, which qualifies for 1 LU of continuing education credit.

You can also read about IEQ, learn about designing and funding FEMA-compliant storm shelters as part of learning facilities, and see some great examples of how architects and engineers have used precast concrete to help meet their design and program goals.

Years ago, I never would have guessed that I would learn how to use an iPad, text, maintain social media accounts, and play Angry Birds, but the process of learning continues. So as you enjoy reading this issue of *Ascent*, I am sure you will learn something new. G2G, TTYL.

PCI

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ASCENT

On the cover: Tucker High School (see page 33)

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- If you have a project to be considered, send information to Whitney Stephens, PCI Communications Manager, (312) 428-4945 wstephens@pci.org

20 Buildings Honored in the 49th Annual PCI Design Awards

CHICAGO, ILLINOIS

Juries awarded 20 building projects a **PCI Design Award**. Included among the winning projects are commercial buildings, a retail/mixed-use project, parking structures, sports facilities, public/institutional buildings, higher education developments, healthcare buildings, multi-family homes, retirement facilities, and a hotel. Building winners include both a Sustainable Design winner and an All Precast Solution winner. For a complete summary of winner, including photos and projects details, visit www.pci.org and click the Design Awards icon.

The PCI Design Awards program started 49 years ago to recognize design excellence with precast concrete. The special 50th year of the program will begin accepting entries in Jan. 2012. Look for more information on www.pci.org or email Jennifer Peters at jpeters@pci.org to be placed on a list to receive a special announcement when the 2012 awards program opens for submissions.

Blakeslee Prestress Inc. Creates Stairway at West Point

BRANFORD, CONNECTICUT

Blakeslee Prestress Inc. helped design and cast a new precast concrete stairway as a donation to the United States Military Academy at West Point, N.Y. after being approached by four senior cadets who wanted to create a lasting structure for their school as an independent-study project.

The stairway provides safe and convenient access along an incline, replacing a dirt path that was heavily-trafficked. After receiving approval on the project from administrators, the cadets—James Vidal, Marc Orozco, Lukas Rennebaum, and Philip Neumann—surveyed and staked their project and worked with Blakeslee on the final design.

The precaster modeled and designed the stairway as a simply supported beam. The stairway, featuring 7,000-psi concrete, is 1-foot thick with a large, 9-foot landing, over which 5 feet rests on the upper foundation. The 20 treads are $6^3/_4$ inches in height and 11 inches long with a 1-inch overhang. The cadets' thorough surveying and cross-coordination with Blakeslee ensured the dimensions matched the site while still meeting code requirements for stairway slope and tread dimensions.

Heldenfels Produces Longest Prestressed Concrete Bridge Beams in Texas
SAN MARCOS, TEXAS

Heldenfels Enterprises Inc. recently produced and delivered the longest prestressed concrete bridge beams ever manufactured for a Texas bridge project, as confirmed by David Hohmann, Texas Department of Transportation Bridge Division Director.

Heldenfels manufactured 14 Type VI modified beams with a length of 164 ft. 8 in. (50.2 m) for Central Texas Highway Constructors' State Highway 130 project. The beams were offloaded and erected by **Archer Western Contractors** for Bridges 17 and 18 over County Road 179 in Segment 5.2, as part of the new toll road project being developed by Central Texas Highway Constructors.

BergerABAM Acquires Flores Lund
FEDERAL WAY, WASHINGTON

BergerABAM has completed its acquisition of Flores Lund Consultants (FLC) of San Diego, California. FLC has provided civil and structural engineering services for more than 30 years to its client base in the southwest region, including California, Arizona, Nevada, and New Mexico.

The acquisition broadens BergerABAM's geographical reach and presence into a region within the firm's detailed strategic growth plan.

Bill Lund will become a vice president of BergerABAM and continue in a leadership capacity while remaining focused on business development efforts for civil engineering service in California. He will be supported by Hamid Liaghat and Armando Valdos, who continue their focus on promoting the firm's structural engineering services.

Oldcastle Acquires Select Duratek Assets

ATLANTA, GEORGIA

Oldcastle Precast Inc. has acquired select assets of Duratek Precast Technologies Inc. Duratek, a Florida-based precast concrete company, specializes in the design, manufacture, and installation of precast concrete site walls, department of transportation walls, sound barriers, hurricane hangars, safe harbor marinas, precast concrete homes, and commercial, residential, and industrial structures. In addition, Duratek recently filed for a patent for its "unitized" construction methods that create a virtual fortress for structures of any function.

The intellectual property and manufacturing assets gained through the procurement will allow Oldcastle Precast to take Duratek's product line to a national level, offering all customers the latest product technologies in the fields of environmental acoustics for industrial, commercial, and transportation issues; privacy walls for water treatment plants, airports, schools, and government buildings; and environmentally-friendly perimeter wall systems for gated communities and developments.

Hanson Building Products Names Jay Cariveau, AIA, LEED AP, Vice President of Sales for Hanson Structural Precast Division

MAPLE GROVE, MINNESOTA

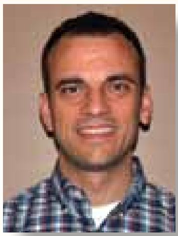
– Jay Cariveau

Hanson Building Products North America has named Jay Cariveau, AIA, LEED AP, as vice president of sales for its structural precast division.

In this capacity, Cariveau is responsible for sales, estimating, and project management for Hanson's architectural and structural precast concrete manufacturing facilities in Minnesota, Utah, Idaho, and California. He will help develop and execute strategies to enhance the customers' experience while securing valuable revenue streams.

Molin Concrete Products Names Matthew Westgaard as Chief Operations Officer

LINO LAKES, MINNESOTA



– Matthew Westgaard

Molin Concrete Products hired Matthew Westgaard for the newly-created role of chief operations officer. In this role, Westgaard will be responsible for the overall safety, quality, productivity, customer satisfaction, and profitability of the manufacturing operations of the company.

Prior to this position, Westgaard served as vice president/general manager for Hanson Structural Precast in Maple Grove, Minn.

Gate Precast's Committment to Safety Earns SHARP Certification at Four Precast Plants

JACKSONVILLE, FLORIDA

Gate Precast Company earned SHARP (Safety and Health Achievement Recognition Program) certification at its plants in Winchester, Kentucky; Ashland City, Tennessee; Kissimmee, Florida; and Jacksonville, Florida.

SHARP recognizes employers who operate exemplary safety and health management systems and are committed to making safety for employees a priority.

"Our employees strive to provide for the health and welfare of their families. It is important for them to know they work in a safe environment and will return to their families in good health each day. Gate Precast's safety mindset boosts employee retention and overall morale," said Dean Gwin, president, COO of Gate Precast.

Gate Precast, Jacksonville recently received SHARP re-certification for an additional three years, which is the longest extension granted in the program. Gate Precast continues its commitment to safety and wellness of its employees as it aspires to earn SHARP certification in its plants in Alabama, North Carolina and Texas.

Spancrete Adds Two Project Management Positions

WAUKESHA, WISCONSIN

Spancrete recently expanded its project management team. Dick Baumgartner and Davin Stitgen were promoted to the new roles of project managers. Both Baumgartner and Stitgen will work closely on projects from initial project conception to final completion. Baumgartner has spent 25 years at Spancrete and was involved in every phase of the company's precast concrete business. Stitgen has been with Spancrete for more than five years serving as an engineer in the company's drafting and engineering department.

PCI Joins Twitter

CHICAGO, ILLINOIS

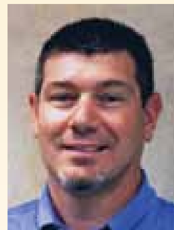
PCI has joined Twitter! The PCI Twitter account (@PCIprecast) will share relevant industry news, as well as information on PCI continuing education opportunities, new publications and articles, upcoming events, and more.

Follow us at www.twitter.com/PCIprecast.

Submit your headline news for consideration in a future issue of *Ascent* to Whitney Stephens at wstephens@pci.org.

Thermomass® Names New Regional Manager

BOONE, IOWA



– *Bob Bertig*

Thermomass, a manufacturer of concrete building insulation systems, has named Bob Bertig as its South East Region Sales Manager. In this position, Bertig will have primary responsibility of managing Thermomass' South East Region which includes Florida, Georgia, Alabama, Tennessee, North Carolina, and South Carolina.

Spancrete Undergoes Internal Changes to Further Leadership and Direction

WAUKESHA, WISCONSIN

– *Paul Staroszczyk*

Spancrete has recently added Paul Staroszczyk as manager of quality assurance. In this role, he will focus on continuous improvements in Spancrete's products and processes as well as leverage lean, Six Sigma, and other quality methodologies to drive process improvements for the Precast Global machinery divisions.

Spancrete has also promoted the previous vice president/chief operating officer, Alan Antoniewicz, to serve as president and chief operation officer to provide a new wave of leadership and direction to the organization.

In addition, two project management positions were added to work closely with Spancrete projects from initial project conception to final completion. Dick Baumgartner and Davin Stitgen have been appointed to take on these roles and assist with projects that have a need for Spancrete's value-added services, helping to manage the complexities of project requirements.

Finfrock Signs Two Design-Build Garage Contracts

ORLANDO, FLORIDA

Finfrock Construction, Inc. has signed contracts for complete design-build services with Westminster Services, Inc. to deliver a 383 stall parking garage at Winter Park Towers in Winter Park, Florida and with Equity Residential for a 315 stall garage at Sunrise Village in Sunrise, Florida. The two garages total over $8,000,000. Design work is underway on each garage and both projects are scheduled to be complete in June 2012.

IEQ – A Key to Better Learning Environments

Creating healthy schools for our children.

— By Scott E. Powell, AIA, LEED AP, Craig Gaulden Davis

Gone are the days of the new-building smell. While many people enjoy that smell, the VOCs (volatile organic compounds) and other chemicals that make up those scents are not healthy for us. Spurred by the rating system for sustainable buildings from the USGBC (U.S. Green Building Council), more attention is being paid to the Indoor Environmental Quality (IEQ). This focus has generated a wide range of design techniques that can improve IEQ for school buildings, often with little cost premium.

IEQ essentially looks at items that impact the environment inside a building such as natural lighting, ventilation, occupant comfort, air quality, acoustics, etc. Sustainable design includes guidelines for greatly improving IEQ, and since most people spend the majority of their lives indoors, this becomes an important design consideration.

Schools have focused attention on IEQ with good reason: Poor air quality has been shown to be a deterrent to learning. Studies have shown that children perform better on tests, have fewer headaches, and are less tired in buildings with better IEQ. In addition, many children have allergies that are easily activated by pollutants in the air. The USGBC has recognized these effects and offers certification targeted toward schools.

A.J. Whittenberg Elementary School of Engineering in Greenville, S.C. Photograph © Michelle Gunning 2010

– Scott E. Powell, AIA, LEED AP, is Principal, Secretary, and K-12 Studio Director at Craig Gaulden Davis in Greenville, S.C.

The LEED for Schools certification has a number of requirements, including several that focus on ensuring proper indoor air quality. The loss of the new-building smell is the result of products with low VOCs. VOCs are emitted as gases from certain solids or liquids, such as paints, sealants, carpets, cleaning products, etc. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. A decade ago, it was a challenge to specify products with low VOCs, but today manufacturers offer a broad range of low-emitting products.

Increasing Occupant Comfort

The comfort of a building's occupants, including children, is vital to whatever tasks they hope to complete. Increased thermal comfort and attention to the overall building envelope is required by the building code and current ASHRAE standards. Insulated glass and special coatings such as low-E film allow fenestration in exterior walls without compromising the thermal integrity of the building shell.

Precast concrete panels provide outstanding thermal qualities along with many other benefits. For example, typical exterior precast concrete sandwich wall panels can provide 3 or more inches of continuous insulation sandwiched between wythes of concrete. This maximizes both the insulating properties desired and thermal mass, which can reduce HVAC system requirements and improve energy efficiency. The lag effect of thermal mass can also help maintain a more uniform temperature within the building, further enhancing occupant comfort.

Acoustics and Mold

LEED for Schools has a prerequisite for acoustics. Recent studies confirm common sense: students perform better when they can hear the teacher. There are several factors that affect school acoustics, including isolation and insulation from external noise sources and absorption of internally generated noise.

In the late 1990s, mold as it related to flooring materials, in schools was a big issue, and it resulting in carpet being removed from classrooms, sometimes unnecessarily. Part of the problem was that maintenance personnel were given insufficient equipment and virtually no training. For example, maintenance crews would clean classroom carpets during the summer, leaving a surplus of water in the carpet. Then the staff would leave for vacation, shutting down the mechanical system—which encouraged mold growth.

With proper equipment and training, carpets can save districts money on long- term maintenance costs and help solve the acoustic issue. A.J. Whittenberg Elementary School of Engineering in Greenville, South Carolina, for example, was seeking Silver LEED certification and most likely would not have met the prerequisite for minimal acoustical performance without carpet tile in the classrooms.

The design team eliminated the concern that carpet would absorb contaminants by specifying carpet squares. If a carpet tile becomes soiled, it can be replaced by a surplus tile while the stained tile is shipped to a dry cleaner. In addition to outstanding sound absorption, carpet facilitates differentiation where children can sit on the floor and learn in small groups.

Another method to reduce mold is to eliminate both the moisture and food sources for mold. Today, many schools are moving away from traditionally designed cavity-wall systems to reduce the uncertainty that can be concealed inside the cavity. Often, moisture issues are not known until the damage is great. Face-sealed systems, such as precast concrete, can help greatly reduce moisture penetration and reduce mold potential. Of course, concrete also does not provide a food source for mold.

Acoustics in classrooms often are affected when air conditioning is added to older schools. The least expensive solution has been to replace a window with a wall-mounted mechanical unit. The units typically are loud and primarily benefit the students sitting closest to the air source. Schools continue to struggle with sufficient funding for facilities, so wall-mounted mechanical units are still popular today, but they have been greatly improved.

Units today are available with ductwork to properly distribute the air across the classroom. They are also designed to run more quietly and can be placed inside the classroom so only a louver is visible from the exterior rather than the hanging unit. While the units are not energy efficient when compared to a four-pipe system with a sophisticated control system, they allow for individual classroom control and help meet budget constraints.

Finally, noise must be limited from nearby activities, such as outside the classroom. The selection of envelope systems and interior partitions with the appropriate STC rating to help isolate external noise sources will help.

Daylighting

Natural lighting provides the biggest IEQ benefit in children's learning environments. Research shows that children perform better on standardized tests when they are educated in naturally-lit classrooms. However, the daylighting point in the LEED system can be expensive. To pull natural light into classroom interiors, higher ceilings and light shelves are typically necessary, in addition to corridor light wells.

Daylighting may be cost-prohibitive, but architects should continually strive to ensure as many classrooms as possible have exterior exposures facing north or south to reduce glare and provide views to the exterior (achieving 90% of spaces will secure a LEED point). Windows in all spaces are desired, but teachers are likely to close the blinds to block the eastern light when the sun is low and often do not open the blinds in the afternoon.

At the A.J. Whittenberg school, the structural system was changed to allow for ribbon windows on the north- and south-facing classrooms. Horizontal precast panels were hung from a steel frame to accommodate the windows, while sunshades were placed along the south elevation. The result is a light-filled classroom with outstanding thermal comfort and excellent acoustics. The building is used as a learning tool in the school's engineering curriculum.

Impacting Construction Techniques

Enhancing air quality starts during construction. Duct cleaning has become a popular business, but measures should be taken to protect against dust accumulation from installation onward. It has become common for contractors to install the equivalent of Saran Wrap on each end of ductwork when it is delivered on site to prevent dust from collecting during construction.

All HVAC units should also be provided with temporary filters that are changed periodically during construction. Increased ventilation and the introduction of more outside air allows for more air exchanges, which eliminate the germs and odors that can reside in schools.

Traditional school materials such as brick and block are slowly being replaced with alternative construction materials. Due to durability, low maintenance, speed of construction and other benefits, there has been an increase in the use of precast concrete for educational construction projects. The rapid enclosure helps to minimize outdoor contaminents and moisture exposure. Increased moisture exposure during construction, can lead to mold and other indoor air-quality issues.

The biggest driver for focusing attention on IEQ is the proven benefits it provides to the learning environment, and its value in helping children succeed in school. We may miss that new-building smell, but the creation of a positive atmosphere for learning is worth the sacrifice. Regardless of whether owners are concerned with LEED certification, the design community should strive to create quality indoor environments. These considerations should include solar orientation of the classrooms, an efficient building envelope, mechanical systems with proper temperature controls, and effective acoustics. Many available options do not cost more—but do require more education on the benefits of their use. Our children's future—and ours – depends on our efforts. ■

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

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 buildings 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."

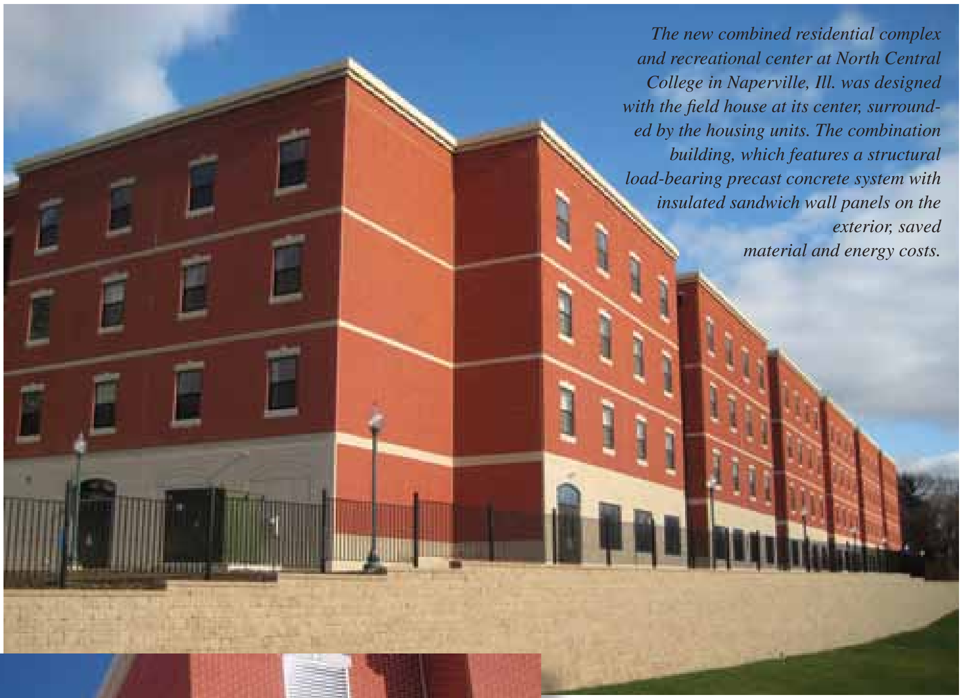
North Central College Complex

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.*

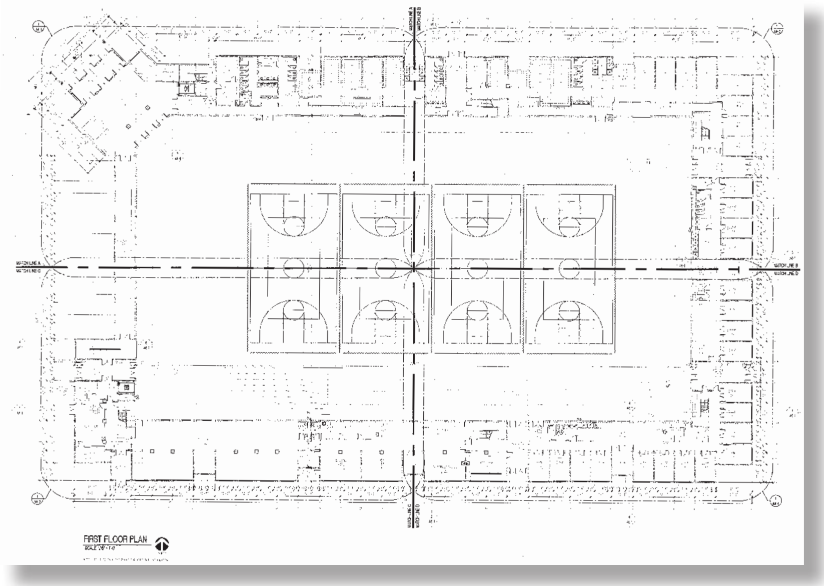
Owner: *North Central College, Naperville, Ill.*

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 tack, 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 concrete 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 precast 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.

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.

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*

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 precast 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 "sandwhich 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 Mechanical 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. Coreslab 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 precaster, 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 concrete 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 $^{3}/_{4}$ 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.

Designing Schools for a Changing Future

New teaching techniques and sustainable-design requirements are reflected in design concepts that impact K-12 schools

— By Patrick Glenn, AIA, REFP, LEED AP BD+C, Perkins+Will

Designers today are realizing that 21st Century schools must be designed for a new century of learning skills. Student are becoming more agile and mobile, allowing them to process information at a much more rapid pace than their parents (and sometimes their teachers). To provide a successful environment for these evolving learning skills, schools must be flexible, adaptable and capable of accommodating various-sized groups performing a range of activities. These design requirements must blend with other growing challenges, including sustainable-design concepts and both short- and long-term budget needs.

The concept of planning and building schools to support a new generation's learning and cognitive skills has been developing for some time. The December 18, 2006 issue of *Time* magazine, for instance, featured an article on "How to Build a Student for the 21st Century." It noted that schools have not kept pace with the changes in learning skills and the demand for a more integrated and project-based curriculum.

– Patrick Glenn is an Associate Principal and the K12 Market Sector Leader at Perkins+Will in Dallas.

Budget restraints and a search for new delivery methods have brought precast concrete construction to the forefront for many schools. The Carolina High School in Greenville, S.C., was designed by Perkins+Will with a total-precast concrete system of load-bearing wall panels and double tees. The project won the award as Best School Design in the 2007 PCI Design Awards competition.

Shortly after, *Architectural Record* began offering an annual supplement dedicated to "Schools of the 21st Century." Perkins+Will was featured on the cover of the inaugural issue with its design of Blythewood High School in Blythewood, South Carolina. The project highlighted the growing need for "intimate learning environments" dedicated to specific curricula within larger school campuses. In January 2011, *Architectural Record* showcased another Perkins+Will project: the new Cedar Ridge High School in Round Rock, Texas.

Intensive Collaboration

Today's agile and mobile students are collaborating with fellow students in group projects more often, driving more aspects of school design. Integrated curriculum and project-based learning activities are gaining traction as well. Instead of segregating subjects into several one-hour classes, the subjects are merged into one group project, in which students collaborate and accomplish multiple assignments.

This type of learning approach has proven more engaging and fun while allowing students to inherently retain more of the project's learning aspects compared to the more traditional lecture-assignment approach. Architects can relate to this: Our work environments are not set up in silos but as collaborative efforts. Why should we expect students to perform best in another way?

Learning spaces must offer a variety of group settings.

As a result, learning spaces must offer a variety of group settings, including traditional lecture-style classrooms, group project rooms accommodating 6-8 students and one-on-one project/tutor rooms. That means schools must have open spaces that can accommodate these activities and be revised to accommodate changes. Maintaining a 200-foot-long, double-loaded corridor with flanking 850-square-foot classrooms is becoming extinct. Today, schools are being designed with the necessary smaller group-learning spaces integrated into the social life of the

The student courtyard at Cedar Ridge High School in Round Rock, Texas, is flanked by two of the four small learning communities designed for the school, which includes upper-level distributed media center and teacher planning areas. Photo: Charles D Smith Photography

This floor plan demonstrates the concept of breaking up a large high school into small learning community groups that encourage more interaction and make the school less overwhelming. Diagram: Perkins+Will

The central student cafeteria at Cedar Ridge High School in Round Rock, Texas, is located in the center of the school and fronts the central student outdoor learning courtyards. Photo: Charles D Smith Photography

school, or they are including operable partitions so spaces can quickly be divided into smaller spaces.

Smaller learning communities also are growing within the larger institution. Large comprehensive high schools and middle schools are incorporating this planning idea more than smaller schools, so they can break down the overwhelming social expectations a high school student endures during a normal school day. The idea takes a large school, perhaps 2,400 students, and organizes the private instructional learning spaces into learning clusters. These smaller units house up to 600 students, allowing day-to-day activities to be more compact and less overwhelming.

The integrated curriculum and project-based learning at Cedar Ridge High School in Round Rock, Texas, is highlighted by the Culinary Arts Classroom and Lab, which is part of the Academy of International Business & Economics curriculum. Photo: Charles D Smith Photography

Students today have never been without a computer, the internet or even iPods.

Shared spaces, such as the media center, gymnasium, performing arts center, and cafeteria, are typically organized around a central campus region. Enhancing each cluster's independence is the trend toward creating a smaller central media center and using the saved space as dedicated media centers for each learning cluster, specializing in that unit's respective focus. Distributing administration, counselors and teacher-planning areas throughout the cluster allows adults to be more dispersed, increasing teacher-to-student interaction, furthering the academic-support process.

These types of design strategies help to facilitate schools that are more student-focused, instead of past generation designs that were more teacher-focused. Today the teacher is more of a roaming guide to instructional projects rather that the former teaching pedagogy of one way delivery of information.

Advanced, portable technology also drives planning. Students today have never been without a computer, the internet or even iPods. Incorporating infrastructure so students can utilize laptops, smart boards and other digital-presentation devices enhances the learning process and allows it to be presented in a form with which students are comfortable. These techniques are critical to a 21st Century school's mission. Providing resources for blogging, tweeting and internet research allow students to have fingertip access to project-related information.

Focus on Sustainable Design

Sustainable design concepts, more widely known as "green design," are playing a big social and environmental role in school design, especially for recruiting and retaining highly-regarded teachers and administrators. They also increase the school's attractiveness to relocating families, creating a marketing advantage.

Students benefit as well. A large amount of research and data directly support the notion that sustainable-design techniques generate better student performance in addition to long-term operational savings. Among the techniques becoming standard today are the proper passive orientation of the building and the inclusion of daylight in the classroom. Studies show students perform better in math and reading especially when they are able to receive direct daylight in the classrooms.

Positioning the building in such a way as to capture indirect north daylight provides the best option without generating heat in the late spring and early fall months. Providing windows on the southern exposure allows indoor spaces to take advantage of sunlight during the winter, but overhangs and sunshades should be properly integrated to control and shade summer sun. Providing minimal window openings on the east and west façades will also help control transitional temperature swings throughout the day.

Other sustainable strategies may include collecting rainwater to be used for site irrigation, installing internal plumbing devices such as infrared sensors to control water waste, maximize use of highly energy-efficient mechanical units, and improving indoor air quality—which in turn helps lower student absenteeism and raises focus and attention. (For more on Indoor Environmental Quality, see the article on page 14.)

Another common strategy that helps schools become good stewards of our environment is specifying materials with high levels of recycled content that are harvested and manu-

Research supports the notion that sustainable-design techniques generate better student performance and long-term operational savings.

Adding visual interest to interiors, such as in the upper school media center at St. Alcuin Montessori School, provides a playful look that encourages learning (by mimicking the night time constellation Ursa Major). A series of glass-block windows limit the amount of direct west sun that penetrates into the learning space. Photo: Charles D Smith Photography

Large amounts of daylight, which filter into the upper-school media center at St. Alcuin Montessori School in Dallas brighten the space naturally and aid student performance. Photo: Charles D Smith Photography

The Carolina High School in Greenville, South Carolina, shows that precast concrete can simulate the traditional look of brick that administrators want to retain while providing more contemporary benefits of an engineered material. Photo: Perkins+Will

factured within a 500 mile radius. This focus can aid in lowering costs while demonstrating a commitment of environmental awareness to the school community.

Designing on a Budget

School budgets today are tighter than ever. Most school districts have gone through some level of operational and maintenance cuts, whether in cutting back supplies and other operational costs, or the more extreme option of laying off personnel. Financial constraints on the operational and maintenance side sometimes create confusion when communities look at capital-construction and building-improvement programs.

To be sensitive to these concerns, school districts are asking architectural and construction teams to do more with less. For example, Texas school districts are focusing more attention on improving existing school buildings rather than continuing to build new schools, which require more teachers and staff. Such projects as roof replacements, window replacements or chiller and boiler upgrades are becoming more common as districts try to be more creative and strategic with their construction and maintenance dollars. Some of these are designated as "20-year renovations," which are intended to last 20 years before any additional improvements are made.

These renovations take existing schools designed from the 1950s, 1960s or 1970s and bring them up to current standards. On occasion, the renovations can be quite complex, especially when older schools have implemented design trends that are now antiquated. It is not uncommon for our firm to be asked to take an existing school with an open-classroom plan or a layout featuring a departmental structure and redesign it to create small learning communities with distributed media resources and administration.

It can become difficult for contractors to support the architect's design because they are excluded from early discussions.

Although providing the same end result for an existing renovated school can be much more complex, substantial dollars can be saved while preserving older schools, which have a neighborhood heritage. Improvements can unify a once struggling community, as it sees the local district making a commitment to not only improving the school's physical appearance but also to upgrading the design to enhance the academic support that will prepare students for 21st-Century challenges.

Efficient Delivery Methods

Regardless of whether the project involves a new design, a renovation or a combination, there are a variety of construction-delivery models to choose among. The two most commons for schools are CSP (Competitive Sealed Proposal) and CM@R (Construction Manager at Risk). The CSP process is essentially the traditional design-bid-build method, with contractor qualifications and experience added to the evaluation. A combination of qualitative factors are analyzed, not just the bid price.

The CM@R methodology has gained in popularity in the past ten years, and is becoming the preferred method of delivery for many school districts across Texas. Allowing the construction manager to participate in the design process creates many benefits for the client. The biggest and most influential benefit, especially for an architect, is the ability for the CM to participate in the conceptual design stage and understand the client's expectations from the beginning of the design process.

Too often, it becomes difficult for contractors to support the architect's mission and design because they are excluded from the early discussions and presentations. As a result, they are unaware of the owner's key priorities as the project develops. Understanding the design from its infancy, the contractor or CM can adjust as situations arise and filter for options in construction methods, material costs or schedules that align with those needs.

The CM can also be used as a resource by the architect during the design process to price new or design-specific systems and to evaluate their practicality and budget impact. Additionally, the CM can participate in the detailing process, to help make financially- and schedule-sound recommendations that support the overall design expectations. Delivering a project with the CM@R method generally requires greater CM services cost, but typically that cost should be offset with the added savings and schedule benefits that result.

The newly discussed Integrated Project Delivery method is gaining popularity but has not fully reached the school community. This concept is similar to the design-build methodology but includes the owner in a three-part team that shares financial performance and risk. Because of the traditional manner in which schools are funded and

Travelers Rest High School in Travelers Rest, South Carolina, welcomes students with an exterior featuring precast concrete exterior wall panels accented with thin brick. Photo: Perkins+Will

the public, tax-supported way in which schools operate, this type of design/construction delivery method has made it difficult to create agreeable solutions for all three parties.

Precast Concrete Use Grows

Current budget constraints and a search for new delivery methods have brought precast concrete construction to the forefront for many school projects. Understanding the material's benefits can be advantageous for architects facing limited financial means and aggressive construction schedules. Utilizing precast concrete structural panels, for instance, provides structural benefits via lower costs and faster erection schedules.

They also provide many other benefits such as flexible, open-interior spaces, thermal mass, a much greater fire-resistance rating than steel structure, and a more durable and maintenance-free finish. Increasing durability and lowering maintenance needs are always added values for projects involving school kids. The precast concrete industry has also made advances in the aesthetic choices for large structural panels, including thin brick that can resemble traditional means of construction as well as the brick façade that administrators still want even as traditional teaching methods fall by the wayside.

Precast concrete structural panels not only can improve the bottom line for tight school budgets, but their capabilities for producing repetitive designs provide an efficient way to duplicate small learning communities. Some schools have as many as four identical building wings in their overall design, which plays to precast concrete's efficiency.

The structural panels also provide benefits to some aggressively growing districts by creating a prototypical design that can be used for multiple school buildings of the same design built to accommodate rapidly increasing student enrollments.

Precast concrete panels provide a much higher level of quality control since much of the fabrication and curing happens off-site under controlled production measures. This quality is evident as students and parents see the rapid enclosure of the building and its durability once it is occupied.

Schools are changing in many ways to accommodate new generations of students. The design and construction industries need to be open to this change and be ready to provide leadership to plan and construct schools for the 21st Century. Airports have changed their appearance, operation and security measures since the 1940s. Hospitals and research facilities have changed immensely since the early 1900s in pursuit of increasing healthcare standards and technology. Why would schools still be designed as if our society is stuck in the 1950s?

State policy makers, school boards and school administrators will continue this trend of recognizing that change is necessary for today's generational student to compete. The learning and cognitive principles behind 21st Century school designs will continue to evolve, and the built learning environment must be designed to evolve with them as we cope with integrating into a global society. ■

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

The Aesthetic Versatility of Precast

Precast concrete provides excellent aesthetic versatility. It is available in practically any color, form, and texture. Precast concrete can be veneered with other traditional building materials such as brick, granite, limestone, terra cotta, tile, and more. This provides the look and feel of these materials while adding all the benefits of precast concrete.

Different finishes can also be combined for one project, even in one panel, without requiring multiple trades and additional detailing for movement and waterproofing. It offers an efficient way to develop a multitude of façade treatments with less cost and detailing time.

K-12 schools and higher-education projects both have specific aesthetic qualities they must provide, either to invoke a traditional appearance that blends with other buildings or to inject a contemporary image of cutting-edge learning. The next few pages show precast concrete's aesthetic versatility in projects throughout the United States.

Kearney Elementary School

Kearney, Neb.

Architect: *Wilkins Hinrichs Stober Architects, Kearney, Neb.*

Structural Engineer: *DLR Group, Omaha, Neb.*

Contractor: *Hampton Commercial Construction, Lincoln, Neb.*

Owner: *Kearney Public Schools, Kearney, Neb.*

Precaster: *Coreslab Structures (OMAHA) Inc., Omaha, Neb.*

This 57,862-square-foot K-5 school uses precast concrete insulated sandwich wall panels to help meet its program requirements. The combination of three finishes on the exterior walls creates a unique look that helps the school blend into its surroundings.

The dominant portion of the façade consists of thin brick embedded into the precast concrete. The brick consists of real clay brick that allows for the character and beauty of masonry with the added benefits of precast concrete. The darker buff concrete features an acid-etch finish while the lighter finish was provided by a deep sandblast. This finish strategy allowed the designers to use a single precast panel to mimic the look of several interfacing materials while reducing the number of trades required.

The school's windows were placed higher on the walls to allow for natural light while preserving classroom wall space. The higher window locations also help reduce the amount of outside distractions interfering with class time. The precast concrete wall panels were left exposed in the high volume areas to provide a durable interior surface.

The interior surface of the panels received a smooth troweled finish during casting allowing for an efficient application of paint in the field.

Tucker High School

Tucker, Ga.

Architect: *Milton Pate Architects, Tucker, Ga.*

Structural Engineer: *Bennett & Pless, Atlanta, Ga.*

Contractor: *Turner Construction Company, Atlanta, Ga.*

Owner: *DeKalb County School System Design & Construction, Tucker, Ga.*

Precaster: *Metromont, Hiram, Ga.*

Photo: George Spence, Metromont.

The Tucker High School project consists of a 340,000-square-foot high school that was built in two phases. It replaces the existing school that was built in 1963, on the same site as the original 1918 school. The building program dictated that the new construction occur around the existing buildings to accommodate ongoing and uninterrupted school activities on site.

Phase one included two-story and four-story precast concrete academic classroom buildings plus a three-level parking facility. This phase also featured a separate two-story administration building that contains all administration, a media center, art and science labs, and the ninth-grade academy classroom spaces.

Phase two construction followed immediately and completed the campus with technology classroom labs, a 600-seat auditorium, a 1,200-seat gymnasium, a renovated cafeteria and kitchen space, athletic fields, and landscaped courtyards.

The exterior finish comprises a thin brick veneer embedded into precast concrete panels with lightly sandblasted precast to mimic limestone. The stone veneer at the bottom of the Media Center was hand-set to the precast backup panel. The interior precast concrete walls contained a smooth trowel finish and were painted, providing a durable finish.

Rochester Memorial Elementary School

Rochester, Mass.

Architect: *Flansburgh Architects, Boston, Mass.*

Structural Engineer: *EDG Inc., Medford, Mass.*

Contractor: *Gilbane Building Company, Boston, Mass.*

Owner: *Town of Rochester, Rochester, Mass.*

Precaster and Precast Specialty Engineer: *J. P. Carrara & Sons, Middlebury, Vt.*

Photo: Joanna Callas.

The town's only elementary school, a pre-K–6th grade facility serving more than 600 students, has seen significant enrollment increases in recent years. The school needed to expand quickly to keep class sizes reasonable. The decision was made to renovate all portions of the existing school and add new classrooms, along with additional space for music and support activities; approximately 34,000 square feet in all.

Precast concrete was selected for the addition due to the many benefits associated with it. Some of the key benefits included superior sound isolation, thermal mass and energy efficiency, fire and storm resistance, and speed of construction, which was of particular importance on this project. The two-story, 22-classroom addition was completed in just 10 months from design to occupancy. The entire addition was enclosed in just three weeks.

Another advantage of using precast concrete panels was the variety of exterior choices. In this case, the use of thin brick embedded in the precast panels matched the existing school and eliminated the periodic sealing or tuck-pointing required with traditional brick. The base, banding and sills consisted of gray-colored precast. On the inside, the precast concrete panels were smooth and ready for painting with no additional preparation.

The completed school addition complies with MA-CHPS (Massachusetts Collaborative for High Performance Schools), a certification which encompasses school design, construction and operation, energy and water use, lighting, temperature control, and acoustics. Precast concrete panels helped meet several of the criteria for environmentally-friendly schools.

University of Minnesota Science Teaching and Student Services Building

Minneapolis, Minn.

Photo: Jim Gallop, Gallop Studios.

Architect: *Kohn Pedersen Fox Associates, New York, N.Y.*

Parking Designer/Engineer: *HGA, Minneapolis, Minn.*

Contractor: *McGough Construction, St. Paul, Minn.*

Owner: *University of Minnesota, Minneapolis, Minn.*

Precaster: *Gage Brothers Concrete Products Inc., Sioux Falls, S.D.*

The Science Teaching and Student Services building is prominently sited on a bluff overlooking a river, opposite a prestigious art museum and at the head of a prominent bridge.

The building serves a dual purpose: a state-of-the-art learning center with Active Learning Classrooms (ALCs) and science teaching classrooms as well as a "one-stop center" for student services such as registration, financial planning and life planning/career services. In addition, the center includes a student lounge, cafe and numerous informal student study areas.

The building links the east and west campuses and facilitates pedestrian flow through the building while visually engaging the user with panoramic views of the river and downtown skyline.

The five-story building's architecture incorporates various building materials on its façade, which takes cues from the urban campus structures, the serenity of the museum and the fluidity of the winding river.

Scalloped and curved architectural precast concrete components anchor the building into the river's bluff, while the building's base echoes the warm ochre color of native limestone. The precast concrete components transition to a glass curtain wall with energy-efficient glazing, which creates a fluid façade on the river side.

The eastern facade utilizes striated brick-faced precast concrete wall panels and horizontal strip windows to link the structure to the orthogonal nature of the existing campus buildings. Given the complexity of urban campus design and the program requirements, precast concrete met or exceeded the architectural design requirements. The integrated architectural finishes and durability of the high-strength concrete will stand the test of time for years to come.

Willow Creek Elementary School

Fleetwood, Pa.

Photo: AEM Architects, Inc.

Architect: *AEM Architects, Inc., Reading, Pa.*

Structural Engineer: *Multani Associates, Reading, Pa.*

Contractor: *Wohlsen Construction, Lancaster, Pa.*

Owner: *Fleetwood Area School District, Fleetwood, Pa.*

Precaster: *High Concrete Group LLC, Denver, Pa.*

The $22.1-million, 108,000-square-foot Willow Creek Elementary School, which opened for the 2009–2010 academic year, features 44 classrooms, a cafeteria, gymnasium, library, computer labs, and art and music classrooms for about 700 students. The two-story school was enclosed with masonry-clad precast concrete sandwich wall panels that provide a thermally efficient R-16.

The exterior design is simple, providing an academic schoolhouse feel with a positive sophistication. The main visual field is a reddish-gray Glen-Gery thin-brick veneer complemented with strong buff-pigmented lintels and sills. Buff stair towers and accents in a light sandblast finish break up the field. Cut stone-like reveals bring a classic element that creates contrast while conveying substance.

According to project architect Justin H. Istenes of AEM Architects, Inc., the enclosure was chosen because "precast is built to last." The precast walls were constructed with carbon-fiber shear trusses to be fully structurally composite, allowing the interior and exterior wythes to act together to resist gravity, lateral and seismic forces. Rigid XPS foam insulation was sandwiched inside.

Back surfaces of the insulated panels were trowel-finished "with a smoothness that almost looks like gypsum board," says Istenes. The walls were painted off-white to serve as the exposed surfaces of the classrooms and halls. Precast concrete also was used for the interior walls to allow the project to flow more smoothly during erection than using steel and block would have allowed. Conduit for exterior lighting and fixtures was cast into the interior wythes for aesthetics and durability over time.

Hickory Hills Elementary School

Springfield, Mo.

Architect: *Jack Ball Architects, Springfield, Mo.*

Engineer: *Pinnacle Design Consultants, Springfield, Mo.*

Contractor: *DeWitt & Associates, Springfield, Mo.*

Owner: *Springfield Public School District, Springfield, Mo.*

Photo: Ryan Faust.

Precaster: *Prestressed Casting Company, Springfield, Mo.*

The Hickory Hills Elementary School was designed to follow the contours of the existing site. Building form and materials pay homage to the area's agricultural heritage in a modern way with a touch of technicality. Constructed of precast concrete with some masonry, the building's durability is one of its most sustainable features.

A custom-mix design was created for the precast concrete, balancing color throughout the building's exterior and interior. Material used in the custom mix design was all found within the state, helping the regional and local economies while providing an environmental connection. The precast concrete panels are light gray and feature black granite sand to add contrast and character to the light matrix color. The panels also received a medium sandblast finish. Panels are angled at the outside edges, making them a focal point of architectural vernacular on the building.

The project was designed to achieve LEED Silver certification by encouraging decisions that promote sustainable development and create educational tools for students and the community. Precast concrete contributed to reaching these objectives in many ways, including using regional materials, incorporating recycled materials in the concrete and accelerating the speed of construction. The latter was vitally important, as the substantial completion date and the start of the 2010 Spring semester were only days apart.

Acoustical performance of interior spaces is a critical element in the design of LEED certified buildings, and precast concrete helped achieve this goal. It reduced the acoustical treatments for sound transmission through walls, which helped maintain a responsible budget towards the overall project.

Idaho Broadview University

Boise, Idaho

Architect: *Mahler & Associates Architecture, St Cloud, Minn.*

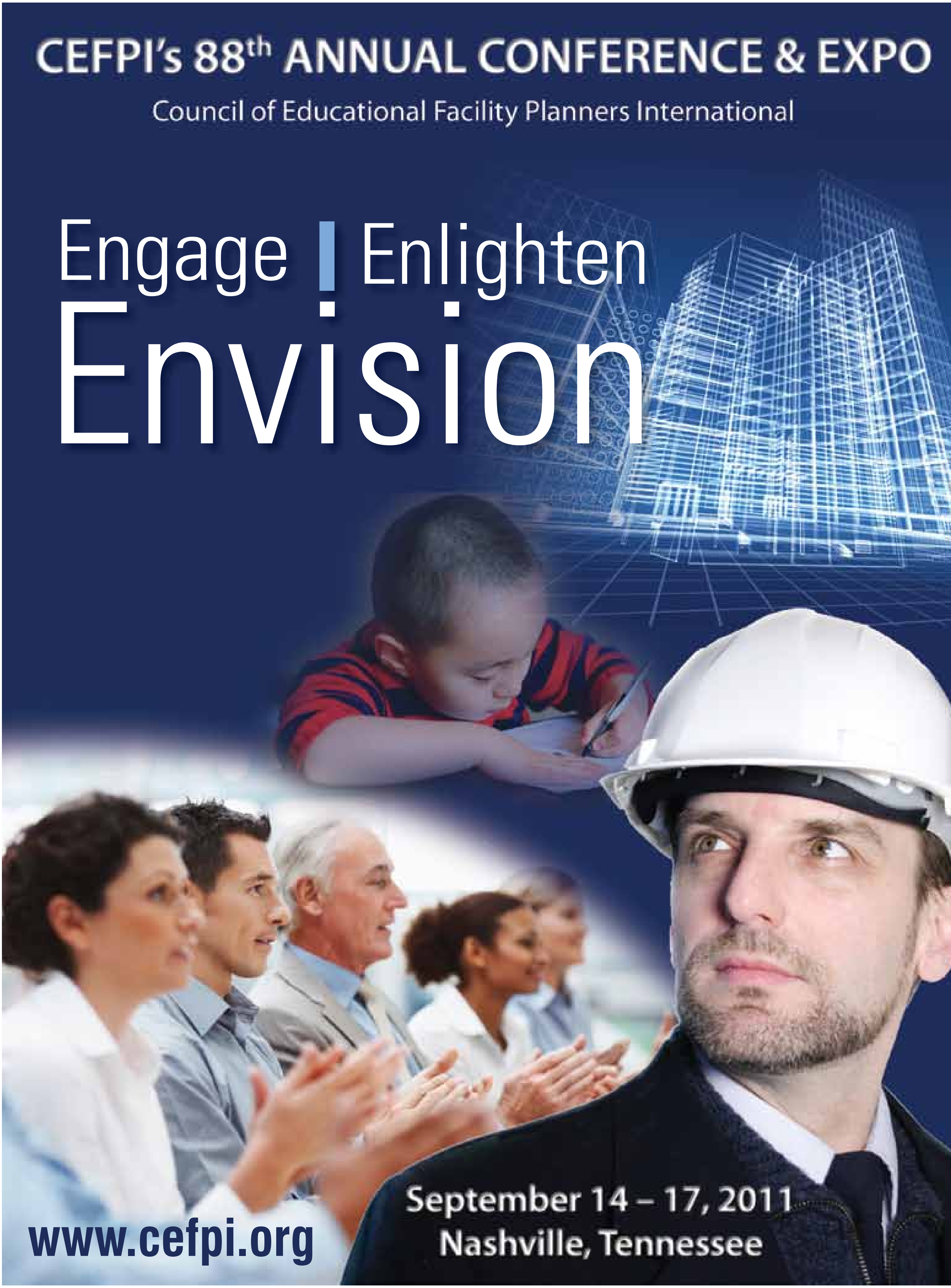
Engineer: *Duffy Engineering & Associates, Inc., St Cloud, Minn.*

Contractor: *Winkelman Construction, St Cloud, Minn.*

Owner: *Globe University*

Precaster: *Hanson Structural Precast, Salt Lake City, Utah*

The two-story, 30,000 square foot building is used for vocational and technical training. The college serves the greater Boise area. Precast concrete was used for both the structural system and the building's envelope. The aesthetic versatility of precast concrete allowed for several finishes to be combined into single panels. Formliners were used to create the split block-like stone at the base. The upper sections used a combination of thin brick embedded into the precast concrete and a light acid-etched finish.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Designing School Safe Rooms

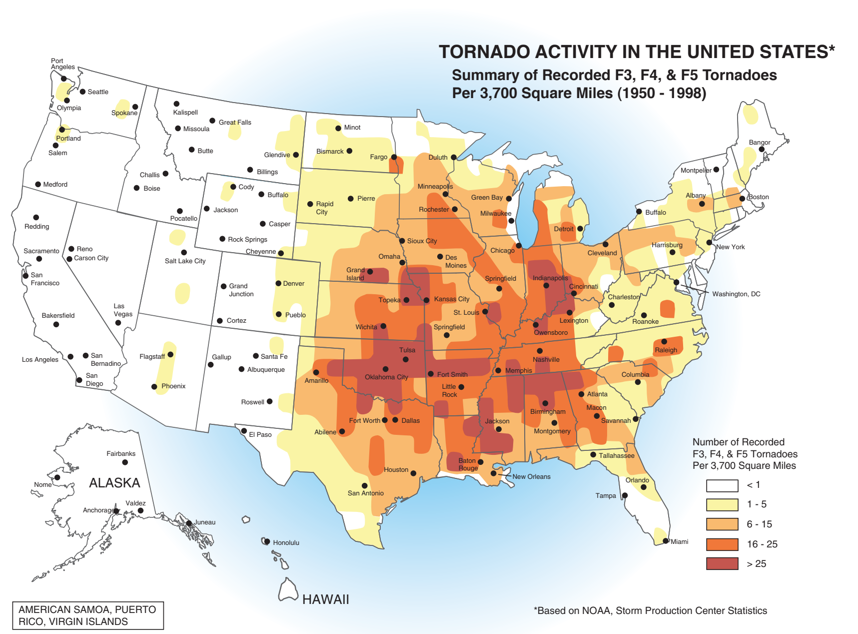
Creating safe havens in schools to protect against tornadoes can greatly aid communities while not blowing the budget if they are designed efficiently and early in the process

— By Brian M. Orr, P.E. and Brent M. Davis, P.E. S.E.

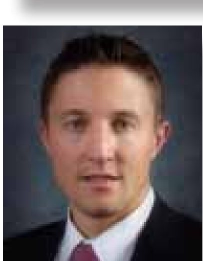
Recent devastating tornados in Missouri, Alabama and Mississippi have prompted school superintendents, public officials and building owners to more closely evaluate the benefits of incorporating tornado safe rooms into existing and new construction. These facilities can greatly aid local communities without drastically impacting the construction budget thanks to efficient design techniques and funding grants.

In addition to budget impacts, tornado safe rooms often don't receive sufficient consideration because they presumably require a "bunker" appearance due to the protection restrictions that eliminate fenestration and visual accents. This representation is untrue, as numerous safe rooms have been successfully constructed as gymnasiums, higher-education classroom buildings, performing-arts centers and community centers.

Typically, schools and other public facilities are not specifically designed to protect occupants from tornadoes. Designated shelter areas in these facilities are generally hallways or areas not designed to withstand high winds and wind-borne debris. Designing to accommodate these needs will add significant value to the facility that will benefit users and the community.



Tornado activity occurs throughout the eastern half of the United States but particularly in the Midwest and South.



– Brian M. Orr, P.E., and Brent Davis, P.E. S.E. are structural engineers with Toth and Associates in Springfield, Missouri. They have successfully designed and prepared grant applications for countless safe rooms across the Midwest.

Design Requirements

Code requirements for Safe Rooms include FEMA 361—Design & Construction Guidance for Community Safe Rooms, ICC-500—Standard for Design & Construction of Storm Shelters, and the locally-adopted building code. Section 423 of the 2009 International Building Code requires that shelters (and safe rooms) be built in compliance with ICC-500.

The publications' intent is to minimize the probability of death and injury during an extreme wind event by providing near-absolute protection for occupants of safe rooms. Also, if federal grant funding is involved, the plans must undergo a peer review along with a plan review by FEMA to ensure plans and specifications are in accordance with all code requirements.

To be sure, the design requirements of a safe room go above and beyond standard building design. Depending on the geographic location, design wind speeds range from 130 mph to 250 mph, and the facilities are required to meet specific flying-debris or missile-impact criteria. In the Midwest, where tornadoes are more prevalent and intense, safe rooms are designed for a 250-mph wind speed or the equivalent of an EF5 tornado (see chart).

The Dallas County School District in Buffalo, Mo., created a FEMA safe room for students during construction that added onto its gymnasium.

Design requirements create many potential challenges for the secondary use of the safe room.

Other code requirements include a 100-pound-per-square-foot roof live load and modified load factors for load combinations, including wind effects. In addition to more stringent design requirements, a quality-assurance plan that incorporates Special Inspections is required during construction.

The size of a safe room is determined by the surrounding or target population. Codes require a minimum of 5 square feet of open space per person (10 square feet for wheelchair-bound and 30 square feet for bedridden) along with provisions for restrooms, backup power source, storage area and mechanical area. The target population for a community safe room is a 5-minute walking radius of the facility, or it can be limited to concentrated population centers, such as schools or higher-education facilities. The radius cannot exceed ½-mile in any direction. In addition, natural barriers, such as railroad crossings, creeks and highways, can limit the target population area.

Design Challenges

Design requirements create many potential challenges for the secondary use of the safe room. Challenges include daylighting, acoustics and overall aesthetic appearance. All openings and penetrations in the building envelope are required to meet the missile-impact criteria for the design wind event.

Providing glass that meets the requirements can be cost-prohibitive, but providing standard storefront glass with FEMA-rated door assemblies to act as storm shutters can reduce the budget impact of providing natural light. The hard materials such as concrete or CMU required to construct safe rooms can lead to poor acoustics in an open facility such as a gym or performing-arts center. Softer materials, including acoustical panels, drapes and gypsum soffits, can help improve acoustics.

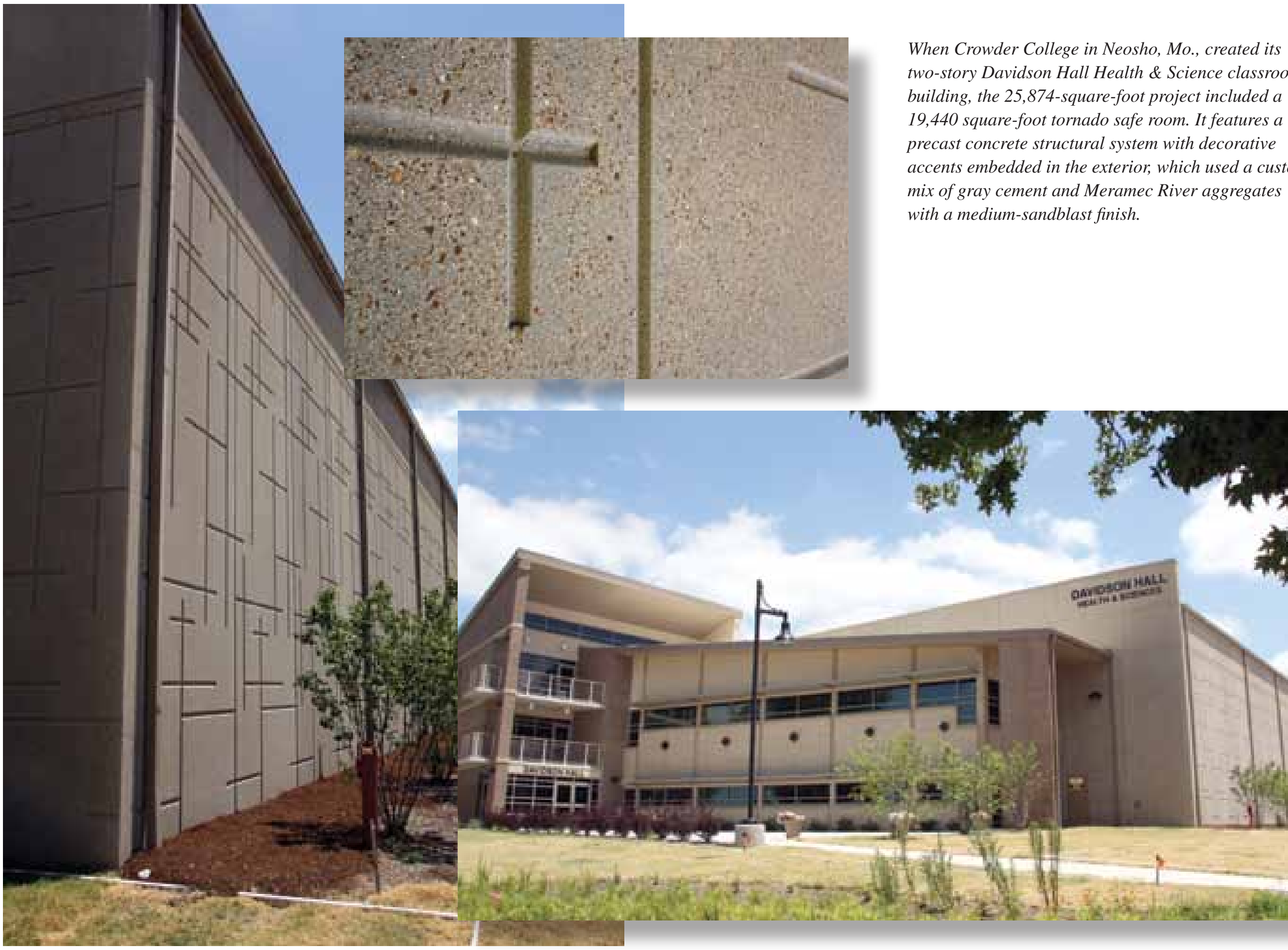
The gym features a Frezno Trowel finish on the exterior of its precast concrete walls and a Steel Form finish on the exterior. The panels were cast by Prestressed Casting Co. in Springfield, Mo.

Aesthetic challenges vary by the type of construction materials and the project's overall size. If the safe room is part of a larger project, the protected area can be incorporated within the new facility. If a stand-alone facility is planned, the choice of

Tornado Frequencies in the United States, 1950-2006

F Scale	Number of Tornados	Percentage of Total
F0	20,728	43.68%
F1	16,146	34.03%
F2	7,944	16.74%
F3	2,091	4.41%
F4	491	1.03%
F5	50	0.11%
Total	47,449	

Source: FEMA, 2008



When Crowder College in Neosho, Mo., created its two-story Davidson Hall Health & Science classroom building, the 25,874-square-foot project included a 19,440 square-foot tornado safe room. It features a precast concrete structural system with decorative accents embedded in the exterior, which used a custom mix of gray cement and Meramec River aggregates with a medium-sandblast finish.

Designing safe-room doors and windows often frustrates designers.

construction materials grows in importance. Variations of CMU construction can be used, or precast concrete, which provides a great array of aesthetic options including different colors, forms, and textures, as well as veneered materials, such as brick or stone.

LEED certification, a growing desire for school administrators, creates another challenge for safe-roof design. While certain aspects of these designs can negatively impact the ability to meet LEED standards, such as daylighting, others offer huge advantages, such as energy efficiency through thermal mass, local materials, and recycled content. As with any construction project, a FEMA tornado safe room can achieve LEED certification with careful planning. A recently-completed safe room in the Midwest, which Toth and Associates was involved with, is in the process of being certified by LEED, with a Gold rating expected.

Typical Construction

Building-envelope requirements lead to facilities often constructed with precast concrete wall panels and double-tee girders for roof structures. Historically these have provided a cost-effective method of construction. Specifying certified precast concrete ensures a known quality-control process will be used (a requirement) and construction time can be better minimized and quantified. Another popular approach is concrete masonry-unit walls with a concrete-topped system of steel beams and metal deck. Other construction types have been used, including monolithic domes and cast-in-place concrete, but they are not as common.

When designing with precast concrete, the design team should consult with the local precaster prior to finalizing the layout. While the design process is the same as with a traditional project, typical connections or layouts may not work under the safe-room design criteria due to the extreme loads that are required. For example, a double door usually cannot be placed in a single panel, as the door must be centered on a panel joint. In addition, specific considerations are required for the uplift of the roof members to the wall panels and for transfer of the uplift and shear loads into the foundations.

While safe rooms can be located immediately adjacent to existing structures, it is recommended that they be separated from adjoining facilities with a non-FEMA rated connector installed between the buildings. This can eliminate the use of property-line foundations and avoid impacting the existing foundation, as the safe-room foundation loads are typically three to five times higher than traditional structures. With a creative design, the connector can be used to allow natural light and additional architectural features that complement the safe room's appearance and help it fit in with nearby buildings. The safe room also must be designed for the collapse load of all non-FEMA 361 buildings located nearby.

The design team has to consider how to provide and protect a back-up power source from the force of the tornado as well. Typically, a generator is installed and enclosed within a structure similar to that of the safe room. The fuel source also has to be protected, including any gas meters, a key element that often is overlooked by first-time designers. Some designers provide battery backups to avoid the cost of the generator and generator enclosure.

Designing safe-room doors and windows often frustrates designers. Fortunately, manufacturers are offering more products that comply with FEMA design guidance as more safe rooms are constructed. Careful consideration should be given to the specification of doors and windows, as FEMA does not approve or certify safe-room assemblies. The products have to meet stringent laboratory-test requirements outlined in the codes pertaining to safe rooms.

Fujita Tornado Damage Scale

EF0 Light: Chimneys are damaged, tree branches are broken, shallow-rooted trees are toppled.

EF1 Moderate: Roof surfaces are peeled off, windows are broken, some tree trunks are snapped, unanchored mobile homes are overturned, attached garages may be destroyed.

EF2 Considerable: Roof structures are damaged, mobile homes are destroyed, debris becomes airborne (missiles are generated), large trees are snapped or uprooted.

EF3 Severe: Roofs and some walls are torn from structures, some small buildings are destroyed, non-reinforced masonry buildings are destroyed, most trees in forest are uprooted.

EF4 Devastating: Well-constructed houses are destroyed, some structures are lifted from foundations and blown some distance, cars are blown some distance, large debris becomes airborne.

EF5 Incredible: Strong frame houses are lifted from foundations, reinforced concrete structures are damaged, automobile-sized missiles become airborne, trees are completely debarked.

Secondary Uses

A safe room's main function is to protect occupants from extreme environmental events, but the secondary use can be just as important to the owner, especially in mitigating budget costs. Secondary uses of safe rooms include (but are not limited to) gymnasiums, cafeterias, band rooms, classroom buildings, park facilities, and community centers.

Integrating a secondary use provides multiple benefits. The safe room can be used every day and not forgotten, ensuring everyone is comfortable with its use and knows its location. Specific maintenance costs are eliminated, as the safe room is part of everyday operations. Incorporating the facility into a larger project can help reduce out-of-pocket cost and possibly allow for other construction that could not be funded if a standalone safe room was created. The key benefit is that a refuge is specifically created for building users and the community rather than requiring them to gather in an area simply designated as least likely to fail.

Federal-grant opportunities can help cover costs for the design and construction of safe rooms.

Safe Room Costs

Many factors influence the cost of a safe room. Key factors include number of uses, design simplicity, wind-speed design, debris-impact criteria, exterior wall and roof materials, and location with regard to foundation and site-development requirements. Costs generally range from \$150-\$240 per square foot, depending on geographic location and the secondary use.

The absolute range is much wider; safe rooms have been constructed for as little as \$90 per square foot and as much as \$490 per square foot. The increase in cost for constructing a structural system and building envelope that withstands 250-mph design wind speed rather than a standard 90-mph design wind speed is about 20% to 32%.

The impact on overall project cost is much higher for standalone safe rooms than for safe rooms incorporated into larger projects. The most cost-effective means of constructing a safe room is to incorporate it into a new facility in the initial planning stages. The relative cost per square foot for safe rooms included as a part of a building project is higher than typical construction due to the life-safety protection being provided. For large new building projects, however, the percent increase in overall project cost is quite small. Many safe rooms constructed as part of a new school add only 1 to 2% to the total project cost when the safe room is included in the design process from the beginning.

Federal Grants Available

Federal-grant opportunities can help cover costs for the design and construction of tornado safe rooms along with hurricane shelters. Grants can cover up to 75% of the FEMA-approved costs of a safe room. While various federal funding opportunities exist, there are two main avenues for public entities to pursue funding.

The first is the Pre-Disaster Mitigation (PDM) grant program, a nationally-competitive funding source. The other is the Hazard Mitigation Grant Program (HMGP), which is competitive at the state level and is funded based on declared disasters within a state. To determine if funds are available at a specific project site, contact the State Hazard Mitigation Officer or a local grant writer specializing in these grants.

Earlier this summer, our engineering firm created bid information for a tornado safe room designed to meet

This cutaway BIM drawing shows a gymnasium with a total-precast concrete structural system designed as a FEMA safe room for the Marquand Zion School District in Marquand, Mo. The 1,400-square-foot, two-story addition on the side of the 8,000-square foot gym qualifies as part of the safe room but contains restrooms below and mechanical systems above that feed into the gym. Photo: Toth and Associates

This BIM drawing shows the FEMA safe room designed for the Nixa School district in Nixa, Mo. Originally planned as a 10,000-square-foot building constructed of block and bar joists, Toth and Associates redesigned it as a total-precast concrete structure to convert it into a FEMA safe room eligible for federal funding. Only 4,000 square feet qualified for funding, but that savings, combined with cost efficiencies of the precast concrete design, made the new plan cheaper while also providing the safe-room benefits. BIM drawing: Toth and Associates

FEMA 361 as part of a new middle school being constructed in the Midwest. The safe room is approximately 12,000 square feet, and will be constructed with 12-inch-thick precast concrete wall panels and a double-tee roof structure. A bid alternate also was provided that consisted of 8-inch-thick precast concrete wall panels with a bar-joist and acoustical-deck roof system.

The low bid for the safe room was $1.79 million, or $149.17 per square foot, while the bid alternate was $1.38 million, or $115.00 per square foot. To offset the increased construction cost for the safe room, the school district applied for a safe-room grant under HMGP. The grant will cover up to 75% of FEMA-approved construction items.

It is estimated that the school district's portion of the safe-room construction will cost about $716,000 or $60 per square foot. This represents a cost savings of $664,000 to the owner over conventional construction for this same facility while providing added benefit of a community safe room designed to withstand 250-mph wind speeds. The owner's share for the project is estimated to be approximately 40% of the overall project cost, which is typical for similar projects.

These grants make a compelling case for architects to broach the subject of providing a tornado safe room within a school project if administrators don't request it on their own. Safe-room grants not only can reduce construction costs, allowing funds to be shifted to other areas, but they help create a safer structure providing added benefits to the community. Being aware of design and funding techniques provides designers with a significant value-added design element to offer to clients. ■

More Information

To learn more about requirements for FEMA safe rooms, visit:
http://www.fema.gov/plan/prevent/saferoom/index.shtm

http://www.fema.gov/plan/prevent/saferoom/fema361.shtm

To learn about grant programs, visit:
http://www.fema.gov/plan/prevent/saferoom/srfunding.shtm

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Total-Precast System Creates LEED-Certified School

Precast concrete insulated sandwich wall panels and double tees create new facility adjacent to existing one, boosting energy efficiency, lowering maintenance costs, and improving air quality

— By Craig A. Shutt

The usual demands of constructing a new high school building—including a tight budget and air-tight scheduling—weren't the only challenges that had to be met in designing the new Riverside High School in Greer, South Carolina. Once administrators decided to start from scratch and build a new facility, they wanted to incorporate as many sustainable-design concepts as possible. The result was one of the first LEED-certified high schools in the country, built with a total-precast concrete structural system and panels.

The process was complicated by two factors. As always, the transition from the existing school term to the new one had to be completed seamlessly during the summer, so students could leave one school and enter the new one as the school year began without disruptions.

In addition, the project began as a massive renovation and addition to the existing school. But halfway into the design process, administrators realized that the cost to renovate and add to the existing building was approaching that of a new building. "They decided that it made better business sense to replace the high school with a completely new one and take advantage of more sustainable-design concepts in siting and design, which could offset some of the costs long-term," explains Richard Powell, project manager at BPRH Architects-Engineers, Inc. in Atlanta.

That provided a more controlled approach, but a lot of time had been lost in the meantime and would require a second building to be placed on the site. That added more challenges, says Herb Marshall, project manager at M.B. Kahn Construction Co. in Greenville, South Carolina. "We basically had to shoehorn a full-blown, 4A high school for 1,500 students onto a site with an existing school already there while the school's day-to-day events and extracurricular activities continued unaffected by construction activity."

The new Riverside High School in Greer, S.C., was changed from a major renovation into a project built from scratch after design work showed remodeling costs were exceeding budget. The new school, featuring a total-precast concrete structural system and panels, was built adjacent to the existing school, where class remained underway.

Siting Challenges Arose

To segregate the old and new, designers sited the new 268,000-square-foot, two-story facility into space being used for parking. Even so, a new auxiliary gymnasium bumped against the existing school building. To accommodate construction, the new gym was left unbuilt until the rest of the new school was completed. Once the rest of the facility was ready for occupancy and the school year began, the original school was demolished. Once it was out of the way and grading was completed for parking and tennis courts, the new gym was built.

The classroom design was modified from a straight wall to a sawtooth design that ensured that each room featured fenestration that opened to the southwest or southeast.

'The precast concrete helped make up a lot of time during construction that kept us on schedule.'

This phased approach was possible in part due to the structural design, which consisted of load-bearing precast concrete insulated sandwich wall panels and long double tees. Field-topped floor double tees and untopped roof double tees used the exterior walls and interior corridor walls for load-bearing support as well as for shear walls for lateral stability. Precast concrete stair and elevator shafts also were included, providing a complete precast concrete structural system. Tindall Corp. of Spartanburg, South Carolina provided the precast concrete components.

"The precast concrete design was optimal because so much time was lost during the initial renovation planning," explains Powell. "It helped us make up a lot of time during construction that kept us on schedule. It also helped reach a lot of the sustainable-design goals that allowed us to achieve LEED certification."

The precast concrete design also gave the building's exterior a connection to the original high school. The finish features a low-maintenance design of sandblasted concrete with accent blocks of inlaid thin bricks. The bricks were chosen to replicate the color and texture of those used on the original high school. "The new building's walls went up right beside the existing high school's façade, so we could see that we made the right choice with the new bricks," Powell notes.

The panels consist of 2 inches of insulation sandwiched between a 3-inch exterior layer of concrete and a 5.5-inch interior layer to provide structural support for the double tees. The insulation layer was increased beyond what might be typical, Powell adds, to provide a higher R-value to meet LEED standards. The panels feature plastic wythe connectors to ensure continuous insulating value without any thermal breaks due to conductive connections.

Construction time also was saved with the sandwich panels by giving the interior layer of concrete a smooth, finished surface. It was simply painted with a heavy-duty paint to hide imperfections, which saved time and material that otherwise would have been spent on furring out and drywalling the interiors. The concrete surface also provides added impact resistance that will lower maintenance and replacement costs often needed with drywall.

The school's design consists of activity and mechanical rooms on one end of the structure, a central welcoming/administrative center, and classrooms on the other end. A courtyard runs through the center of the classroom wing, bringing daylight into the classrooms along the interior corridor. Rooms along the classroom wing's exterior wall were enhanced by a design change late in the program,

PROJECT SPOTLIGHT

Riverside High School

Location: *Greer, S.C.*

Project Type: *High school*

Size: *268,000 square feet*

Cost: *$36 million*

Designer: *BRPH Architects-Engineers Inc., Atlanta, Ga.*

Owner: *Greenville County School System, Greenville, S.C.*

Contractor: *M.B Kahn Construction Co. Inc., Columbia, S.C.*

Structural Engineer: *Professional Engineering Associates Inc., Greenville, S.C.*

PCI-Certified Precaster: *Tindall Corp, Spartanburg, S.C.*

Precast Components: *Sandwich insulated wall panels, field-topped floor double tees, untopped roof double tees, stairs and elevator shafts*

Thin brick embedded into the architectural panels used both for interior and exterior facings replicated the color and texture of those used on the original high school.

as the architectural team realized an alteration could have a big impact on the building's sustainable design.

Classroom Wing Revamped

The flat, straight exterior wall of the classroom wing was revamped into a stepped design with windows added on each step. The windows face either southwest or southeast, adding daylight. "Every classroom has daylight streaming in from the south with this change," Powell explains. "We believe very strongly that daylight is a motivating factor in learning for students, and we wanted to provide as much as possible."

Daylighting is controlled in some spaces, especially larger public areas, with monitors that track lighting levels. Spaces feature arrays of lights that can be cut back or turned on as needed. The system ensures lighting remains sufficient while taking full advantage of daylight as the first source for lighting. Fabric banners and clerestory windows help control daylighting to ensure heat levels don't build up. Occupancy sensors also are used to turn off lights when students leave.

'We believe very strongly that daylight is a motivating factor in learning for students.'

The public areas were aided by the precast concrete system, which provided clear, open spaces thanks to the double tees' long-spanning capabilities. "We created some very exciting public spaces by using the precast system to open them up,"

Putting the Green in Greenville Schools

Riverside High School is part of an ambitious $700 million green initiative in the Greenville School district to encourage the construction of green schools to both provide more sustainable design and also to serve as a teaching tool. In all, the program is aimed to replace or upgrade 70 school buildings.

The program is financed and directed by Institutional Resources (InRe), which provides protocols for the schools to follow to maximize efficiency and qualify for LEED certification.

The costs to include the various sustainable elements used in the high school are being offset in part by grants that could not have been earned otherwise, according to Andy Crowley, Riverside principal. "There are a lot of environmental-study grants out there that, in the past, we couldn't touch because the existing school didn't come close to meeting minimum efficiency requirements," he said when the school opened. "The grants we expect to get with LEED certification will definitely help offset the cost of attaining the certification. The results of LEED will far outweigh the costs in every aspect."

Powell says. "They allow us to take full advantage of daylighting and create welcoming rooms. The cafeteria and media rooms in particular are very popular meeting places and are very conducive to fulfilling their functions." In addition, the long-span double tees make it easy to adapt the spaces in the future as needs change and new equipment is brought in.

The use of long-span precast concrete double tees allowed for the creation of large open spaces for key gathering spaces, such as the auditorium and science lab.

Sustainability Concepts Used

A variety of efforts were made to meet LEED standards, incorporating a wide range of energy-efficient techniques and other sustainable-design concepts. Most dramatic were solar panels installed on the roof and a 5,000-square-foot green roof that was located on top of a first-floor room adjacent to the gymnasium's mezzanine.

The solar panels provide 550 gallons of pre-heated water storage for use in the kitchen and athletic locker rooms' hot-water system. Radiant-heat barriers also were added on the roof to reflect sunlight and reduce the heat load. Additional efficiency was created by using a series of five smaller boilers to provide heated water throughout the school, rather than one or two larger ones that would need to heat larger amounts of water with every hot-water need. This system reduces energy needs and provides hot water as needed in an efficient way.

The 5,000-square-foot green roof features a variety of plantings native to South Carolina as well as a bog pond to encourage plantings from nearby swamp areas. The space, which also includes a weather station, is used by the school as a teaching element for its agricultural classes.

Initially, the green space was planned for the upper roof alongside the solar panels, but it was moved to a more prominent and accessible location during the design process, Powell says. "On the upper roof, it couldn't be seen, and it was more difficult for students to access it. In its new location, it's a prominent feature that can be seen by fans in the bleachers during basketball games in the gym." The adjustment did not require any loading changes for the precast concrete double tees used to support it.

Construction Moved Smoothly

Erection of the precast concrete components moved smoothly despite the congested and active site, Powell says. "We had no problems during construction; it was a highly organized job site. We were very good neighbors to the existing school and its users."

The precast concrete structural

LEED Techniques

Riverside High School achieved LEED certification under the original system in which 26 points were required. The precast concrete structural system and insulated wall panels contributed to 23 of those points.

Among its contributions were energy efficiency, minimizing construction waste, use of recycled materials, use of local materials, local manufacture of products, meaningful recycling efforts during construction, and lessened impact on the environment during and after construction.

- Included in the sustainable-design features for the new school are:
- A waste-management system that recycles or salvages 50% of construction, demolition and land-clearing waste.
- Precast concrete insulated sandwich wall panels, which included 2 inches of insulation to provide an enhanced R-value.
- Solar panels to provide pre-heated water to the kitchen and athletic facilities.
- A green roof accessible to faculty and students.
- A reflective Energy Star roof that reduces heat emissions and provides R-30 insulation.
- Water systems designed to reduce water use by 20%.
- Light-well monitors that maximize daylight use for indoor lighting.
- Diffused-lighting system to prevent glare on neighboring properties, streets and the night sky.
- Use of low-VOC materials for adhesives, glues, paints, coatings and carpets.
- Use of 50% local and regional building materials within a 500-mile radius.
- Bicycle racks and a changing/shower room for bicyclists to encourage alternative-transportation methods.

Solar shields above windows help control daylight to ensure rooms stay bright but don't become too sunny or hot.

system played a significant role in that, he notes. The capability to cast components as foundation work progressed ensured that pieces were ready to be erected as soon as the site was ready. Trucks delivered each component to the site as needed along a segregated construction roadway away from the existing school, and the pieces were lifted from the truck and set in place.

The contractor shifted the precasting schedule, however, as the precast concrete was prebid and work was underway when the contractor was selected, Marshall notes. "They began casting the sawtooth classroom walls, but we needed them to first create the 'back of the house' elements at the other end of the school," he explains. Those spaces needed to be enclosed first so all of the equipment for the mechanical and electrical rooms and kitchens could begin work. We had to change the thinking quickly to ensure everything came together in the end."

Once those components were fabricated, the precasters returned to the classroom wing. "We essentially erected the two ends to meet together in the center," Marshall explains. "Classrooms are typically easy to finish." That doesn't mean the classroom wing didn't present challenges, he adds. "The sawtooth design complicated the erection. There weren't too many right angles anywhere in the school, and few parallel lines. It was more challenging than a typical school project usually is."

On-Time Opening

That effort paid off in a project that opened on-time with no disruptions to the school term. "Any time we can move load-bearing masonry away from the critical path of the project will likely improve the construction schedule," Marshall says. The schedule also was aided by the installation of precast concrete stairs and elevator shafts. The quick installation provided quick and easy access to upper levels, which also aided safety.

The precast helped the schedule further by being able to erect quickly through the winter to ensure the transition could take place over the summer. "Even in South Carolina, the cold and wet periods in the winter often aren't conducive to laying brick and block," says Marshall. "That's not a problem we have with the precast concrete panels. A big school project always moves faster with precast concrete."

The efforts also paid off in improved long-term energy efficiency. The school, possibly the first to achieve LEED certification when it was completed, has been returning impressive savings since. The combination of techniques, materials and products used to minimize energy use created a 30% to 40% savings in energy over a more traditional design, according to the LEED calculations done when the project was submitted, Powell says. "Everything factored into the savings, including the precast concrete structure."

School administrators are pleased with the decision to take this approach. "We're beside ourselves with the prospect of having a LEED-certified school that we know will benefit our environment, too," said Riverside principal Andy Crowley when the school opened. "As a country, we don't do enough of this." Adds Powell, "LEED construction is where the school industry is headed. This project exemplifies the potential in the school market and serves as an example for other designers to follow." ■

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

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  Level I/II
  September 14-16, 2011, Chicago, Ill.
  November 14-16, 2011, Nashville, Tenn.
- **Quality Control School**
  Level III
  September 13-16, 2011, Chicago, Ill.
  November 16-19, 2011, Nashville, Tenn.
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  November 14-19, 2011, Nashville, Tenn.
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High Performance Precast Insulated Sandwich Wall Panels

designer's**notebook**

High Performance Precast Insulated Sandwich Wall Panels

High performance buildings are designed to satisfy functional, human comfort, environmental and economic considerations. They incorporate the highest level of design, construction, operation and maintenance principles to provide maximum performance while meeting the owner's project requirements. All the components of the building should be addressed in a cohesive, whole building approach, taking into account cost effectiveness—particularly life-cycle costs, sustainability, security and safety, accessibility, productivity of occupants, functionality and serviceability, and aesthetics.

Whether derived from reduced energy and operating costs, lower maintenance costs, improved functionality or productivity, or continued operational capability after a catastrophic event, a high performance building offers its owners a greater return on investment than a conventional building. High performance precast insulated sandwich wall panels can provide significant contributions toward these goals. These panels are composed of two wythes of concrete separated by a continuous (edge-to-edge) wythe of insulation. Panels can be bearing walls, supporting gravity loads, as well as resisting wind, seismic, and blast loads, or they can be cladding panels transmitting wind, seismic, and blast loads to the structural frame and foundation. Sandwich wall panels provide a versatile and economical means to meet the structural, thermal, moisture, and architectural requirements of a structure.

Energy Efficiency. A high performance building must deliver better energy efficiency than a building meeting the minimum requirements of the governing energy code. A building's energy performance involves the interplay of the environmental (climate and weather), the building's systems (envelope, mechanical, plumbing, and lighting), and the building's occupancy (people, appliances, equipment, devices, and function). An energy efficient envelope is one that integrates and optimizes insulation levels, shading of glazing, solar reflectivity of exterior surfaces, air and vapor barriers, and thermal mass.

The interior and exterior concrete layers (wythes) protect the insulation layer against damage during construction. They limit the production of toxic gases during and after building fires and do not promote the spreading of flames to adjacent components. The concrete wythes are resistant to rodent, insect and impact damage, and they do not support mold growth. The insulation cannot shift or settle during or after construction, so there are no gaps in thermal protection. The concrete wythes provide excellent air barriers and limit air infiltration.

The thermal performance of edge-to-edge insulated precast concrete sandwich wall panels with no or minimal thermal bridges maintains the R-values for continuous insulation as defined by ASHRAE 90.1-2010[1], thereby lowering energy costs (Figure 1.) In some climates, increasing wall and roof R-values by as little as 5 can reduce energy costs by 5 to 20%.[2] High performance precast concrete sandwich wall panels commonly have steady state R-values ranging from 12 to 20 hr ft^2 °F/Btu. The thickness of the insulation is determined by the thermal characteristics of the insulating material and the thermal loads on the structure.

Specific wall thermal characteristics can be designed for each face of the structure to suit its sun orientation. Precast concrete cladding can be detailed with integral shading devices or deep window recesses to manage solar heat gain. They can also be detailed with shallow recesses or light shelves to maximize daylighting, significantly reducing reliance on artificial illumination and its associated energy costs.

A key benefit of a concrete structure is its "thermal mass", its ability to absorb and release heat. Concrete has a high specific heat, high density and low conductivity, therefore a large amount of heat energy can be absorbed with little change in temperature. The high thermal mass provides thermal storage, reducing daily and seasonal temperature swings, absorbing heat during the day in summer and cooling the building by storing heat from the sun over the surface of the building rather than allowing it to flow into the building. This cycle reverses at night, during the cooler time of the day, when heat is released back out into the atmosphere. By damping and shifting peak loads to a later time, thermal mass reduces peak energy requirements for building operations.

Figure 1 Insulated sandwich wall panel with continuous edge to edge insulation..

As an added benefit, indoor temperature fluctuations are reduced and occupant comfort is enchanced. The required capacity of the heating/cooling equipment is also reduced, lowering initial costs as well as ongoing operating costs since smaller equipment running continuously uses less energy than large equipment running intermittently. (See Designer's Notebook "Energy Conservation and Condensation Control", www.pci.org/publications.)

ASHRAE 90.1-2010 acknowledges the thermal mass benefits of concrete walls in specifying lower minimum insulation R-values and higher maximum wall U-factors for mass (concrete) wall construction in specific geographic areas. Thermal mass is not a total substitute for insulation. Although much of the heat stored in mass exterior walls is reradiated to the exterior of the building, some is also radiated to the interior. High performance precast concrete sandwich wall construction is an excellent way to combine mass and insulation in walls. The function of insulation is to form a zone with low thermal conductivity (high R-value) that slows transmission of heat energy through the building envelope. When used in the right combination, insulation and thermal mass, along with a building design that captures solar light and heat energy, can improve the thermal performance of buildings and lower overall energy requirements. Also, smooth steel trowelled interior concrete walls or ceilings can be painted or left bare to provide a clean, durable and mold resistant surface. Not only is less material used, but the exposed thermal mass elements can more readily absorb heat from the interior spaces and later release the heat in the evenings when buildings are not occupied.

Due to the thermal mass effect of high performance insulated sandwich wall panels, the effective whole wall R-value of the high performance wall system can be up to two times greater than that of the material (steady state) R-value, resulting in energy cost savings. The degree of improvement in R-value in a given structure is greatly dependent upon the climate (location), the occupancy type, the building orientation and other features of the building design.

A continuous air barrier is also important for building performance. Low air infiltration leads to reduced sensible and latent heat loads in summer and reduced sensible and latent heat demand in winter. Unfortunately, air infiltration is not readily modeled in many energy analysis tools, so air infiltration is often overlooked. However, concrete 4 in. or more in thickness functions as an air barrier and reduces air infiltration.

Solar reflectance index. The solar reflectance index (SRI), is the ratio of the amount of solar radiation reflected from a material surface to the amount that shines on the surface. It is measured on a scale of 0.0 (not reflective) to 1.0 (100% reflective). Concrete has the following SRI values:

Material surface	Solar Reflectance Index
Aged concrete	0.2 to 0.3
New concrete (traditional)	0.4 to 0.5
New concrete with white portland cement	0.7 to 0.8

Solar reflectance requirements for walls are contained in Section 5.3.2, Mitigation of Heat Island Effect of ASHRAE 189.1-2009, "Standard for the Design of High Performance Green Buildings". On exterior surfaces, SRIs above 0.3 (generally light colors) result in low solar heat gain. For instance, a low solar reflectance north wall and high solar reflectance east and west walls and roof form the most energy-conserving arrangement in a northern hemisphere climate that uses both heating and cooling. Changing an insulated wall from a low solar reflectance to a high solar reflectance can reduce annual cooling energy flux (heat flow through the building envelope). High solar reflectance surfaces are especially important where cooling dominates the energy requirements. It should be noted, however, that the solar reflectances of exterior walls will have less effect on energy consumption when the walls have high R-values and thermal mass. The benefit of high solar reflectance surfaces in decreasing cooling loads is often greater than the benefit of low solar reflectance surfaces in decreasing heating loads even in cold climates. This occurs because of the decreased benefit of the sun in the winter due to its low angle of incidence, shorter days, and cloudier conditions.

Commissioning. Green building rating approaches include prerequisites for minimum energy performance and may include commissioning to verify performance of building components and systems. Commissioning or the verification of how a building performs once the certificate of occupancy is issued is the only way to ensure the design and performance of the building is being maintained, therefore reducing energy and emissions. The commissioning process is outlined in ASHRAE Guideline 0-2005[3]: "The Commissioning Process." The National Institute of Building Sciences' (NIBS) Guideline 3-2006: "Exterior Enclosure Technical Requirements for the Commissioning Process"[4] describes the specific tasks necessary for implementation. The minimum energy performance prerequisite is a design submission item, meaning that the project can submit and earn approval of the prerequisite at the end of the design phase. Because the completed project may be slightly different than it was modeled, the measurement of energy consumption should be conducted over time. This will be a requirement of the International Green Construction Code.[5] The first step of any energy audit or commissioning should be thermal imaging of the building envelope to verify actual building performance and compliance with owner's project requirements. Thermal imaging includes an infrared survey of the exterior walls, windows (from both the outside and inside), and roof to locate thermal bridges or breaches in the air barrier. Once the high performance building is thermally efficient, the next step in the energy auditing process should be to evaluate HVAC, plumbing, electrical power, lighting, and building equipment and systems. This analysis should

Figure 2 Thermographs of a high performance precast building show that the exterior concrete surfaces have a nearly uniform temperature, verifying the lack of thermal bridges or air leaks. Only the windows and parapet areas show higher local temperatures.

consider optimization, not just proper operations. ASHRAE Guideline 32P, "Sustainable High Performance Operation and Maintenance" provides guidance on optimizing operation and maintenance of buildings to achieve the lowest economic and environmental life cycle cost without sacrificing safety or functionality. In addition, the building should be properly pressurized and the HVAC dehumidifying properly.

Thermal imaging or infrared thermography of a building envelope provides a visual representation of temperature differences which allows for the analysis of heat losses. It makes it possible to immediately detect air or water leakage pathways, as well as identify thermal bridges caused by conductive materials or a lack of insulation (see Figure 2.) An infrared survey is a relatively inexpensive process to perform, but is infrequently done. Instead, the focus is on the mechanical and electrical systems within the buildings.

Reduced Life Cycle Costs. Making full life-cycle costs of a building project part of the cost benefit analysis will provide a major step towards a unified approach for the construction of high performance buildings. Life-cycle costing is a sound means of assessing the cost of all elements involved in constructing and operating a building throughout its life so that rational economical choices can be made. Energy and maintenance costs can be significant over a building's life, so the owner and designer should consider the long-term impact of these costs throughout the design process.

Precast's speed of erection helps bring the structure on-line quickly as high performance wall panels can be preglazed at the plant or window installation can be immediately completed in the field resulting in quick enclosure of the shell in any weather condition. Faster completion reduces interim financing and construction management costs, results in earlier cash flows, and produces other economic benefits. Loadbearing architectural precast concrete walls support floor loads and simultaneously form the exterior finish of the building, eliminating the redundancy between exterior finish and structural components. This ultimately lowers the building's long-term overall cost and can make the use of precast concrete more economical. Cost savings are greatest for low to mid-rise structures with a large ratio of wall-to-floor area.

Precast concrete manufacturing cost efficiencies have made precast concrete walls and structural systems very competitive. The cost advantages shift strongly to precast's favor when the long-term benefits are factored in. Due to precast's high durability, a high performance precast concrete structure can be designed to match the intended life of a building with minimal maintenance, providing substantial long-term savings. Because precast concrete panels are normally large, the quantity of joints in the building is reduced. Fewer joints reduce the life-

Figure 3 The insulated sandwich wall panels of the high school media center allowed the interior finish to be exposed painted precast concrete..

cycle cost of replacing joint sealants and add value to the client's project. Typically, the only maintenance precast concrete panels require is recaulking (service life of caulking depends on sealant material, installation, and exposure conditions). Joint sealants should annually be inspected and repaired if necessary. Precast concrete panels present a durable, aesthetically pleasing exterior surface that is virtually air and watertight and does not require painting. Within a building's interior, precast insulated sandwich wall panels provide a finished steel trowelled surface that doesn't require furring or drywalling after installation, eliminating some interior work. They can be left exposed or painted (Figure 3.) They also eliminate the need for separate insulating and finish subcontractors. Integral finishes not only result in a savings of material and labor, but also reduce the overall thickness of the exterior wall, permitting maximum interior space utilization.

Design Flexibility or Functionality. In building practice, the most economical application of precast concrete wall units is as loadbearing structural-aesthetic components. The loadbearing units become an integral part of the structure, transferring loads to the foundation, including gravity loads from the floors and roof and lateral forces from the effects of wind or seismic events. Such an arrangement can be economical, not only from a structural design viewpoint, but also from the viewpoint of overall construction. The loadbearing elements also provide for the horizontal stability of the building.

From a design perspective, the greatest advantage of a loadbearing precast concrete system is the flexibility it provides for space planning as it allows interior space to be unencumbered by a multitude of perimeter columns. Large open floor plates can then be accommodated quite easily offering great flexibility in marketing the space.

Figure 4 Electrical conduit and outlet box being installed in insulated sandwich wall panel.

Combining loadbearing wall panels with an economical precast structural floor system creates long, clear unobstructed spans with large, open bays with interior heights up to 55 feet. In most cases, the height is restricted only by what can be transported and delivered to the site. For offices, 45 to 50 foot spans are optimal because beyond that length, bays become so deep that daylighting is compromised.

With early coordination, panels can be designed with electrical conduits and outlet boxes cast right into the panel, eliminating additional interior furring and material (Figure 4.) This decreases trade overlap problems and eliminates unsightly surface mounted materials and the need for a separate wall cavity. Field labor costs are reduced, as installations can be completed simply by pulling the wires, installing fixtures and covering the boxes.

The integration of architectural and structural precast concrete offers an aesthetically pleasing and structurally efficient marriage. It allows the precast insulated sandwich panels to serve structural functions, limiting the need to incorporate multiple materials and trades.

Precast concrete walls usually do not need additional treatments to provide adequate sound insulation, as mass is concrete's greatest asset when used as a sound insulator. Table 1 presents the acoustical ratings of various solid flat precast concrete panels. The STC of a sandwich panel is about the same as the STC of a wall with a thickness equal to the sum of the two concrete wythes (ignoring the insulation). The opaque portion of a high performance wall should have an STC of 50[5].

Figure 5 Insulated sandwich wall panels provided excellent protection from hurricane force winds and flying debris.

Table 1 Sound Transmission Class (STC) and Outdoor-Indoor Transmission Class (OITC) of Precast Concrete

Description	STC (OITC)
4 in. flat panel, 54 psf	49 (43)
5 in. flat panel, 62 psf	52[1]
6 in. flat panel, 75 psf	55 (46)
8 in. flat panel, 95 psf	58 (50)
10 in. flat panel, 125 psf	60[1]

1. Estimated values

Life Safety/Environmental Conditions. A high performance building must assure the continued operational capacity and performance of a facility after natural disasters or manmade catastrophic events. For example, the Gulfport Federal Courthouse Figure 5, constructed of a concrete frame with architectural precast concrete cladding panels, sustained 130 mph winds and the storm surge from Hurricane Katrina with no damage to the precast. Water reached a level of 2 feet in the courthouse, which is about 28 feet above sea level. There was evidence of impact damage from floating debris to the granite cladding at the base of the building. However, the precast concrete panels behind the granite were unaffected by these forces, as the outer wythe of the integrally insulated walls provided excellent protection from any flying debris during high winds. Courthouse employees were able to return to work soon after the interior had dried.

In the interest of life safety and property protection, building codes require that resistance to fire be considered in the design of buildings. Precast concrete panels are inherently non-combustible and do not serve as fuel or contribute to the fire load. The panels can be designed to meet any degree of fire resistance that may be required by building codes or insurance companies. Precast concrete eliminates the need for and cost of additional fireproofing measures. The insulation is protected by the concrete and also does not contribute to the fire load. Also, the danger of toxic fumes caused by burning of cellular plastics is practically eliminated when the plastics are completely encased within concrete sandwich panels.

Insulated precast concrete walls provide structural integrity and security, plus an added measure of fire safety. The fire resistance of insulated sandwich wall panels is conservatively equivalent to the fire resistance of a solid panel with a thickness equal to the sum of the thickness of the two wythes. Fire ratings of one, two, three or more hours can be achieved by varying the thickness of the wythes (Table 2.)

Table 2 Thicknesses of Concrete Wall Panels for Various Fire. Endurances Based on Results of Fire Tests

Aggregate	Thickness in inches for various fire endurances			
	1 hour	2 hour	3 hour	4 hour
All lightweight	2.5	3.6	4.4	5.1
Sand-lightweight	2.7	3.8	4.6	5.4
Carbonate	3.2	4.6	5.7	6.6
Siliceous	3.5	5.0	6.2	7.0

In today's environment of enhanced risk, some facilities require protective design and management for risk of intentional and accidental explosions. Solid architectural precast concrete and precast, prestressed concrete insulated sandwich wall panels can provide a significant level of protection from blast loads. Insulated sandwich wall panels have been tested at Tyndall Air Force Research Laboratory in Panama City, Florida with a combination of standoff distance and amount of explosive. Results provided valuable information concerning precast insulated sandwich panels' ability to withstand explosive blasts. For more information on the insulated sandwich wall panel tests performed by the Air Force, visit www.pci.org/ascent, winter 2011.

Indoor Air Quality. Condensation control and mold prevention focuses on preventing infiltration (which can carry significant amounts of water vapor) through the building envelope, interrupting water-vapor diffusion, typically by using a vapor retarder, and maintaining temperatures above the dew point for surfaces exposed to moisture, typically by installing insulation or increasing circulation of warmer air. Guidance on design for mold avoidance is available in Designer's Notebook "Avoidance of Mold" at www.pci.org/publications.

A concrete panel with concrete on the indoor surface generally serves the dual function of primary air barrier and vapor retarder, eliminating the need for additional materials required with other façade systems. By using edge-to-edge, closed-cell foam insulation in high performance precast concrete sandwich wall panels, the primary vapor retarder is prevented from reaching the temperature at which condensation may occur, thereby reducing the potential for mold. The insulation also resists moisture and provides a barrier to liquid and vapor transfer through the wall. The dewpoint temperature will usually fall within the insulation. For cooler and freezer structures, it may be desirable to add a vapor retarder rolled and pushed in joint or add moisture resistant fire rated expandable polyurethane foam-in-place insulation in the joint. Insulation and a moisture and air-barrier system are critical parts of a high performance building envelope. Depending on its thickness, concrete is either a semi-impermeable or semi-permeable vapor retarder; thicker and drier concretes are more impermeable.

Because of its panelized construction, fewer points of potential moisture penetration exist with precast concrete. Fewer joints help control moisture and eliminate the possibility for mold growth from water that may penetrate walls. Precast concrete is not a food source for mold as it is not organic. As a result, it does not promote mold growth, even if wetted.

Concrete has low volatile organic compounds (VOC) emittance and no off-gassing that can cause deteriorated indoor air quality. ASHRAE Guideline 10-2011 "Interactions Affecting the Achievement of Acceptable Indoor Environments" summarizes available knowledge on the complexity of the indoor environment and its impact on building occupants.

Durability. Precast concrete wall panels provide proven long-term durability. They provide a façade that is exceptionally resistant to impact, break-ins, corrosion, weathering, abrasion, and other ravages of time, making it virtually maintenance-free and resulting in preservation of the building's original look. High performance insulated precast concrete wall panels are strong enough to withstand high winds and wind driven projectiles, hurricanes and wildfires. The high strengths and low water-cement ratios used in the precasting process, combined with proper compaction and curing in a controlled factory environment ensure a dense, highly durable concrete. Low water-cement ratio concrete has been proven to resist weathering and corrosion of embedded steel. Air-entrainment is used to improve freezing and thawing resistance, particularly in severe environments.

Precast concrete also creates a durable interior wall that can be finished to provide a distinctive and aesthetically pleasing look. At the same time, the wall features a surface that will not be dented, punctured, corroded, rusted or otherwise damaged by heavy-duty use or equipment. Damage-resistant interior steel-trowelled concrete walls can accept direct-applied coverings, coatings or paint to minimize interior obstructions and fit-out costs. Precast concrete resists abrasion and high-moisture atmospheres that can corrode metal. Panels can be cleaned easily, even with harsh chemicals and steam pressure, ensuring a clean, crisp, hygienic environment. Vermin and insects cannot destroy concrete because it is inedible.

High performance precast concrete insulated sandwich wall panels can provide an aesthetically pleasing durable exterior finish, a paint-ready, durable interior surface, and effective thermal and moisture protection for a building[6]. These durability advantages can reduce costs over the building's life—a great advantage to owners who understand the need to consider long-term costs during the design phase. High performance insulated precast concrete panels can provide a building with a long design service life (a minimum of 50 to 60 years) that far outpaces other façade designs due to their durable and low maintenance concrete surfaces.

Precast concrete has functional resilience due to its robustness, longevity, and durability combined with disaster resistance. This creates safe, secure, comfortable, and productive environments to live and work.

Aesthetics. Architectural precast insulated sandwich concrete panels provide the designer an unlimited vocabulary of design expression with visually interesting shapes that are functional in application and project an image of strength. Concrete offers limitless potential for the development and manipulation of massing, color, form, texture and detail.

The plasticity of concrete allows the designer to achieve a high level of detail in the profile, scale, and character of a building. Design flexibility is possible in both color and texture by varying aggregate and matrix colors, size of aggregates, finishing processes and depth of exposure. Combining different finishes using the same or different concrete mixes within a single precast concrete unit can provide additional flexibility.

Finishing techniques include sandblasting, acid etching, and retarding (exposed aggregate). Each technique renders a distinctly different appearance, and varying the aggregate exposure depth of any one of these finishing techniques changes the precast's surface appearance. In addition, color and/or texture can be altered even within a single panel. Employing standard or custom molded formliners is another effective and economical way to heighten aesthetic interest.

Thin brick, tile, terra cotta, or natural stone can be cast into the panel either as a feature or as an entire facing, increasing color options. Thin brick faced precast concrete gives the traditional appearance of brick while leveraging the strength, speed of enclosure and economy of precast concrete. Due to low absorption of thin brick, efflorescence is reduced or eliminated. In addition, inlaid thin brick precast concrete walls do not require periodic tuckpointing. Using cast-in thin brick precast concrete panels reduces the cost of coordinating numerous exterior wall subcontracting trades.

REFERENCES

1. ASHRAE 90.1, *Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, George, 2010, www.ashrae.org.
2. Marceau, Medgar L. and VanGeem, Martha G., *Modeling Energy Performance of Concrete Buildings for LEED-NC Version 2.2: Energy and Atmosphere Credit 1*, R&D Serial No. 2880a, Portland Cement Association, Skokie, Illinois, USA, 2007, 55 pages.
3. ASHRAE Guideline 0, *The Commissioning Process*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, Georgia, 2005, www.ashrae.org.
4. NIBS Guideline 3, *Exterior Enclosure Technical Requirements for the Commissioning Process*, National Institute of Building Sciences, Washington, DC, 2006. (see Journal of Building Enclosure Design, Winter 2008).
5. *International Green Construction Code*, International Code Council, Washington, DC, to be published in March, 2012 (Public version 2.0, November 2010 is available) (see www.iccsafe.org)
6. PCI Committee on Precast Sandwich Wall Panels, 2011. *State of the Art of Precast/Prestressed Concrete Sandwich Wall Panels*, Chicago, IL, PCI.

AIA Learning Units

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Instructions

Review the learning objectives below.

Read the AIA Learning Units article.

Answer the 12 questions at the end of the article and submit to PCI. Submittal instructions are provided on the Learning Units form. You will need to answer at least 80% of the questions correctly to receive the 1.0 HSW Learning Units associated with this educational program. You will be notified when your Learning Units are submitted to AIA.

Learning Objectives

After reading this article, readers will be able to explain solar reflectance index and its impact on heat island effect;

define requirements for a high-performance building;

identify ways to reduce life-cycle costs; and

describe the critical components of a high performance building envelope.

.

Ascent 2011 – High Performance Precast Insulated Sandwich Wall Panels

Name (please print): ______________________________

Company Name: ______________________________

Address: ______________________________

City: ____________________ **State:** __________ **Zip:** __________

Phone Number: ______________ **Email Address:** ______________________

Title: ______________________________

Background (circle one): Architect – Engineer – Business – Marketing/Sales – Finance – Other

1. Energy performance of a building involves which factors:
    a. Climate and weather
    b. Building envelope
    c. MEP systems
    d. Building occupancy
    e. All of the above

2. Increasing R-values of walls and roof can reduce energy costs by:
    a. 50%
    b. 40%
    c. 30%
    d. 20%

3. Thermal mass decreases energy requirements for building operations.
    a. True
    b. False

4 The minimum thickness of concrete necessary to function as an air barrier:
    a. 3 inches
    b. 4 inches
    c. 5 inches

5. Solar reflectance index requirements are contained in which ASHRAE publication:
    a. ASHRAE 189.1 - 2009
    b. ASHRAE 90.1 – 2010

6. Commissioning does not include which of the following:
    a. Proper operation of MEP equipment and systems
    b. Optimization of equipment and systems
    c. Envelope R-values
    d. Thermal imaging

7. Insulated sandwich wall panels can reduce life cycle costs by:
    a. Being used as loadbearing
    b. Minimizing maintenance
    c. Reducing the quantity of joints
    d. Utilizing integral finishes
    e. All of the above

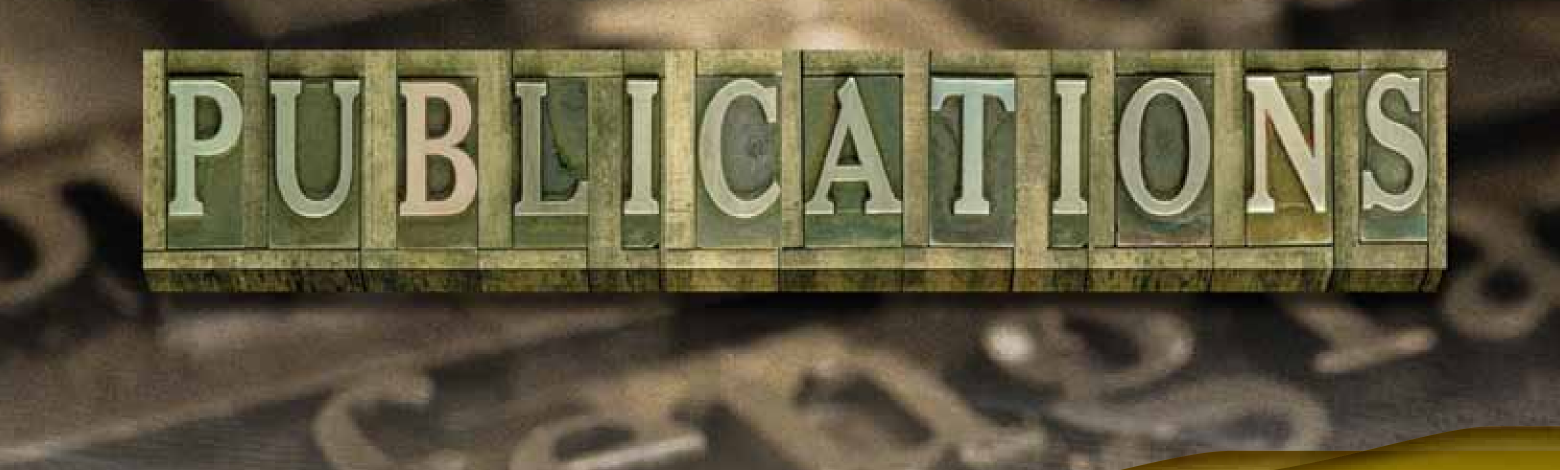
8. Early coordination allows electrical conduits and outlet boxes to be cast-in the panels.
   a. True
   b. False

9. The opaque portion of a high performance wall should have an STC of:
   a. 45
   b. 50
   c. 55

10. The danger of toxic fumes caused by the burning of cellular polymer insulation is eliminated when encased within concrete sandwich panels.
    a. True
    b. False

11. Concrete has high volatile organic compounds (VOC) emittance with off gassing which affects indoor air quality.
    a. True
    b. False

12. Precast concrete has functional resilience due to its robustness, longevity, and durability combined with disaster resistance.
    a. True
    b. False



New Publications from PCI

More Sustainable Than Ever: *Architectural Precast Concrete,* 3rd edition

This fully revised edition of *Architectural Precast Concrete* includes new sections on sustainability, condensation control, and blast resistance. You'll get extensive updates in the areas of color, texture, finishes, weathering, tolerances, connections, and windows, along with detailed specifications to meet today's construction needs. With more than 400 beautiful, full-color photographs and a bonus DVD, no architecture firm, design-build firm, or precaster should be without a copy.

Architectural Precast Concrete, Third Edition
MNL-122-07. ISBN: 978-0-937040-78-3
$180 / AIA Members $135 / PCI Members $90

Breaking Down the Code: *Seismic Design of Precast/Prestressed Concrete Structures*

This book provides engineers with approaches for applying the seismic design provisions of ACI 318-02, ASCE 7-02, and IBC 2003 to precast concrete structures. The authors examine various styles or classifications of precast concrete lateral force-resisting systems, review code and behavior requirements, and then apply these requirements to realistic examples. Included are examination of energy-dissipation, review of ongoing research, diaphragm design, and anticipated code developments.

Seismic Design of Precast/Prestressed Concrete Structures, First Edition
MNL-140-07. ISBN: 978-0-937040-77-5
$350 / PCI Members $175

Other Available Titles:

***PCI Design Handbook*, Seventh Edition**. The standard for the design, manufacture, and use of structural precast/prestressed concrete and architectural precast concrete.
MNL-120-10. ISBN: 0978-0-937040-87-4
$390 / PCI Members $195

***Manual for the Evaluation and Repair of Precast, Prestressed Concrete Bridge Products*, First Edition**. Includes information on imperfections or damage that can occur during production, handling, transportation, and erection.
MNL-137-06. ISBN: 0-937040-75-4 / 978-0-937040-75-9
$50 / PCI Members $25

***Recommended Practice for Glass Fiber–Reinforced Concrete Panels*, Fourth Edition**. Includes information on planning, preparing specifications, design, manufacture, and installation.
MNL-128-01. ISBN: 0-937040-67-3 / 978-0-937040-67-4
$30 / PCI Members $15

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PCI-Certified Plants

(as of July 2011)

When it comes to quality, why take chances? When you need precast or precast, prestressed concrete products, choose a PCI-Certified plant. You'll get confirmed capability—a proven plant with a quality assurance program you can count on.

Whatever your needs, working with a PCI plant that is certified in the product groups it produces will benefit you and your project.

- You'll find easier identification of plants prepared to fulfill special needs.
- You'll deal with established producers—many certified for more than 30 years.
- Using quality products, construction crews can get the job done right the first time, keeping labor costs down.
- Quality products help construction proceed smoothly, expediting project completion.

Guide Specification

To be sure that you are getting the full benefit of the PCI Plant Certification Program, use the following guide specification for your next project:

"***Manufacturer Qualification***: The precast concrete manufacturing plant shall be certified by the Precast/Prestressed Concrete Institute Plant Certification Program. Manufacturer shall be certified at time of bidding.

Certification shall be in the following product group(s) and category(ies): [Select appropriate groups and categories (AT or A1), (B1,2,3, or 4), (C1,2,3, or 4), (G)]."

Product Groups and Categories

The PCI Plant Certification Program is focused around four groups of products, designated A, B, C, and G. Products in Group A are audited to the standards in MNL–117. Products in Groups B and C are audited to the standards in MNL–116. Products in Group G are audited according to the standards in MNL–130. The standards referenced above are found in the following manuals:

- MNL–116 *Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products*
- MNL–117 *Manual for Quality Control for Plants and Production of Architectural Precast Concrete*
- MNL–130 *Manual for Quality Control for Plants and Production of Glass-Fiber-Reinforced Concrete Products*

Within Groups A, B, and C are categories that identify product types and the product capability of the individual plant. The categories reflect similarities in the ways in which the products are produced. In addition, categories in Groups A, B, and C are listed in ascending order. In other words, a plant certified to produce products in Category C4 is automatically certified for products in the preceding Categories C1, C2, and C3. A plant certified to produce products in Category B2 is automatically qualified for Category B1 but not Categories B3 or B4.

Please note for Group B, Category B1: Some precast concrete products such as highway median barriers, box culverts, and three-sided arches are not automatically included in routine plant audits. They may be included at the request of the precaster or if required by the project specifications.

GROUPS

GROUP A – *Architectural Products*

Category AT – Architectural Trim Units

Wet-cast, nonprestressed products with a high standard of finish quality and of relatively small size that can be installed with equipment of limited capacity such as sills, lintels, coping, cornices, quoins, medallions, bollards, benches, planters, and pavers.

Category A1 – Architectural Cladding and Load-Bearing Units

Precast or precast, prestressed concrete building elements such as exterior cladding, load-bearing and non-load-bearing wall panels, spandrels, beams, mullions, columns, column covers, and miscellaneous shapes. This category includes Category AT.

GROUP B – *Bridges*

Category B1 – Precast Concrete Bridge Products

Mild-steel-reinforced precast concrete elements that include some types of bridge beams or slabs, sheet piling, pile caps, retaining-wall elements, parapet walls, sound barriers, and box culverts.

Category B2 – Prestressed Miscellaneous Bridge Products

Any precast, prestressed element excluding super-structure beams. Includes piling, sheet piling, retaining-wall elements, stay-in-place bridge deck panels, and products in Category B1.

Category B3 – Prestressed Straight-Strand Bridge Members

Includes all superstructure elements such as box beams, I-beams, bulb-tees, stemmed members, solid slabs, full-depth bridge deck slabs, and products in Categories B1 and B2.

Category B4 – Prestressed Deflected-Strand Bridge Members

Includes all products covered in Categories B1, B2, and B3.

GROUP BA – *Bridge Products with an Architectural Finish*

These products are the same as those in the categories within Group B, but they are produced with an architectural finish. They will have a form, machine, or special finish. Certification for Group BA production supersedes Group B in the same category. For instance, a plant certified to produce products in Category B2A is also certified to produce products in Categories B1, B1A, and B2 (while it is not certified to produce any products in B3A or B4A).

GROUP C – *Commercial (Structural)*

Category C1 – Precast Concrete Products

Mild-steel-reinforced precast concrete elements including sheet piling, pile caps, piling, retaining-wall elements, floor and roof slabs, joists, stairs, seating members, columns, beams, walls, spandrels, etc.

Category C2 – Prestressed Hollow-Core and Repetitive Products

Standard shapes made in a repetitive process prestressed with straight strands. Included are hollow-core slabs, railroad ties, flat slabs, poles, wall panels, and products in Category C1.

Category C3 – Prestressed Straight-Strand Structural Members

Includes stemmed members, beams, columns, joists, seating members, and products in Categories C1 and C2.

Category C4 – Prestressed Deflected-Strand Structural Members

Includes stemmed members, beams, joists, and products in Categories C1, C2, and C3.

GROUP CA – *Commercial Products with an Architectural Finish*

These products are the same as those in the categories within Group C, but they are produced with an architectural finish. They will have a form, machine, or special finish. Certification for Group CA production supersedes Group C in the same category. For instance, a plant certified to produce products in Category C2A is also certified to produce products in C1, C1A, and C2 (while it is not certified to produce any products in Groups C3 or C4A).

Group G – *Glass-Fiber-Reinforced Concrete (GFRC)*

These products are reinforced with glass fibers that are randomly dispersed throughout the product and are made by spraying a cement/sand slurry onto molds. This produces thin-walled, lightweight cladding panels.

Visit www.pci.org for the most up-to-date listing of PCI-Certified plants.

ALABAMA
Gate Precast Company, Monroeville (251) 575-2803 — A1, C3A
Hanson Pipe and Precast Southeast, Pelham (205) 663-4681 — B4, C4
Standard Concrete Products, Theodore (251) 443-1113 — B4, C2

ARIZONAA
Coreslab Structures (ARIZ) Inc., Phoenix (602) 237-3875 — A1, B3, C4A
CXT Concrete Ties, Tucson (520) 644-5703 — C2
TPAC, Phoenix (602) 262-1360 — A1, B4, C4A

ARKANSAS
Coreslab Structures (ARK) Inc., Conway (501) 329-3763 — C4A

CALIFORNIA
Bethlehem Construction, Inc., Shafter (661) 391-9704 — C3A
Clark Pacific, Woodland (916) 371-0305 — B3, C3
Clark Pacific, West Sacramento (916) 371-0305 — A1, C3A
Clark Pacific, Fontana (909) 823-1433 — A1, C3A, G
Con-Fab California Corporation, Lathrop (209) 249-4700 — B4, C4
Con-Fab California Corporation, Shafter (661) 630-7162 — B4
Coreslab Structures (L.A.) Inc., Perris (951) 943-9119 — A1, B4, C4A
CTU Precast, Olivehurst (530) 749-6501 — C2
Hanson Structural Precast, Irwindale (626) 962-8751 — C4
Hanson Structural Precast, San Diego (619) 423-9030 — C4
KIE-CON Inc., Antioch (925) 754-9494 — B4, C3
Mid-State Precast, L.P., Corcoran (559) 992-8180 — A1, C3A
StructureCast, Bakersfield (661) 833-4490 — A1, B3, C3A
US Concrete Precast Group /dba Pomeroy, Perris (951) 657-6093 — B4, C2A
Walters & Wolf Precast, Fremont (510) 226-5162 — A1, G
Willis Construction Co., Inc., San Juan Bautista (831) 623-2900 — A1, C1, G

COLORADO
EnCon Colorado, Denver (303) 287-4312 — B4, C2
Plum Creek Structures, Littleton (303) 471-1569 — B4, C3A
Rocky Mountain Prestress, Inc., Denver (303) 480-1111 — B4, C4
Rocky Mountain Prestress, Inc., Denver (303) 480-1111 — A1, AT, C3A
Rocla Concrete Tie, Inc., Denver (303) 296-3505 — C2
Stresscon Corporation, Colorado Springs (719) 390-5041 — A1, B4A, C4A
Stresscon Corporation, Dacono (303) 659-6661 — C4A

CONNECTICUT
Blakeslee Prestress Inc., Branford (203) 481-5306 — A1, B4, C4A
Coreslab Structures (CONN) Inc., Thomaston (860) 283-8281 — A1, B1, C1
Oldcastle Precast, Inc./dba Rotondo Precast, Avon (860) 673-3291 B2, C1A
United Concrete Products Inc., Yalesville (203) 269-3119 — B3, C2

DELAWARE
Concrete Building Systems of Delaware, Inc., Delmar (302) 846-3645 B3, C4
Rocla Concrete Tie, Inc., Bear (302) 836-5304 — C2

FLORIDA
CDS Manufacturing Inc., Gretna (850) 875-4651 — B4, C2
Cement Industries, Inc., Fort Myers (239) 332-1440 — B3, C3
Colonial Construction, Concrete, Precast, LLC, Placida (941) 698-4180 — C2
Coreslab Structures (MIAMI) Inc., Medley (305) 823-8950 — A1, C4A
Coreslab Structures (ORLANDO) Inc., Orlando (407) 855-3191 — C2
Coreslab Structures (TAMPA) Inc., Tampa (813) 626-1141 — A1, B3, C3A
Dura-Stress, Inc., Leesburg (800) 342-9239 — A1, B4A, C4A
Finfrock Industries, Inc., Orlando (407) 293-4000 — A1, C4A
Florida Precast Industries, Inc., Sebring (863) 655-1515 — C2
Florida Rock and Sand Prestress Precast Co., Inc., Florida City (305) 247-9611 — B3, C3
Florida Rock and Sand Prestress Precast Co., Inc., Miami (305) 247-9611 B3
Gate Precast Company, Kissimmee (407) 847-5285 — A1
Gate Precast Company, Jacksonville (904) 757-0860 — A1, B4, C3
Metromont Corporation, Bartow (863) 440-5400 — A1, C3
South Eastern Prestressed Concrete, Inc., West Palm Beach (561) 793-1177 — B3, C3
Stabil Concrete Products, LLC, St. Petersburg (727) 321-6000 — A1
Standard Concrete Products, Inc., Tampa (813) 831-9520 — B4, C3
Stress-Con Industries, Inc., Fort Myers (239) 390-9200 — B3
Structural Prestressed Industries, Medley (305) 556-6699 — C4

GEORGIA
Atlanta Structural Concrete Co., Buchanan (770) 646-1888 — C4A
ConArt Precast, LLC, Cobb (229) 853-5000 — A1, AT, C3
Coreslab Structures (ATLANTA) Inc., Jonesboro (770) 471-1150 — C3A
Gulf Coast Pre-Stress, Inc., Jonesboro (228) 234-7866 — B4
Metromont Corporation, Hiram (770) 943-8688 — A1, C4A
Standard Concrete Products, Inc., Savannah (912) 233-8263 — B4, C4
Standard Concrete Products, Inc., Atlanta (404) 792-1600 — B4
Tindall Corporation, Conley (800) 849-6383 — C2A
Tindall Corporation, Conley (800) 849-6383 — C4A

HAWAII
GPRM Prestress, LLC, Kapolei (808) 682-6000 — A1, B3, C4
GPRM Prestress, LLC, Puunene (808) 682-6000 — C4

IDAHO
Hanson Structural Precast Eagle, Caldwell (208) 454-8116 — A1, B4, C4
Teton Prestress Concrete, LLC., Idaho Falls (208) 523-6410 — B4, C3

ILLINOIS
ATMI Precast, Aurora (630) 896-4679 — A1, C3A
AVAN Precast Concrete Products, Lynwood (708) 757-6200 — A1, C3
County Materials Corporation, Salem (618) 548-1190 — A1, B4, B4-IL, C4
County Materials Corporation, Champaign (217) 352-4181 — B3, B3-IL
Dukane Precast, Inc., Aurora (630) 355-8118 — A1, C3
Illini Concrete Company of Illinois, LLC, Tremont (309) 925-5290 — B3, B3-IL
Illini Precast, LLC, Marseilles (708) 562-7700 — B4, B4-IL, C3
Lombard Architectural Precast Products Co., Alsip (708) 389-1060 — A1
Mid-States Concrete Industries, South Beloit (608) 364-1072 A1, B3, B3-IL, C3A
Prestress Engineering Corporation, Blackstone (815) 586-4239 — B4, B4-IL, C4
Spancrete of Illinois, Inc., Crystal Lake (815) 459-5580 — C2
St. Louis Prestress, Inc., Glen Carbon (618) 656-8934 — B3, B3-IL, C3
Utility Concrete Products, LLC, Morris (815) 416-1000 — B1A, C1A

INDIANA
ATMI Indy, LLC, Greenfield (317) 891-6280 — A1, C2A
Coreslab Structures (INDIANAPOLIS) Inc., Indianapolis (317) 353-2118 — A1 C4A,
Hoosier Precast LLC, Salem (812) 883-4665 — B3, C1A
Precast Specialties, Inc., Monroeville (260) 623-6131 — A1
StresCore, Inc., South Bend (574) 233-1117 — C2

IOWA
Advanced Precast Co., Farley (563) 744-3909 — C1A
Andrews Prestressed Concrete, Inc., Clear Lake (641) 357-5217 — B4, C4
IPC, Inc., Iowa Falls (515) 243-5118 — A1, B4, B4-IL, C4A
IPC, Inc., Des Moines (515) 243-5118 — B3, C4
MPC Enterprises, Inc., Mount Pleasant (319) 986-2226 — A1, C3A

KANSAS
Coreslab Structures (KANSAS) Inc., Kansas City (913) 287-5725 — B4, C4
IPC, Inc., Pleasanton (913) 352-8800 — B3, C3
Prestressed Concrete, Inc., Newton (316) 283-2277 — A1, B4, C4
Stress-Cast, Inc., Assaria (785) 667-3905 — C3A
Waffle-Crete International, Inc., Hays (785) 625-3486 — C3A

KENTUCKY
Bristol Group, Inc., Lexington (859) 233-9050 — C3
de AM - RON Building Systems LLC, Owensboro (270) 684-6226 — C3
Gate Precast Company, Winchester (859) 744-9481 — A1
Prestress Services Industries LLC, Lexington (260) 724-7117 B4, B4-IL, C4A
Prestress Services Industries LLC, Lexington (859) 299-0461 — A1, B4, C4A
Prestress Services Industries LLC, Melbourne (859) 441-0068 — B4, C3

LOUISIANA
Boykin Brothers, Inc./Louisiana Concrete Products, Baton Rouge (225) 753-8722 — A1, B4, C3A
F-S Prestress, LLC, Princeton (318) 949-2444 — B4, C3
Fibrebond Corporation, Minden (318) 377-1030 — A1, C1A

MAINE
Oldcastle Precast, Auburn (207) 784-9144 — B2, C1

MARYLAND
Atlantic Metrocast, Inc., LaPlata (301) 870-3289 — B3, C1
Larry E. Knight, Inc., Glyndon (410) 833-7800 — C2
Oldcastle Precast Building Systems Div., Edgewood (410) 612-1213 — A1, C3A

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MASSACHUSETTS

Oldcastle Precast, Inc./dba Rotondo Precast, Rehoboth (508) 336-7600 **B4, C3**
Unistress Corporation, Pittsfield (413) 499-1441 **A1, B4, C4A**
Vynorius Prestress, Inc., Salisbury (978) 462-7765 **B3, C2**

MICHIGAN

Grand River Infrastructure, Inc., Grand Rapids (616) 534-9645 **B4, C1**
International Precast Solution, LLC, River Rouge (313) 843-0073 **A1, B3, C3**
Kerkstra Precast Inc., Grandville (800) 434-5830 **A1, B3, C3A**
Nucon Schokbeton / Stress-Con Industries, Inc., Kalamazoo (269) 381-1550 **A1, B4, C3A**
Stress-Con Industries, Inc., Saginaw (989) 239-2447 **B4, C3**
Stress-Con Industries, Inc., Detroit (313) 873-4711 **B3, C3**

MINNESOTA

Crest Precast, Inc., La Crescent (507) 895-8083 **B3A**
Cretex Concrete Products North, Inc., Elk River (763) 545-7473 **B4, C2**
Fabcon, Inc., Savage (952) 890-4444 **B1, C3A**
Hanson Structural Precast Midwest, Inc., Maple Grove (763) 425-5555 **A1 C4A**
Molin Concrete Products Co., Lino Lakes (651) 786-7722 **C3A**
Wells Concrete Products, Albany (320) 845-2299 **A1, C3A**
Wells Concrete Products Co., Wells (507) 553-3138 **A1, C4A**

MISSISSIPPI

F-S Prestress, LLC, Hattiesburg (601) 268-2006 **B4, C4**
Gulf Coast Pre-Stress, Inc., Pass Christian (228) 452-9486 **B4, C4**
J.J. Ferguson Prestress-Precast Company, Inc., Greenwood (662) 453-5451 **B4**
Jackson Precast, Inc., Jackson (601) 321-8787 **A1, C2A**
Rotondo Weirich Enterprises, Inc., Yazoo City (215) 256-7940 **C1**
Tindall Corporation, Moss Point (228) 435-0160 **A1, C4A**

MISSOURI

Coreslab Structures (MISSOURI) Inc., Marshall (660) 886-3306 **A1, B4, C4A**
County Materials Corporation, Bonne Terre (573) 358-2773 **B4**
Mid America Precast, Inc., Fulton (573) 642-6400 **A1, B1, C1**
Prestressed Casting Company, Ozark (417) 581-7009 **C4**
Prestressed Casting Company, Springfield (417) 869-1263 **A1, C3A**

MONTANA

Missoula Concrete Construction, Missoula (406) 549-9682 **A1, B3, C3**
Montana Prestressed Concrete, Billings (605) 718-4111 **B4, C3**

NEBRASKAA

Concrete Industries, Inc., Lincoln (402) 434-1800 **B4, C4A**
Coreslab Structures (OMAHA) Inc., LaPlatte (402) 291-0733 **A1, B4, C4A**
CXT, Inc., Grand Island (308) 382-5400 **C2**
Enterprise Precast Concrete, Inc., Omaha (402) 895-3848 **A1, C2A**
Stonco, Inc., Omaha (402) 556-5544 **A1**

NEW HAMPSHIRE

Newstress Inc., Epsom (603) 736-9348 **B3, C3**

NEW JERSEY

Boccella Precast LLC, Berlin (856) 767-3861 **C2**
High Concrete Group LLC, Buena (856) 697-3600 **C3**
Jersey Precast Corp., Hamilton Township (609) 689-3700 **B4, C4**
Precast Systems, Inc., Allentown (609) 208-1987 **B4, C4**

NEW MEXICO

Castillo Prestress, Belen (505) 864-0238 **B4, C4**
Coreslab Structures (ALBUQUERQUE) Inc., Albuquerque (505) 247-3725 **A1 B4, C4A**
Ferreri Concrete Structures, Inc., Albuquerque (505) 344-8823 **A1, C4A**

NEW YORK

David Kucera Inc., Gardiner (845) 255-1044 **A1, G**
Lakelands Concrete Products, Inc., Lima (585) 624-1990 **A1, B3A, C3A**
Oldcastle Precast Building Systems Div., Selkirk (518) 767-2116 **B3, C3A**
The Fort Miller Co., Inc., Greenwich (518) 695-5000 **B1, C1**
The L.C. Whitford Materials Co., Inc., Wellsville (585) 593-2741 **B4, C3**

NORTH CAROLINA

Gate Precast Company, Oxford (919) 603-1633 **A1, C2**
International Precast Inc., Siler City (919) 742-3132 **A1, C3A**
Metromont Corporation, Charlotte (704) 372-1080 **A1, C3A**
Prestress of the Carolinas, Charlotte (704) 587-4273 **B4, C4**
S & G Prestress Company, Wilmington (910) 763-7702 **B4, C3**
S & G Prestress Company, Leland (910) 397-6255 **B4**
Utility Precast, Inc., Concord (704) 721-0106 **B3A**

NORTH DAKOTA

Wells Concrete, Grand Forks (701) 772-6687 **C4A**

OHIO

DBS Prestress of Ohio, Huber Heights (937) 878-8232 **C2**
Fabcon LLC, Grove City (614) 875-8601 **C3A**
High Concrete Group LLC, Springboro (937) 748-2412 **A1, C3A**
KSA, Sciotoville (740) 776-3238 **C2**
Mack Industries, Inc., Valley City (330) 483-3111 **C2**
Prestress Services Industries LLC, Grove City (614) 871-2900 **B4, C1**
Sidley Precast, Thompson (440) 298-3232 **A1, C4A**
Prestress Services Industries of Ohip, LLC., Mt. Vernon (800) 366-8740 **B4, C3**
Prestress Services Industries of Ohip, LLC., Mt. Vernon (740) 393-1121 **B3, C1**

OKLAHOMA

Coreslab Structures (OKLA) Inc. (Plant No.1), Oklahoma City (405) 632-4944 **A1, C4A**
Coreslab Structures (OKLA) Inc. (Plant No.2), Oklahoma City (405) 672-2325 **B4, C1**
Coreslab Structures (TULSA) Inc., Tulsa (918) 438-0230 **B4, C4**
Tulsa Dynaspan, Inc., Broken Arrow (918) 258-1549 **A1, C3**

OREGON

Knife River Corporation, Harrisburg (541) 995-6327 **A1, B4, C4**
R.B. Johnson Co., McMinnville (503) 472-2430 **B4**

PENNSYLVANIA

Concrete Safety Systems, LLC, Bethel (717) 933-4107 **B1A, C1A**
Conewago Precast Building Systems, Hanover (717) 632-7722 **A1, C2A**
Dutchland, Inc., Gap (717) 442-8282 **C3**
Fabcon East, LLC, Mahanoy City (570) 773-2480 **C3A**
High Concrete Group LLC, Denver (717) 336-9300 **A1, B3, C3A**
J & R Slaw, Inc., Lehighton (610) 852-2020 **A1, B4, C3**
Newcrete Products, Roaring Spring (814) 224-2121 **B4, C4**
Nitterhouse Concrete Products, Inc., Chambersburg (717) 267-4505 **A1, C4A**
Northeast Prestressed Products, LLC, Cressona (570) 385-2352 **B4, C3**
Pittsburgh Flexicore Company, Inc., Donora (724) 258-4450 **C2**
Say-Core, Inc., Portage (814) 736-8018 **C2**
Sidley Precast, Youngwood (724) 755-0205 **C3**
Technopref Industries Inc., Royersford Plant, Royersford (450) 569-8043 **B1, C1**
U.S. Concrete Precast Group Mid-Atlantic, Middleburg (570) 837-1774 **A1, C3A**
Universal Concrete Products Corporation, Stowe (610) 323-0700 **A1, C3A**

SOUTH CAROLINA

Florence Concrete Products, Inc., Sumter (803) 775-4372 **B4, C3A**
Metromont Corporation, Greenville (864) 295-0295 **A1, C4A**
Parker Marine Contracting Corporation, Charleston (843) 723-2727 **B2**
Tekna Corporation, Charleston (843) 853-9118 **B4, C2**
Tindall Corporation, Fairforest (864) 576-3230 **A1, C4A**

SOUTH DAKOTA

Gage Brothers Concrete Products Inc., Sioux Falls (605) 336-1180 **A1, B4, C4A**

TENNESSEE

Construction Products, Inc. of Tennessee, Jackson (731) 668-7305 **B4, C4**
Gate Precast Company, Ashland City (615) 792-4871 **A1, C3A**
Metromont Corporation, LaVergne (615) 793-3393 **A1, C4A**
Mid South Prestress, LLC, Pleasant View (615) 746-6606 **C3**
Prestress Services Industries of TN, LLC, Memphis (901) 775-9880 **B4, C3**
Ross Prestressed Concrete, Inc., Knoxville (865) 524-1485 **B4, C4**
Ross Prestressed Concrete, Inc., Bristol (423) 323-1777 **B4, C3**
Sequatchie Concrete Service, Inc., Chattanooga (423) 867-4510 **C2**

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TEXAS

Coreslab Structures (TEXAS) Inc., Cedar Park (512) 250-0755 ______ **A1, C4A**
CXT, Inc., Hillsboro (254) 580-9100 ______ **B1, C1**
Eagle Precast Corporation, Decatur (940) 626-8020 ______ **A1, C3**
East Texas Precast Co., Ltd., Hempstead (936) 857-5077 ______ **C4A**
Enterprise Concrete Products, LLC, Dallas (214) 631-7006 ______ **B3, C**
Gate Precast Company, Hillsboro (254) 582-7200 ______ **A1**
Gate Precast Company, Pearland (281) 485-3273 ______ **C2**
GFRC Cladding Systems, LLC, Garland (972) 494-9000 ______ **G**
Heldenfels Enterprises, Inc., San Marcos (512) 396-2376 ______ **B4, C4**
Lowe Precast, Inc., Waco (254) 776-9690 ______ **A1, C3A**
Manco Structures, Ltd., Schertz (210) 690-1705 ______ **B4, C4A**
North American Precast Company, San Antonio (210) 509-9100 ______ **A1, C4A**
Rocla Concrete Tie, Inc., Amarillo (806) 383-7071 ______ **C2**
Tindall Corporation, San Antonio (210) 248-2345 ______ **C2A**

UTAH

EnCon Utah, LLC, Tooele (435) 843-4230 ______ **A1, B4, C3A**
Hanson Structural Precast Eagle, Salt Lake City (801) 966-1060 ______ **A1, B4, C4A, G**
Harper Contracting, Salt Lake City (801) 326-1016 ______ **B2, C1**
Owell Precast LLC, Bluffdale (801) 571-5041 ______ **B3A, C3**
The Shockey Precast Group, LLC, Harriman (540) 667-7700 ______ **C3**

VERMONT

Dailey Precast, Shaftsbury (802) 442-4418 ______ **A1, B4A, C3A**
J. P. Carrara & Sons, Inc., Middlebury (802) 388-6363 ______ **A1, B4A, C3A**
S.D. Ireland Companies, South Burlington (802) 658-0201 ______ **A1**

VIRGINIA

Atlantic Metrocast, Inc., Portsmouth (757) 397-2317 ______ **B4, C3**
Bayshore Concrete Products Corporation,
Cape Charles (757) 331-2300 ______ **B4, C4**
Bayshore Concrete Products/Chesapeake, Inc.,
Chesapeake (757) 549-1630 ______ **B4, C3**
Coastal Precast Systems, LLC, Chesapeake (757) 545-5215 ______ **A1, B4, C3**
Metromont Corporation, Richmond (804) 222-8111 ______ **A1, C3A**
Mid-Atlantic Precast LLC, King George (540) 775-2275 ______ **C2**
Rockingham Precast, Inc., Harrisonburg (540) 433-8282 ______ **B4, C3**
Smith-Midland Corporation, Midland (540) 439-3266 ______ **A1, B2, C3**
The Shockey Precast Group, Winchester (540) 667-7700 ______ **A1, C4A**
The Shockey Precast Group, Fredericksburg (540) 898-1221 ______ **A1, C3A**
Tindall Corporation, Petersburg (804) 861-8447 ______ **A1, C4A**

WASHINGTON

Bellingham Marine Industries, Inc., Ferndale (360) 676-2800 ______ **B3, C2**
Bethlehem Construction, Inc., Cashmere (509) 782-1001 ______ **B1, C3A**
Central Pre-Mix Prestress Co., Spokane (509) 533-0267 ______ **A1, B4, C4**
Concrete Technology Corporation, Tacoma (253) 383-3545 ______ **B4, C4**
CXT, Inc., Spokane (509) 921-8716 ______ **B1**
CXT, Inc., Spokane (509) 921-7878 ______ **C2**
EnCon Northwest, LLC, Camas (360) 834-3459 ______ **B1**
EnCon Washington, LLC, Puyallup (253) 846-2774 ______ **B1, C2**
Wilbert Precast, Inc., Yakima (509) 248-1984 ______ **B3, C3**

WEST VIRGINIA

Carr Concrete Corporation, Waverly (304) 464-4441 ______ **B4, C3**
Eastern Vault Company, Inc., Princeton (304) 425-8955 ______ **B3, C3**

WISCONSIN

Advance Cast Stone Co., Inc., Random Lake (920) 994-4381 ______ **A1**
County Materials Corporation, Roberts (800) 426-1126 ______ **B4, C3**
County Materials Corporation, Eau Claire (800) 729-7701 ______ **B4**
International Concrete Products, Inc., Germantown (262) 242-7840 ______ **A1, C1**
MidCon Products, Inc., Hortonville (920) 779-4032 ______ **A1, AT, C1**
Spancrete, Inc., Valders (920) 775-4121 ______ **A1, B3, C3A**
Spancrete, Inc., Green Bay (920) 494-0274 ______ **B4, C4**
Stonecast Products, Inc., Germantown (262) 253-6600 ______ **A1, C1**
Wausau Tile Inc., Rothschild (715) 359-3121 ______ **AT**

WYOMING

VAE Nortrak North America, Inc., Cheyenne (509) 220-6837 ______ **C2**

CANADA

ALBERTA

Armtec Limited Partnership, Calgary (403) 248-3171 ______ **A1, B4, C4**

BRITISH COLUMBIA

Armtec Limited Partnership, Richmond (604) 278-9766 ______ **A1, B4 C3**

MANITOBA

Armtec Limited Partnership, Winnipeg (204) 338-9311 ______ **B4, C3A**

NEW BRUNSWICK

Strescon Limited, Saint John (506) 633-8877 ______ **A1, B4, C4A**

NOVA SCOTIA

Strescon Limited, Beford (902) 494-7400 ______ **A1, B4, C4**

ONTARIO

Artex Systems Inc., Concord (905) 669-1425 ______ **A1**
Global Precast INC, Maple (905) 832-4307 ______ **A1**
Prestressed Systems, Inc., Windsor (519) 737-1216 ______ **B4, C4**

QUEBEC

Betons Prefabriques du Lac Inc., Alma (418) 668-6161 ______ **A1, C3A, G**
Betons Prefabriques du Lac, Inc., Alma (418) 668-6161 ______ **A1, C2**
Betons Prefabriques Trans. Canada Inc.,
St. Eugene De Grantham (819) 396-2624 ______ **A1, B4, C3A**
Prefab De Beauce, Sainte-Marie De Beauce (418) 387-7152 ______ **A1, C3**
Schokbeton Quebec, Inc., St. Eustache (450) 473-6831 ______ **A1, B4A, C3**

MEXICO

PRETECSA, S.A. DE C.V., Atizapan De Zaragoza (011) 52-1036077 ______ **A1, G**
Willis De Mexico S.A. de C.V., Tecate (011) 52-6652222 ______ **A1, C1, G**

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PCI-Qualified & PCI-Certified Erectors

(as of January 2011

When it comes to quality, why take chances? When you need precast or precast, prestressed concrete products, choose a PCI-Qualified/Certified Erector. You'll get confirmed capability with a quality assurance program you can count on.

Whatever your needs, working with an erector who is PCI Qualified/Certified in the structure categories listed will benefit you and your project.

- You'll find easier identification of erectors prepared to fulfill special needs.
- You'll deal with established erectors.
- Using a PCI-Qualified/Certified Erector is the first step toward getting the job done right the first time, thus keeping labor costs down.
- PCI-Qualified/Certified Erectors help construction proceed smoothly, expediting project completion.

Guide Specification

To be sure that you are getting an erector from the PCI Field Certification Program, use the following guide specification for your next project:

"Erector Qualification: The precast concrete erector shall be fully qualified or certified by the Precast/Prestressed Concrete Institute (PCI) prior to the beginning of any work at the jobsite. The precast concrete erector shall be qualified or certified in Structure Category(ies): [Select appropriate groups and categories S1 or S2 and/or A1]."

Erector Classifications

The PCI Field Certification Program is focused around three erector classifications. The standards referenced are found in the following manuals:

MNL–127 *Erector's Manual - Standards and Guidelines for the Erection of Precast Concrete Products*

MNL–132 *Erection Safety Manual for Precast and Prestressed Concrete*

GROUPS

Category S1 - Simple Structural Systems
This category includes horizontal decking members (e.g., hollow-core slabs on masonry walls), bridge beams placed on cast-in-place abutments or piers, and single-lift wall panels.

Category S2 - Complex Structural Systems
This category includes everything outlined in Category S1 as well as total-precast, multi-product structures (vertical and horizontal members combined) and single- or multistory load-bearing members (including those with architectural finishes).

Category A - Architectural Systems
This category includes non-load-bearing cladding and GFRC products, which may be attached to a supporting structure.

Certified erectors are listed in blue.

ARIZONA

Coreslab Structures (ARIZ), Inc., Phoenix (602) 237-3875 — **S2, A**
TPAC, Phoenix (602) 262-1360 — **S2, A**

ARKANSAS

Coreslab Structures (ARK) Inc., Conway (501) 329-3763 — **S2**

CALIFORNIA

Coreslab Structures (L.A.), Inc., Perris (951) 943-9119 — **S2, A**
Walters & Wolf Precast, Fremont (510) 226-9800 — **A**

COLORADO

Gibbons Erectors, Inc., Englewood (303) 841-0457 — **S2, A**
Rocky Mountain Prestress, Denver (303) 480-1111 — **S2, A**
S. F. Erectors Inc., Elizabeth (303) 646-6411 — **S2, A**

CONNECTICUT

Blakeslee Prestress, Inc., Branford (203) 481-5306 — **S2**
Jacob Erecting & Construction LLC, Durham (860) 788-2676 — **S2, A**

FLORIDA

Concrete Erectors, Inc., Altamonte Springs (407) 862-7100 — **S2, A**
Finfrock Industries, Inc., Orlando (407) 293-4000 — **S2, A**
Florida Builders Group, Inc., Miami (305) 278-0098 — **S2**
Florida Precast Industries, Sebring (863) 655-1515 — **S1**
Gate Precast Erection Co., Jacksonville (904) 757-0860 — **S2, A**
Gate Precast Erection Co., Kissimmee (407) 847-5285 — **S2, A**
James Toffoli Construction Company, Inc., Fort Myers (239) 479-5100 — **S2, A**
Pre-Con Construction of Tampa Inc., Tampa (813) 626-2545 — **S2, A**
Solar Erectors U. S. Inc., Medley (305) 825-2514 — **S2, A**
Specialty Concrete Services, Inc., Altoona (352) 669-8888 — **S2, A**
Structural Prestressed Industries, Inc., Medley (305) 556-6699 — **S2**
Summit Erectors, Inc., Jacksonville (904) 783-6002 — **S2, A**

GEORGIA

Big Red Erectors Inc., Covington (770) 385-2928 — **S2**
ConArt Precast, LLC, Cobb (229) 853-5000 — **S2, A**
Jack Stevens Welding LLP, Murrayville (770) 534-3809 — **S2**
Precision Stone Setting Co., Inc., Hiram (770) 439-1068 — **S2, A**
Rutledge & Son's, Woodstock (770) 592-0380 — **S2**

IDAHO

Precision Precast Erectors, LLC, Worley (208) 660-5223 — **S2, A**

ILLINOIS

Area Erectors, Inc., Rockford (815) 562-4000 — **S2, A**
Creative Erectors, LLC, Rockford (815) 229-8303 — **S2, A**
Mid-States Concrete Industries, South Beloit (800) 236-1072 — **S2**
Spancrete of Illinois, Inc., Crystal Lake (815) 459-5580 — **S2**

IOWA

Architectural Wall Systems Co., West Des Moines (515) 255-1556 — **A**
Cedar Valley Steel, Inc., Cedar Rapids (319) 373-0291 — **S2, A**
Topping Out Inc. / dba Northwest Steel Erection, Des Moines (800) 247-5409 — **S2**

KANSAS

Carl Harris Co., Inc., Wichita (316) 267-8700 — **S2, A**
Crossland Construction Company, Inc., Columbus (620) 429-1414 — **S2, A**
Ferco, Inc., Salina (785) 825-6380 — **S1**
Topping Out Inc. / dba Davis Erection Kansas City, Kansas City (800) 613-9547 — **S2**

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LOUISIANA

Lafayette Steel Erector, Inc., Lafayette (337) 234-9435 ______ **S2**

MAINE

American Aerial Services, Inc., Falmouth (207) 797-8987 ______ **S1**
Cianbro Corporation, Pittsfield (207) 679-2435 ______ **S2**
Reed & Reed, Inc., Woolwich (207) 443-9747 ______ **S2, A**

MARYLAND

E & B Erectors, Inc., Pasadena (410) 360-7800 ______ **S2, A**
E.E. Marr Erectors, Inc., Baltimore (410) 837-1641 ______ **S2, A**
EDI, LLC, Upper Marlboro (301) 877-0000 ______ **S2, A**
L.R. Willson & Sons, Inc., Gambrills (410) 987-5414 ______ **S2, A**
Mid Atlantic Precast Erectors, Inc., Baltimore (410) 837-1641 ______ **A**
Oldcastle Building Systems Div. / Project Services,
Baltimore (518) 767-2116 ______ **S2, A**

MASSACHUSETTS

Prime Steel Erecting, Inc., North Billerica (978) 671-0111 ______ **S2, A**

MICHIGAN

Assemblers Precast & Steel Services, Inc., Saline (734) 429-1358 ______ **S2, A**
Devon Contracting, Inc., Detroit (313) 965-3455 ______ **S2, A**
G2 Inc., Cedar Springs (616) 696-9581 ______ **S2, A**
Pioneer Construction Inc., Grand Rapids (616) 247-6966 ______ **S2**

MINNESOTA

Amerect, Inc., Newport (651) 459-9909 ______ **A**
Fabcon, Inc., Savage (952) 890-4444 ______ **S2**
Hanson Structural Precast Midwest, Inc.,
Maple Grove (763) 425-5555 ______ **S2, A**
Molin Concrete Products Company, Lino Lakes (651) 786-7722 ______ **S2, A**
Wells Concrete Products Co., Wells (507) 553-3138 ______ **S2, A**

MISSISSIPPI

Bracken Construction Company, Inc., Jackson (601) 922-8413 ______ **S2, A**

MISSOURI

Acme Erectors, Inc., St. Louis (314) 647-1923 ______ **S2, A**
J. E. Dunn Construction Company, Kansas City (816) 474-8600 ______ **S2, A**
Prestressed Casting Co., Springfield (417) 869-7350 ______ **S2, A**

NEBRASKA

Moen Steel Erection, Inc., Omaha (402) 884-0925 ______ **S2**
Topping Out Inc. / dba Davis Erection Lincoln, Lincoln (800) 881-2931 ______ **S2**
Topping Out Inc. / dba Davis Erection Omaha, Omaha (800) 279-1201 ______ **S2, A**

NEW HAMPSHIRE

American Steel & Precast Erectors, Inc., Greenfield (603) 547-6311 ______ **S2, A**

NEW JERSEY

CRV Precast Construction LLC, Eastampton (800) 352-1523 ______ **S2, A**
J. L. Erectors, Inc., Blackwood (856) 232-9400 ______ **S2, A**
JEMCO-Erectors, Inc., Shamong (609) 268-0332 ______ **S2, A**
Jonasz Precast, Inc., Westville (856) 456-7788 ______ **S2, A**

NEW MEXICO

Ferreri Concrete Structures, Inc., Albuquerque (505) 344-8823 ______ **S2**
Structural Services, Inc., Albuquerque (505) 345-0838 ______ **S2**

NEVADA

Cedco Commerical, LLC, Las Vegas (702) 361-6550 ______ **A**

NEW YORK

Arben Group LLC, Pleasantville (914) 741-5459 ______ **S2**
Empire Constructors LLC, Pittsford (585) 586-1510 ______ **A**
Koehler Masonry, Farmingdale (631) 694-4720 ______ **S1**
Oldcastle Building Systems Div. / Project Services,
South Bethlehem (518) 767-2116 ______ **S2, A**
Oldcastle Building Systems Div. / Project Services,
Manchester (518) 767-2116 ______ **S2, A**

NORTH CAROLINA

Buckner Steel Erection Inc., Graham (336) 376-8888 ______ **S2**
Carolina Precast Erectors, Inc., Taylorsville (828) 635-1721 ______ **S2, A**

NORTH DAKOTA

PKG Contracting, Inc., Fargo (701) 232-3878 ______ **S2**
Wells Concrete, Grand Forks (701) 772-6687 ______ **S2**

OHIO

Ben Hur Constructionn Company, Fairfield (513) 874-9228 ______ **A**
Precast Services, Inc., Twinsburg (330) 425-2880 ______ **S2, A**
Sidley Precast Group, Thompson (440) 298-3232 ______ **S2**
Sofco Erectors, Inc., Cincinnati (513) 771-1600 ______ **S2, A**

OKLAHOMA

Allied Steel Construction Co., LLC, Oklahoma City (405) 232-7531 ______ **S2, A**
Bennet Steel, Inc., Sapulpa (918) 260-0773 ______ **S1**
Coreslab Structures (OKLA), Inc., Oklahoma City (405) 632-4944 ______ **S2, A**

PENNSYLVANIA

Century Steel Erectors, Kittanning (724) 545-3444 ______ **S2, A**
Conewago Enterprises, Inc., Hanover (717) 632-7722 ______ **S2**
High Concrete Group, Denver (717) 336-9300 ______ **S2, A**
Maccabee Industrial, Inc., Belle Vernon (724) 930-7557 ______ **S2, A**
Nitterhouse Concrete Products, Inc., Chambersburg (717) 267-4505 ______ **S2**
Patterson Construction Company, Inc., Monongahela (724) 258-4450 ______ **S1**

SOUTH CAROLINA

Davis Erecting & Finishing, Inc., Greenville (864) 220-0490 ______ **S2, A**
Florence Concrete Products Inc., Florence (843) 662-2549 ______ **S2**
Tindall Corporation, Fairforest (864) 576-3230 ______ **S2**

TENNESSEE

Hoosier Prestress, Inc., Brentwood (615) 661-5198 ______ **S2**

TEXAS

Empire Steel Erectors LP, Humble (281) 548-7377 ______ **A**
Gate Precast Company, Pearland (281) 485-3273 ______ **S1**
Gulf Coast Precast Erectors, LLC, Hempstead (832) 451-4395 ______ **S2**
Precast Erectors, Inc., Hurst (817) 684-9080 ______ **S2, A**

UTAH

Hanson Structural Precast Eagle, Salt Lake City (801) 966-1060 ______ **S2, A**
OutWest C & E Inc., Bluffdale (801) 446-5673 ______ **S2, A**

VERMONT

CCS Constructors LLC, Morrisville (802) 888-7701 ______ **S2**

VIRGINIA

Sprinkle Masonry Inc., Chesapeake (757) 545-8435 ______ **A**
The Shockey Precast Group, Winchester (540) 665-3253 ______ **S2, A**
W. O. Grubb Steel Erection, Inc., Richmond (804) 271-9471 ______ **A**

WASHINGTON

Central Pre-Mix Prestress Co., Spokane Valley (509) 536-3334 ______ **S2, A**

WISCONSIN

Modern Crane Service, Inc., Onalaska (608) 781-2252 ______ **S1**
Spancrete, Valders (920) 775-4121 ______ **S2, A**
Spancrete, Waukesha (414) 290-9000 ______ **S2, A**
The Boldt Company, Appleton (920) 225-6127 ______ **S2, A**

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