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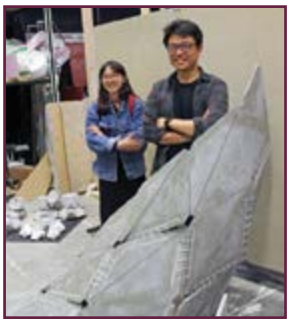

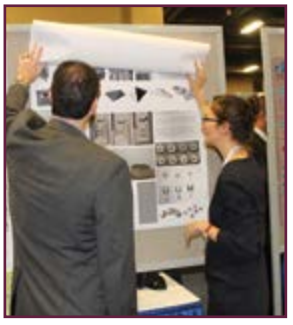

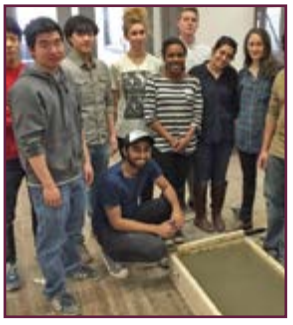

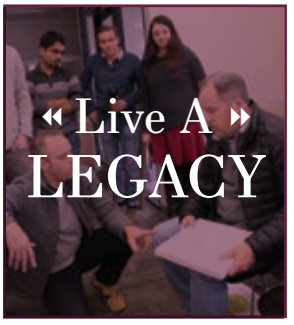

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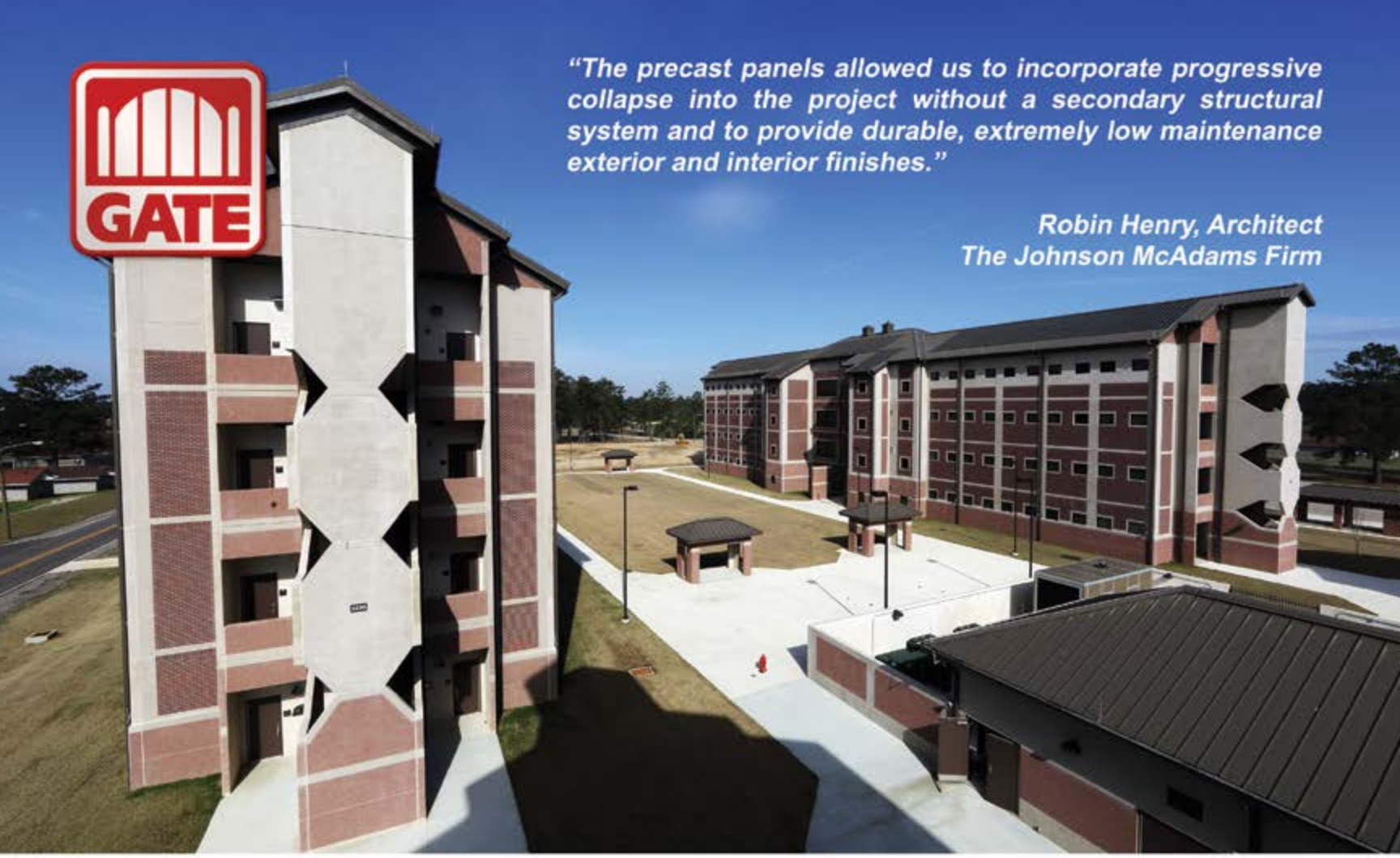

"The precast panels allowed us to incorporate progressive collapse into the project without a secondary structural system and to provide durable, extremely low maintenance exterior and interior finishes."

Robin Henry, Architect
The Johnson McAdams Firm

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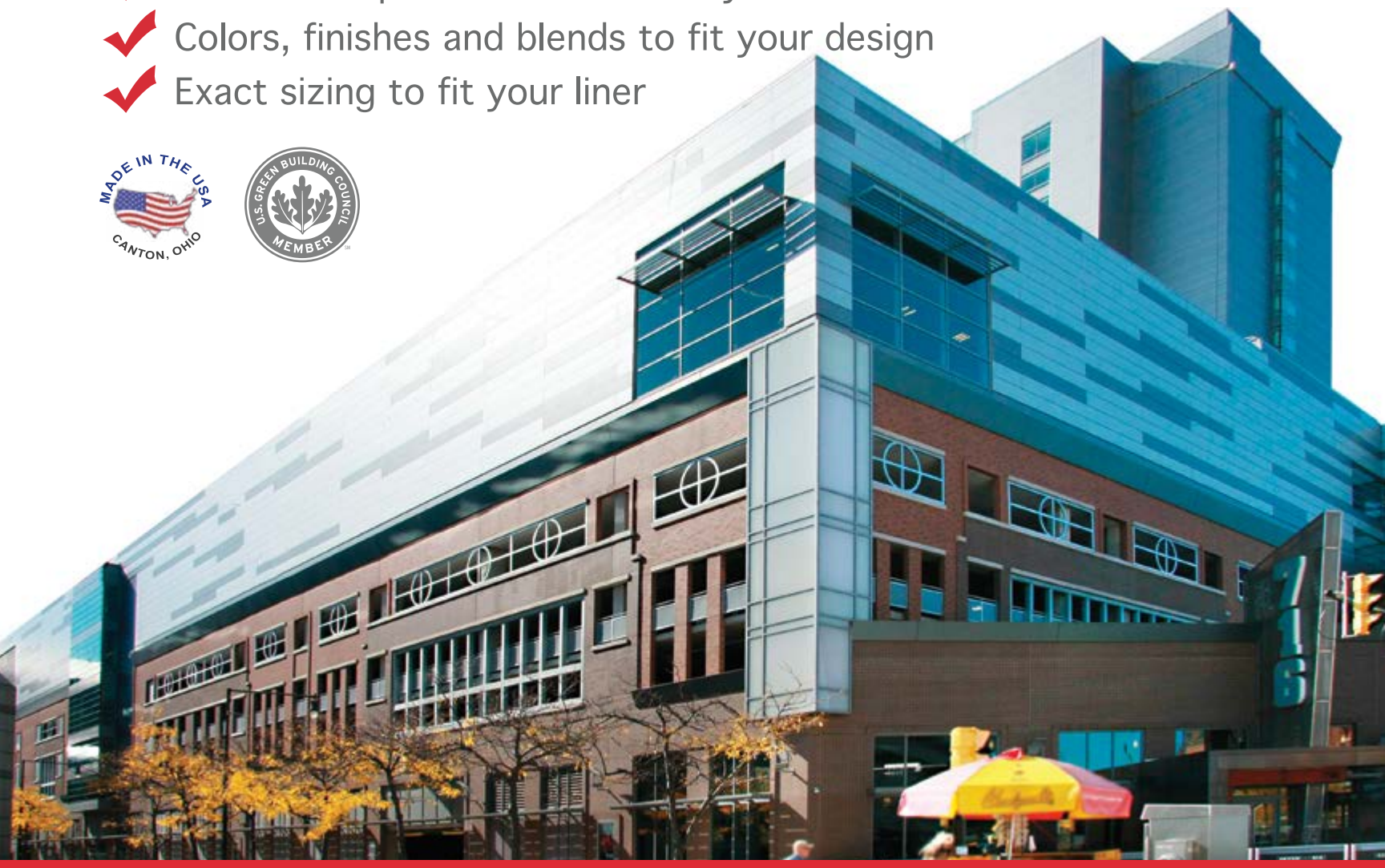

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On the cover: Vernon Street Office Building.
Photo: LPAS Architecture + Design.

FEATURES

The 316 Vernon Street Office Building. Photo: Ryan Colditz.

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Precast Concrete: Inherent Resiliency.

Our communities are under a constant barrage of natural disasters like fires, floods, earthquakes, tornadoes, hurricanes, and even some that are man-made. Architects around the globe are starting to think about resilient designs for their structures, but what does resilient design mean? Is it another (green) word for sustainability?

According to the Resilient Design Institute, resilient design is defined as "the intentional design of buildings, landscapes, communities, and regions in response to vulnerabilities to disaster and disruption of normal life." It's not a buzz word to catch your attention but a cultural shift in our thinking.

The precast concrete industry has inherently offered resiliency solutions for years without being intentional in their use and longevity. The recent tragedy at Grenfell Tower in London heightens the need for resilient design methodology in structures where we live, work, and play.

The 2011, EF-5 tornado that destroyed much of Joplin, Mo., including Mercy Hospital is another example of a natural disaster devastating a community that now is benefiting from the use of resilient design methodology. Mercy Hospital was rebuilt as a tornado-resistant structure using precast concrete construction.

The projects featured within this issue of Ascent are a reflection of what owners, developers, and designers are demanding when it comes to resilient design.

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Roseville City Hall First With USRC Rating

ROSEVILLE, CALIFORNIA

The Roseville City Hall Annex, built with a total–precast concrete structural system, is the first rated by the United State Resiliency Council, receiving a USRC Platinum earthquake rating. It also was the first precast building built for the city of Roseville.

The project's precast concrete structural framing and architectural panels were fabricated by Clark Pacific in West Sacramento, Calif. LPAS was the architect of record, while DPR Construction served as general contractor and Buehler & Buehler was the structural engineer.

With the building scheduled to open in January 2017, city planners had 12 months to design, program, build, and prep the building for occupancy. Other building systems had been explored, including steel and cast-in-place concrete, but the precast concrete hybrid moment frame system was selected as it gave the architect flexibility in the design.

The structural system incorporates a high-performance precast concrete hybrid moment-resisting frame that limited design level drifts to less than 1.25% and is designed to be self-centering after the design seismic event, therefore eliminating residual drifts, limiting damage, and providing for reduced recovery time.

MGM Resort Casino Selects Precast for Parking

SPRINGFIELD, MASSACHUSETTS

The design-build team for the MGM Resort Casino faced several challenges in constructing the large parking structure that enhances the new adjacent casino. They needed an economical approach that met all the functional requirements while blending with the nearby historical buildings and constructing it in the busy downtown area. To meet these needs, they specified a total–precast concrete structural system.

The project, on a 300- by 600-ft footprint, consists of an eight-level structure containing 1.16 million ft^2 to park 3400 cars. The design features double tees, inverted T beams, columns, shear walls, vertical shear walls, horizontal lite walls, spandrels embedded with thin brick and with a sandblasted finish, stairs, slabs, and wall panels with a formliner to achieve a limestone look. Blakeslee Prestress fabricated and erected the components.

Precast concrete was chosen for several reasons, leading off with economics, says Steve O'Connor, senior project manager for Tishman Construction Co., the construction manager. "It was less expensive than alternatives we reviewed by a significant amount," he says. "The 62-ft-long double tees, at a 12.5-ft width, worked out perfectly for our bay design."

Noli Alarcon, vice president at TimHaahs, the architect/engineer on the project, agrees. "It worked very well with our bay sizes," he says. "Using precast concrete, we could create the design for this very large project with only one expansion joint. Cast-in-place concrete would have required many more."

The structure's one key adaptation was making the first level twice the regular height, 26 ft, to create a loading dock at the rear of the facility and ensure any delivery vehicles would have access.

Aesthetic requirements were met with a combination of thin brick embedded in the spandrels and accents finished with a buff-colored sandblast finish to resemble limestones. These included stair towers, some horizontal spandrels, and some of the base. The variations in the appearance help reduce the visual scale of the project. Aesthetics were critical due to the building's location, near the Naismith Memorial Basketball Hall of Fame in a downtown district with historic buildings.

The erection was complicated by the on-going construction of the casino, with the parking structure planned for earlier completion. Material was staged on-site and at an off-site queuing yard, so it was readily available as needed. A large crawler crane was used in the precast erection process, which began in September 2016 and finished in June 2017. Parking finishes will be applied into the fall of 2017, with the casino scheduled to open in 2018.

Submit your headline news for consideration in a future issue of Ascent to Becky King at bking@pci.org.

High Concrete Supplies Statue of Liberty Museum

LIBERTY ISLAND, NEW YORK

High Concrete Group LLC in Denver, Pa., is supplying high-performance insulated architectural precast concrete panels for the new Statue of Liberty Museum on Liberty Island in New York Harbor. Phelps Construction Group in Boonton, N.J., is serving as the general contractor, with FXFOWLE in New York as the architectural firm.

The 26,000 ft^2, state-of- the-art building was designed to reflect the significance and detail of the Statue of Liberty and its island. The Statue of Liberty-Ellis Island Foundation has raised nearly $70 million to build the museum, expected to open in 2019. It is the first new building construction undertaken by the foundation, which has been responsible for historic restoration and preservation since the 1980s.

Reedy Creek Adds Precast Parking Structure

ORLANDO, FLORIDA

Finfrock Construction Inc. has been selected by Reedy Creek Improvement District, the taxing district in which the Walt Disney World resort is located, to design and construct a precast concrete parking structure for about $58 million. The structure will reportedly offer at least 2000 spaces, making it one of the largest parking structures Finfrock has ever constructed in a single phase, according to President Bill Finfrock.

University of Massachusetts Dorm Adds Elevator Tower

LOWELL, MASSACHUSETTS

Administrators at the University of Massachusetts Lowell needed to upgrade the elevators at an 18-story campus residence and dining hall. To achieve this in the most cost-effective way, with the least interference to the building's residents, the design team created an adjacent elevator tower constructed of structural, insulated precast concrete walls with an architectural finish.

The building houses more than 800 students while the dining hall serves 4200 meals per day, so providing a smooth, steady flow through the building was critical. Insulated precast concrete panels were chosen after a review of several materials, according to Darryl T. Filippi, principal at Bergmeyer, the architects on the project.

Specifying a structural precast concrete sandwich panel allowed for the installation of a finished structural product that reduced the amount of scaffolding, site impact, crane operation, and exterior finishing material required. Coreslab Structures (CONN) Inc. fabricated the components.

On-site congestion and time were minimized by having insulation installed within the panels. The system consists of two inches of rigid insulation between an internal 8-in. structural wythe of concrete and an external 3-in. wythe of architectural concrete. The insulation also served as a backer-rod substitute, as sealant could not be installed during the winter months when the erection was performed.

The precast concrete panels were stacked vertically 221 ft high and were laterally tied back to the existing structure using steel beams, with cast-in-place concrete on a metal deck for the flooring. The site featured a unique micro-climate, with winds flowing off the nearby Merrimack River and becoming intense at times. Contractor Walsh Bros. constantly monitored erection conditions and anchored the panels as quickly as possible to avoid any mishandling.

The new shaft not only had to be threaded through a third-floor roof opening but, at its closest point, was positioned only 24 in. away from the existing building. The process moved smoothly, saving about four weeks compared to a steel-frame system with metal-skin wall assembly that was an alternative construction method. The precast option also saved approximately $300,000 in material costs over that option.

Clark Pacific Breaks Ground On New Plant

ADELANTO, CALIFORNIA

Clark Pacific, based in West Sacramento, Calif., has broken ground on a new plant in Adelanto, Calif., to accommodate the continued demands and expansion of the California construction market. The 110-acre plant will replace the company's Irwindale, Calif., plant in June 2017, transferring its existing operations there and expanding its staff. The plant will produce structural precast concrete products.

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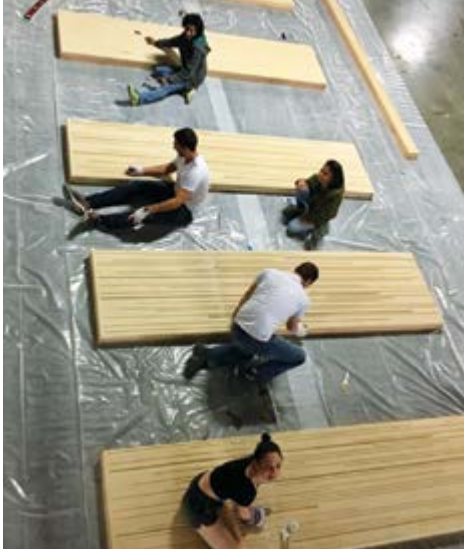

Students Create Sustainable Concrete House

ST. LOUIS, MISSOURI

Students at the Sam Fox School of Design & Visual Arts and the School of Engineering & Applied Science at Washington University in St. Louis are creating a total–precast concrete home to show its sustainable properties for Solar Decathlon 2017. The biennial competition, sponsored by the U.S. Department of Energy, presents awards to university teams worldwide that design and build the most efficient full-size, solar-powered houses.

The project is being overseen by Hongxi Yin, I-CARES associate professor; faculty project architect Pablo Moyano, a senior lecturer in architecture; and faculty project manager Ryan Abendroth.

The students' entry, the 995-ft^2 Crete House, consists of six large precast concrete panels, according to a news article on the School of Engineering's website (engineering.wustl.edu). Oversized gutters will provide shade support, extending the living space outdoors. A water collection system and series of modular planters will support hydroponic gardening.

To counteract the precast concrete's weight, students worked with PCI, especially its Midwest, Mountain States, Central Region and Illinois & Wisconsin regional affiliates, to design and cast sandwich wall panels using a high-performance mixture said to be six times stronger than regular concrete.

The house, which ultimately will serve as the long-term residence for scientists at the university's Tyson Research Center, will take advantage of concrete's high thermal mass to heat and cool the home with water coils embedded in the panels.

The design resulted from four semester-long studios that began in the fall of 2015 to create proposals. The panels are being cast and constructed, after which they will be dismantled and shipped to Denver for the competition.

The competition offers a variety of award categories, including design excellence and innovation, energy and water efficiency, and market potential. More than $2 million in prize money will be awarded at the contest, which will be held in October.

Gage Operations Manager Retires

SIOUX FALLS, SOUTH DAKOTA

Gage Brothers Operations Manager Don Hall retired in March after 35 years of working in nearly every aspect of the precast and prestressed concrete industry at various firms. His duties through the years have included plant ownership, general management, and production and operations management, as well as activities in research and development, engineering, quality assurance, design, and product sales.

Hall served as director of operations at Fabcon Precast in Savage, Minn., from 1995 to 2005, and then spent four years as manager of the prestress and hollow-core division for Wisconsin-based County Materials Corp. In 2009, he became Gage Brothers' quality-assurance manager and in 2015 was named operations manager.

Submit your headline news for consideration in a future issue of Ascent to Becky King at bking@pci.org.

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"High Concrete saw our design as a wonderful opportunity to really show off their skills, talents and products. It has been a sincere joy to work with a group of precasters who are as engaged as they have been, willing to roll up their sleeves to work on solutions rather than seeing obstacles, and I am sure that they are proud of their efforts as much as we are."
Kai-Uwe Bergmann, *AIA, RIBA, partner, BIG—Bjarke Ingels Group*

THE NEW SHAPE OF PRECAST

1200 Intrepid at the Philadelphia Navy Yard is the newly completed precast concrete work of art designed by world-renowned starchitect Bjarke Ingels Group (BIG). The front entrance façade gently curves inward while stretching outward creating a startling and gravity-defying visual that mimics the curved bows of the nearby battleships. The unique engineering requirements of the project meant that the gravity loads flowed directly to the ground and were not tied to the steel frame. Almost every piece of the front entrance façade is unique. This very complicated project presented a challenge that required an innovative solution using technical, engineering and creative expertise, and would not have been possible without the use of BIM and 3D modeling. For more information on this project and others visit us at www.highconcrete.com/news.

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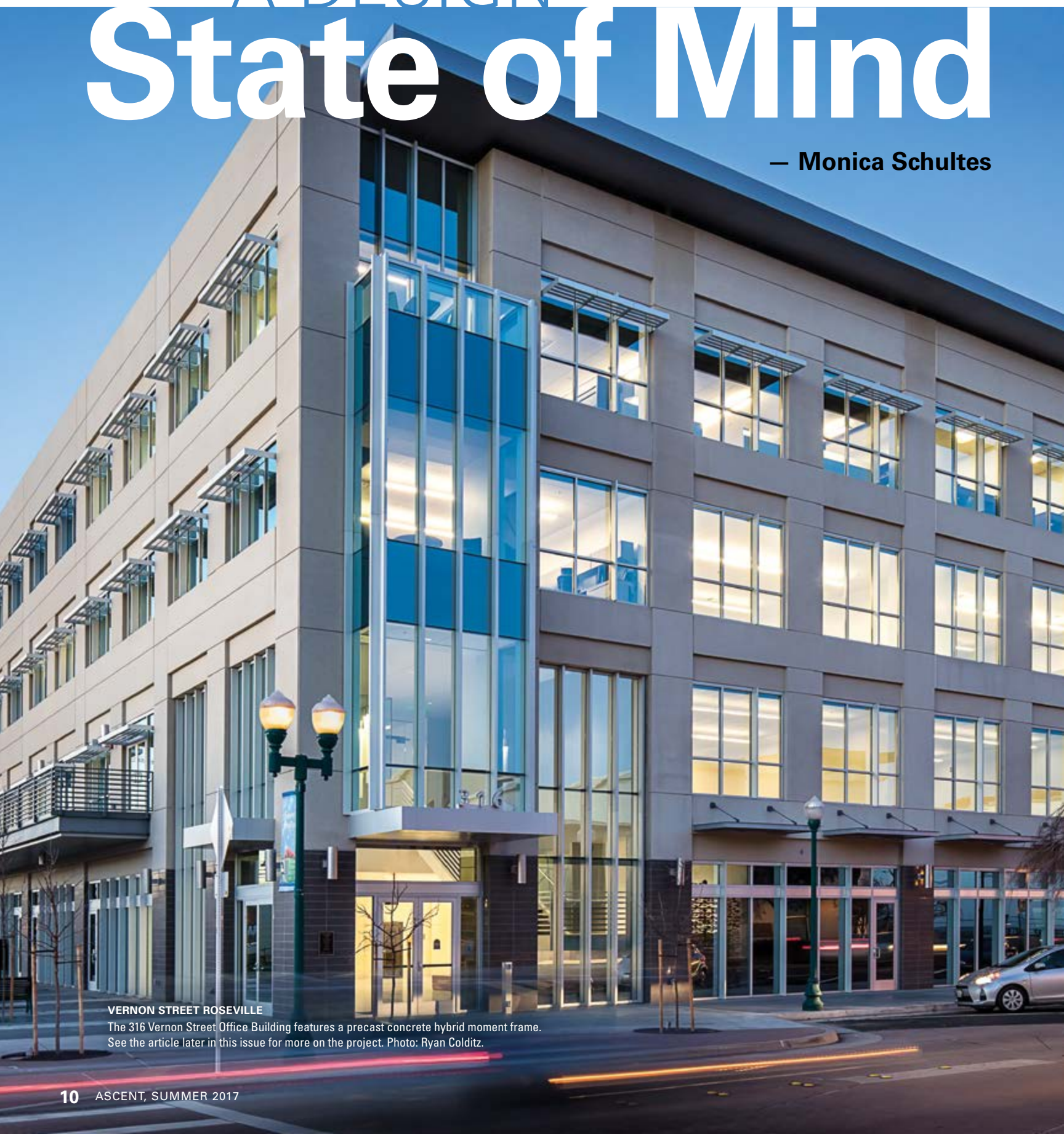

VERNON STREET ROSEVILLE
The 316 Vernon Street Office Building features a precast concrete hybrid moment frame. See the article later in this issue for more on the project. Photo: Ryan Colditz.

A lean construction philosophy drives Curtis Owyang of LPAS Architecture + Design to make the most out of every project.

Curtis Owyang, LPAS Architecture + Design.

Good design starts at home. Curtis Owyang grew up in Sacramento, Calif., and developed an interest in design at an early age. His passion for architecture started at home—literally. The house he grew up in was designed by an architect using the popular Eichler style. These mid-century modern style homes feature indoor/outdoor living, walls of glass, atriums, radiant-heat floors, open floor plans, and exposed structures.

Owyang's house, with its open floor plan and clean geometric lines, contrasted greatly with the more traditional layouts at his classmates' homes. "It really had an impact on me to see things being done differently," he says. "I was lucky to grow up in a house like that. It made me aware how architecture can affect how you live."

Owyang continues to look for ways to bring the outside into his buildings. "Growing up in Sacramento, it is very hot in the summer. You are always aware of the environment and the heat." Thinking back to his days at junior college, he remembers a structure that featured an internal courtyard that was a cool oasis. "That influenced me. I am now designing a building there (Cosumnes River College faculty offices). Going back to where I first started is very exciting and very humbling at the same time."

'As designers, it is our responsibility to create an engaging solution that builds community and encourages enjoyment in the places you live, work, and play.'

As a principal at LPAS, Owyang's focus is on design. He has been with LPAS since 1993, currently as vice president and director of design, and is always looking to bring on associates with a similar passion. He looks for like minds when hiring: people who are excited about what they do and eager to work together. "As designers, it is our responsibility to create an engaging solution that builds community and encourages enjoyment in the places you live, work, and play."

LPAS' design philosophy is simply stated: "Making Buildings Together." They emphasize collaboration where all the participants are engaged and share in the design process. This unique exchange and interaction leads to the best result possible and echoes the construction industry's move toward integrated project delivery (IPD).

CALIFORNIA HIGHWAY PATROL HEADQUARTERS
LPAS initiated the "Guns to Rebar" program for the design of the California Highway Patrol headquarters. Photo: LPAS Architecture + Design.

CHANGING DELIVERY ROUTES

IPD projects mandate highly effective collaboration among the design team from early planning through construction. The result is better, faster, less costly, and less adversarial construction projects, often with the precast producer at the table.

The Vernon Street office building in Roseville, Calif., is just such a success story.

At the core of its success was the IPD that made good use of the collaborative and productive teams composed of key project participants Clark Pacific, DPR Construction, LPAS Architecture + Design, Buehler & Buehler Engineering, and the City of Roseville.

LPAS embraces many of the tools, practices, and techniques of IPD, despite the lack of an actual multiparty agreement for a specific job. "We are big proponents of lean construction. We find that it is an incredible tool for how to design and how to work with clients. It fosters an intense collaboration among parties. That has been a big change in our practice at LPAS," says Owyang.

He adds, "We use lean construction methods on every project. Contractors have embraced lean methods, but not many architects. Some owners see that as unique advantage to working with LPAS."

'We are big proponents of lean construction. It fosters an intense collaboration among parties. That has been a big change in our practice at LPAS.'

Active in the Lean Construction Institute, Owyang adopts their methods to develop and manage a project through relationships, shared knowledge, and common goals. Traditional silos of expertise, work, and effort are reorganized for the good of the project rather than of individual participants. The result? Significant improvements in schedule with dramatically reduced waste, particularly on complex and fast projects.

Owyang faces the typical myriad challenges when collaborating with owners, consultants, and contractors, but like any relationship, it depends on the people at the table. The lean construction tools encourage collaboration, communication, and buy-in to the process. "Hopefully everyone gets on the same page and they support it."

The same applies as the construction industry moves toward three-dimensional (3-D) design as a standard platform. "The lean ideas help us to leverage Revit (software for BIM modeling) so that we are working with all the contractors and consultants in 3-D. It makes for a project with fewer change orders, more consistency with drawings, and easier to build for the contractor. We think that lean ideas maximize the benefits of working in 3-D", says Owyang.

Owyang confesses to being a bit of a dinosaur. "I still use a drafting table. I still sketch on paper or work exclusively on SketchUp Pro. My team tolerates me using Sketch-Up, but they all work with Revit, which is a much higher-level platform in 3-D."

MISSION ACCOMPLISHED

At LPAS, the design process is guided by the desire to reflect the culture, values, and goals of the owner. Owyang incorporated the organization's mission when working with the California Highway Patrol (CHP). While designing the CHP headquarters, LPAS saw thousands of firearms destroyed. Always looking for sustainable opportunities, they thought about how the weapons could be recycled. LPAS proposed melting the confiscated and amnesty guns and reclaiming the steel as reinforcing bars for the headquarters project.

The "Guns to Rebar" program was the first of its kind to receive LEED credits and since has been used by law enforcement agencies across the country. The CHP has made the program a requirement in the construction of all future facilities and the program has developed a sense of pride and accomplishment within law enforcement agencies and the communities they serve.

"It was a sustainable idea, but it had much more value to them culturally. It was a very powerful message," Owyang recounts. "Clients always have expectations about budget and sustainability, but what motivates us is the cultural power of the projects: We try to embed that in the design."

INTEGRATED PHILOSOPHY
LPAS uses integrated project delivery and lean construction methods to meet the needs of owners. LPAS conceived the use of old lottery tickets, shredded and inserted in laminate glass for feature windows. Photo: LPAS Architecture + Design.

Another example is the California Lottery headquarters in Sacramento's River District. Owyang says he liked the challenge of designing an office for a client with high visibility. "We had a unique client with a distinct personality and a request that the building be a part of their public identity and communicate who they are and what they do," he says. "The design is meant to convey the energy and excitement of the lottery and embed their brand into the architecture and interiors of the building."

It boasts a number of distinct features: circular skylights represent ping-pong balls in a lotto drawing tumbler; lights on a glass wall inside the building change color and pulse when the jackpot gets high. LPAS conceived the use of old lottery tickets, shredded and inserted in laminate glass for feature windows. Employees in conference rooms can see the product embedded into the architecture.

The headquarters for the Lottery was a memorable project. "We worked well together and it is great when clients let us do what we do best," reflects Owyang. "There were a lot of first-time strategies that we hadn't done before." The design intent was to generate excitement about who the Lottery is and what they do. "It was our first time with IPD and the first major Revit project. So it set the direction for the company and it was also a success with the client."

"One of the cool things about our firm is that we have both interior design and landscape architecture, so we think about something holistically," he says. This way of thinking helps LPAS to engage in new systems. One of the first total–precast concrete mixed-use structures in California to employ the precast concrete hybrid moment frame as its chief means of seismic resistance was the 800 J Lofts in Sacramento. LPAS used the precast concrete hybrid moment frame because of its ability to resist seismic forces and to expedite the construction process.

CALIFORNIA LOTTERY HEADQUARTERS
The design of the California Lottery headquarters conveys the excitement of the lottery and embeds their brand into the architecture and interiors. Photo: LPAS Architecture + Design.

J LOFTS
800 J Lofts was the first total–precast concrete mixed-use structure in California to employ the new precast concrete hybrid moment frame as its chief means of seismic resistance. Photo: LPAS Architecture + Design.

Owyang remembers the 800 J Lofts. "It had so many benefits that translated to the owner and met all the program requirements." One of the benefits of the precast concrete hybrid moment frame is its ability to absorb and withstand seismic events. "One of the beautiful things about that system is you get an incredible exterior, a beautiful finish, and completed structure at the same time." Owyang compares it to other systems: "With a steel building you have to clad it. The precast is all in one."

"On the Roseville project, it gave us a chance to revisit that precast system." Owyang adds that "it was a great choice and it provided benefits to owner." The owner, the City of Roseville, was great to work with and saw the long-term value that offset the higher first cost of going to hybrid moment frame. Civic buildings have to make responsible use of public funds and provide a long-lasting structure, and at the same time cost less to own and maintain."

J LOFT INTERIOR
The interior precast concrete at 800 J Lofts was left exposed. Integrated high-end architectural finishes on structural elements fully express the design intent. Photo: LPAS Architecture + Design.

SECRETS TO GETTING THE BEST OUT OF IPD

"It is important for us as architects to understand the owner's expectations. There are always budget limitations and schedule constraints with any program." LPAS prides themselves on going the extra mile and finding opportunities to add design in areas where it may not been feasible initially. They always look for opportunities to integrate corporate culture into the physical structure.

BEING AN ARCHITECT

"What is so cool about what we do is that there is always another new project, another chance to get involved. There is always another client, more problems to solve, and something new to create. I don't think I could work in a repetitive work environment every day. It wouldn't be as much fun," Owyang reflects. "The most challenging and frustrating thing in my profession is putting so much investment of everyone's efforts, talents, and skills and not seeing the projects get built. Some of my best projects never were built! We can only wonder what it would be like. It is an art form that doesn't always get realized."

When he isn't sketching at his drafting table, Owyang finds time to play golf. "I used to be all about work. I was lucky to get introduced to golf fairly late in life—in my 40s—and now it is a secondary passion." Owyang enjoys the sport but also realizes that it's also a good opportunity for business connections and to foster relationships. He regularly golfs with a foursome of friends who are old high school classmates. He had his first hole-in-one on the infamous number 17 at Pebble Beach last year. "When asked about it at a business event, it occurred to me that that will now be my legacy!"

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Photo: Cooper Carry.

PIEDMONT CENTRAL STUDENT HOUSING FACILITY

LOCATION
Atlanta, Ga.

PROJECT TYPE
Student housing

SIZE
252,000 ft²

COST
$45.5 million

DESIGNER
Cooper Carry, Atlanta, Ga.

OWNER
Corvias Campus Living, East Greenwich, R.I.

STRUCTURAL ENGINEER
Pruitt Eberly Stone, Atlanta, Ga.

CONTRACTOR
Choate Construction, Atlanta, Ga.

PCI-CERTIFIED PRECASTER
Metromont, Hiram, Ga.

PRECAST COMPONENTS
1803 components, including wall panels, prestressed decking, beams, columns, and stair tread and risers sections.

HOUSING BENEFITS FROM Precast's Resiliency

Advantages in reduced long-term maintenance needs, resistance to fire, high winds, seismic events, and enhancements to safety factors can be created for all types of housing structures

— Craig A. Shutt

Developers of residential housing spaces face key concerns in designing their spaces. They need to make them attractive, affordable, and functional, but they also must build in resiliency that reduces their long-term costs and protects residents from potentially hazardous situations. Many designers are finding that precast concrete structural and architectural components can help achieve these goals.

Precast concrete's inherent inorganic composition can provide a long service life that reduces maintenance time and costs, owing to the panelized system that creates few joints and other benefits it provides. Casting bricks into the panels eliminates costs for tuck-pointing or repairing leaks through many small openings. It also provides a durable, easily cleaned surface. Interior walls made with precast concrete create sturdy surfaces that aid with the often hard use that rental properties can incur.

Precast concrete also can aid with hazard-protection needs, such as resistance to severe storms, hurricanes, and even earthquakes. Designers can use the benefits of a total–precast concrete system to ensure their buildings stand up to nature's wrath and provide a safe haven during harsh weather.

Safety measures also can be enhanced. Precast concrete offers inherent protection from fires, by minimizing flame spread and providing passive fire protection that works even if other systems cut out. It also has no compounds to exacerbate smoke dangers during a fire. It emits no VOCs, improving indoor air quality during construction and long after, and it contributes little waste to the jobsite.

The following examples show some of the ways that precast concrete designs can aid housing projects and help them meet the variety of challenges that arise in balancing all of the functional, aesthetic, and budgetary needs these buildings create.

PIEDMONT CENTRAL STUDENT HOUSING FACILITY

Georgia State University administrators took a new approach to developing a 1150-bed student-housing project at its Atlanta campus. The building represented the first public-private partnership (P3) project in the state, built and operated by Corvias Campus Living for the university. To help achieve both short- and long-term goals, designers used a total–precast concrete structural system and architectural wall panels on the building.

The 252,000 ft^2, 11-story housing facility, known as Piedmont Central, houses first-year students, and is designed to help them meet and socialize smoothly. Eight programmatic concepts were developed, including such activities as

exercise rooms and meeting spaces, with each floor offering a different program suggested by varying color coding. Each floor includes a socializing area (painted purple) with microwave, TV, and laundry room. Housing suites contain two bedrooms with separated toilet and shower rooms to avoid congestion as well as its own HVAC controls. An exterior courtyard also encourages interaction.

"Our design considered how an individual student emerges and succeeds within the environments that make up the college residential experience," explains Tim Fish, principal in the Higher Education division for Cooper Carry, the architectural firm on the project. "Spaces for individual, group, and community interaction were carefully placed and sequenced to enrich the experience and developmental phase of a student."

The total–precast concrete framing solution was developed early in the process, he notes. General contractor Choate Construction was brought onto the project early, creating a construction-manager type of collaboration. "Together, we evaluated different systems, but what really drove our choice was the tight schedule and subcontractor availability," he says. "With student housing, you have to hit that opening date. There's no such thing as not finishing on time for the beginning of the fall semester."

In all, 1803 precast concrete components were constructed, including wall panels, decking, beams, columns, and stair tread and riser sections. The typical 11-in.-thick insulated sandwich wall panel is 12 ft tall floor-to-floor by 24 to 44 ft wide. The typical 8-in. prestressed deck panel is 11 ft wide by 23 ft long for the minor spans and 29 ft long for major spans. Metromont fabricated all the precast concrete components.

PIEDMONT CENTRAL STUDENT HOUSING FACILITY
Piedmont Central at Georgia State University in Atlanta features a total–precast concrete structural system and architectural treatments for the panels that tie the building to the university. Photo: Cooper Carry.

LATE CHANGES COMPLICATE DESIGN

The design came together very quickly, with efficient input from the school and Corvias on the programmatic elements to include. That was complicated by the addition of a dining hall, which was considered but not included until after design was under way. "That played into our existing desire to provide long-span capabilities to facilitate layouts," he says. "The total–precast concrete framing helped minimize columns."

The system also helped reduce congestion at the tight, downtown site, which was bounded by two streets and property boundaries. The construction staging area was minimal, especially once space that was designated for the connecting dining hall at ground level, requiring additional planning for mechanical, electrical, and plumbing (MEP) accommodations.

Designers worked closely with the precaster and MEP contractors to work out all penetrations and layout needs. "We've done many parking structures and skins, but not a full building using an entire system," Fish says. "There was a learning curve to work out what could be done and how to determine the shear values and penetration needs. We knew we needed to have everything set before we went to production, which also sped up the erection."

'We were involved early in the process and helped them understand the benefits and constraints of the precast system.'

BIM plans were used extensively to review engineering details, including window openings, MEP penetrations, shear-wall placements, and expansion joints, he notes. "The precaster was very interactive at the schematic-design phase and helped create efficiencies. There was a lot of sharing of models and adjustments as it progressed. We found a lot of economies in the system. Precast concrete was integral to every facet of the project, creating the structure, forming the walls, and defining the process."

Adds Jeff Wenkel, director of project management at Metromont, "We were involved early in the process and helped them understand the benefits and constraints of the precast system. We helped optimize panel sizes for erection and cost to keep it under budget while still efficient. That helped ensure the design would translate smoothly to the field."

The load-bearing exterior panels were cast in both 10- and 11-in. widths, with 3 in. of expanded polystyrene insulation sandwiched between two wythes of concrete. That gave the panels an *R*-value that exceeded the energy code requirements while saving time for finishing. Both the exterior and interior sides were finished, with the interior receiving a hard-troweled finish that was painted. Interior load-bearing panels also were used to cut requirements for span lengths in half.

THE FIRST PUBLIC-PRIVATE PARTNERSHIP (P3) PROJECT IN THE STATE
The new dormitory was the first P3 project in the state and was designed to house first-year students and encourage socialization. Photo: Cooper Carry.

INVERTED T-BEAM FLOOR

The floor system features the precaster's Metrodeck system, which consists of inverted T beams with beadboard insulation ribs covered with a poured topping. The combination creates a sturdy floor component with voids that reduce weight while expanding its length, similar to hollow-core without being an extruded product, Wenkel explains. The deck rests on the load-bearing wall panels, after which light-gauge steel

The building, erected in only five months, was completed in phases so interior trades could begin work while the next section was erected. Photo: Metromont.

framing was installed to create individual rooms. The ceiling side has a smooth finish, and it was painted after installation.

The system creates a variety of resilient benefits, including fire resistance. "The precast concrete components easily met all of the fire-rating requirements for student housing," Wenkel says. "No additional fire proofing or design changes were needed." That also proved true for meeting wind-load requirements and seismic needs, adds Fish. "We provided the precaster with the code specs and footing designs, and the engineers provided the connections we needed."

'The system also helped reduce congestion at the tight downtown site, which was bounded by two streets and property boundaries.'

Acoustic control, a key challenge for student housing, also was addressed by the precast concrete framing system. "The insulated exterior wall panels solved the problem of external noise interfering with interior activities very effectively," Fish says. Insulation also was added to corridor walls to dampen sound, but not to demising walls.

Three finishes were used on the exterior façade: a medium sandblasted buff color, replicating limestone; cast-in red thin brick; and vertical runs with a smooth finish that were painted in the schools' signature blue color after installation.

"The university wanted to create an appearance that identified the building as part of the campus and wanted a signature building to achieve that," Fish explains. The campus is spread throughout the downtown Atlanta area, with no defined area. "Creating a

FLOOR SYSTEM FEATURES
The precaster's Metrodeck floor system features inverted-tee beams with beadboard insulation ribs covered with a poured topping. Photo: Metromont.

presence was critical to making the building stand out as part of the university."

The brick was chosen for its strong visual appearance, he adds. "We almost went with a darker tone, but decided this red made a better statement." The thin brick was limited to key areas to maintain the limited budget while maximizing its presence. One-foot-square mock-ups were created of several options before a standard 4- by 6-ft mock panel was created of the final choice for review.

A high-performance concrete stain was used to create the blue stripes. "We weren't sure the blue stain was going to work as they desired, but it came out looking really nice," Wenkel says. "The brick works against it very well, so all of the finishes came together well."

Erection of the components moved quickly, taking five months through the fall and winter. The components were erected in sections, allowing interior trades to begin work on the first portion while the second half was constructed. A six-man crew erected the building, with loads delivered on a just-in-time basis to the busy area, where only two loads could be parked at a time. Trucks were brought in at night to avoid traffic congestion. "Once it started, it went up very fast," says Fish. "They were erecting about one floor per day."

Those savings in scheduling ensured the building opened on time with all finishes complete. "Everything moved smoothly despite the need to adapt and keep moving ahead," Fish says. "Everyone was very pleased with the system, especially that it helped us open on time. We've seen a lot of interest in the design from our colleagues on how we did it."

ACOUSTIC CONTROL
To aid with acoustic control, insulated load-bearing precast concrete wall panels were used along corridors as well as on the perimeter. Photo: Metromont.

CHICAGO AFFORDABLE HOUSING

Two related but quite different affordable-housing projects in Chicago, Ill., show the benefits of total–precast concrete structures to create residential housing that meets functional, budgetary, and aesthetic challenges. The first, the Burnham at Woodlawn Park on the city's South Side, was designed to serve as the centerpiece to a community-initiated revitalization plan.

The mixed-use, mixed-income project, replacing an obsolete and distressed public housing building, was created by Preservation of Affordable Housing (POAH) with the encouragement of residents and a grant from the U.S. Department of Housing and Urban Development's Choice Neighborhoods program aimed at improving affordable housing neighborhoods.

"The project's goal is to bridge the neighborhood's past and future and help care for its residents as they age," explains Jack Schroeder, senior associate and project manager at Landon Bone Baker Architects, the architectural firm on the project. The five-story building provides 65 seniors with a healthy home and houses POAH's management and operations headquarters. It also includes a resource center for residents that provides financial and

THE BURNHAM AT WOODLAWN PARK
The Burnham at Woodlawn Park, a mixed-use, mixed-income replacement project in Chicago, Ill., features load-bearing precast concrete wall panels with embedded thin brick and other architectural detailing, hollow-core and other precast concrete components. Photos: Scott Shigley.

employment counseling, public-benefits screening, health services, and other needs.

"The project is supported by the Department of Housing and Urban Development as well as the city, so we were looking to keep it as cost-effective in all ways as possible," says Schroeder. "Using a total–precast concrete structural system helped achieve that and provide additional benefits." The system won out during an early evaluation of several systems. "The client was pretty savvy about materials," he says. "They had an interest in using it and had used it in the past, so it was favored."

The system comprises 228 pieces of precast concrete, including load-bearing architectural wall panels with embedded thin brick, interior wall panels for stair and elevator cores and interior demising walls, beams, columns, hollow-core slabs, stair risers, and solid-slab landings. ATMI Precast fabricated the precast concrete components.

THE BURNHAM AT WOODLAWN PARK

LOCATION
Chicago, Ill.

PROJECT TYPE
Affordable housing

SIZE
73,673 ft²

COST
$16,650,000

DESIGNER
Landon Bone Baker Architects, Chicago, Ill.

OWNER
Preservation of Affordable Housing, Chicago, Ill.

STRUCTURAL ENGINEER
C.E. Anderson and Associates, Chicago, Ill.

CONTRACTOR
Linn-Mathes Inc., Chicago, Ill.

PCI-CERTIFIED PRECASTER
ATMI Precast, Aurora, Ill.

PRECAST SPECIALTY ENGINEER
Precast Engineering Co., Chicago, Ill.

PRECAST COMPONENTS
228 pieces encompassing 41,407 ft², including 10-in. solid exterior load-bearing architectural panels, 8-in. solid interior wall panels for stair and elevator cores and demising walls, beams, columns, 10-in. hollow-core slabs, stair risers, and solid-slab landings.

FIRE RATING FOR THE BUILDING
The precast concrete structure provided an inherent high fire rating for the building, which was a key requirement for housing senior citizens. Photo: Scott Shigley.

FIRE RESISTANCE A MUST

Because the building was intended to house senior citizens, providing high fire resistance was a key issue. "Precast concrete gave us a simple way to reach the fire rating we needed," Schroeder says. "Had we used metal studs, we would have required layers and layers of drywall to achieve the same rating. This was a much easier way to go. It provided a great simplicity to the fire design."

Despite being in the Windy City, wind resistance also proved not to be an obstacle thanks to the concrete system. "It naturally exceeded all codes for wind elements. It inherently met the code without any beefed-up connections for this zone."

Sound attenuation also was a focus, and the concrete system inherently met that need, too. "We didn't need to add insulation between levels or units," he says. "The density of the precast concrete dampened noise levels to our goal."

That was a dramatic improvement over past projects, he notes, including three three-story buildings done with wood frame and truss construction. "In those buildings, sound is a problem. In meeting rooms on the first floor, you can hear kids playing overhead. For this building, with their management spaces and community rooms on the first floor, we wanted to eliminate that."

'Precast allowed us to build quickly and efficiently.'

Interior walls were furred out and drywalled to provide a traditional interior space for the seniors. Ceilings, consisting of the underside of the hollow-core slabs, received a popcorn finish while the top side received a topping and carpeting.

Site security was also a key issue for the seniors, especially as the first floor was composed entirely of public and shared-amenity programming. Those concerns were addressed by increasing visibility within the building via floor-to-ceiling glazing on the entire first floor, shared outdoor porches dispersed throughout the residential floors, and an abundance of in-unit windows. "Precast concrete's design flexibility allowed the construction to support these features in an integrated, cost-effective way," Schroeder says.

AESTHETIC SHOWCASE CONCRETE

The exterior finish was designed to allow the material's raw strength to shine through. "Rather than trying to impersonate brick, the client's design concept was to express the construction method and materiality with a depth of color and textures," Schroeder says. An Endicott Utility-sized thin brick was used, along with white cement and pigmented concrete with an acid-etched finish.

"The goal wasn't to impersonate masonry but to let the concrete show as design elements," he explains. The team performed studies on other combinations, including laid-up red brick with inset steel panels for accents. "As we got into it and looked at more examples, the better we felt about allowing the concrete to express itself."

A slate-gray color was chosen to contrast with but complement the gray concrete. "We liked how the dark color anchored the base. To use it on the entire building would have made it too foreboding, but it worked well as an accent."

ATMI served in a design-assist capacity to help create efficient designs and optimize panels. "We were all ears for their suggestions," Schroeder says. "We wanted to be as collaborative as possible to create efficiencies anywhere we could." ATMI created multiple samples for evaluation by the owners. "The client wanted to know what they were going to be getting in terms of finishes, textures, and stains. We looked closely at the edges of formwork and window returns."

The building was erected with one crane in two phases, to allow interior crews access faster. Components were delivered on a just-in-time basis, with each truck having its pieces picked from the bed. "The front of the building was very congested, so there was little room to create a staging area." Only the sidewalk sections of the street were closed off during construction.

"The speed of erection was a major factor in saving money," he adds. "We were in business building the structure much faster than we typically would have been. It was impressive to see the speed with which it could go up."

The group was pleased with the results of their design. "They've expressed how much they like it," he says. "The building carefully blends into and enriches the surrounding neighborhood and promotes a wider transformation," Schroeder says. "The group's redevelopment goals are embodied in the programming and architectural design of this centerpiece building."

TERRACE 459

On Chicago's North Side, another project developed shortly after the Burnham by the same architectural firm for a different client used a similar framing system in a different way to achieve a striking design. Terrace 459 is part of the Parkside of Old Town mixed-income public housing development, developed as part of the Chicago Housing Authority's Plan for Transformation. The goal is to integrate public housing and its residents into the larger social, economic, and physical fabric of the city. It replaces a portion of the well-known Cabrini-Green facility that was torn down due to its deterioration and high density.

The 160,000-ft^2 building contains 36 units for former Cabrini residents, 27 affordable units, and 43 market-rate apartments, in addition to supplemental off-street parking. The north-facing wall along the street is lined with active office, lobby, and common spaces, while the south back wall features two-story townhouses, creating a welcoming view from the back of the smaller apartments.

The initial design for the building's structural system focused on creating a two-story, cast-in-place concrete parking structure with the housing built on top. But the need to use large transfer beams to direct the loading created too high of a budget.

"We threw out the notion of using a total–precast concrete structural system, and it stuck," says Tom Dreher, senior project manager at Linn Mathes Inc., the general contractor. "The precast system was the same cost as a cast-in-place concrete by function, but we could combine architectural and structural functions with the precast concrete system. That made it a slam dunk to take that approach."

The client was open to using precast concrete from the beginning, which aided the conversion, he notes. "We sat down with the precaster early on to set parameters for perimeter columns and slab-edge positioning. Then the architect worked within those parameters to design the building."

The building features load-bearing architectural precast concrete walls, hollow-core slabs, interior walls, beams, and columns. The designers also created a balcony system for each corner unit that added key structural challenges and additional difficulty to the precast concrete erection. Spancrete fabricated all of the precast concrete components.

PARKSIDE OF OLD TOWN

LOCATION
Chicago, Ill.

PROJECT TYPE
Mixed-income housing

SIZE
160,000 ft^2

COST
$27.4 million

DESIGNER
Landon Bone Baker Architects, Chicago, Ill.

OWNER
Holsten Real Estate Development & Management Corp., Chicago, Ill.

STRUCTURAL ENGINEER
C.E. Anderson and Associates, Chicago, Ill.

CONTRACTOR
Linn Mathes Inc., Chicago, Ill.

PCI-CERTIFIED PRECASTER
Spancrete, Waukesha, Wis.

PRECAST COMPONENTS
1133 components, interior wall panels, exterior wall panels, beams, columns, and 8 ft-wide, hollow-core slab.

BENEFITS OF PRECAST CONCRETE DESIGN
The precast concrete design, which was value-engineered when earlier designs exceeded the budget, aided fire resistance, sound attenuation, construction speed, and other factors. Photos: David Schalliol via Landon Bone Baker Architects.

"We worked closely with the contractor and precaster to develop a precast concrete floor and wall system that delivers an integral structure and skin, a tight envelope, and cost-effective fabrication and assembly," says Tyler Brown, a senior associate at Landon Bone Baker Architects. "Our initial concept didn't follow the structural logic for precast, but once we understood the precaster's approach, we both got excited about it. It made sense economically and architecturally as well as structurally."

The architect's goal was to bring a human scale to the large building, creating modular panels that mediate complicated design constraints, such as planning mandates, program and parking requirements, massing and site relationships, and unit layouts ranging from studios to three-bedroom units, each with a balcony.

The precast concrete system was used to create one below-grade parking level and one at grade level. The below-grade parking level features precast concrete wall panels on cast-in-place concrete caissons and perimeter foundation walls. Cast-in-place transfer beams, cast in the parking level's ceiling, were 5 ft deep and 1-ft 2-in. thick to bear on 4-ft-wide and 1-ft 2-in.-thick columns. That created the base for the first-floor load-bearing walls, and the building built up from there with hollow-core slabs set on the panel tops.

The panels had spray foam applied to the interior side prior to furring out and drywalling the interior spaces, which provided continuous insulation without disruption from the studs. The hollow-core slabs included a 2-in. topping with carpet tile or vinyl, wood-like planks, while the ceilings were left exposed and were painted. Kitchens and baths feature drywalled soffit areas.

The concrete framing system aided with a variety of resiliency features, especially fire resistance, which is important in mixed-income residential units on this scale. "We definitely needed high-quality fireproof construction, and precast concrete met that goal handily," Brown says. It also aided in providing the fire-separation layer required between parking and occupied spaces.

Additionally, it improved acoustic control. "Sound is always an issue in mixed-income residential developments," he says. "It's coming up more frequently with clients because it's seen as adding value, and precast concrete helped us achieve that."

The corner balconies, backed with painted stucco facing, create a colorful checkboard pattern up the building. "En masse, the checkered panels mimic the shared design for a more equitable community full of character and supported by the sum of its parts," the designers noted in its description of the project.

The balconies created a key erection challenge, as two levels of panels had to be erected to install the balcony in between, due to the opening below and above each. A large window opening alternated on each level with the balcony opening and railing, which faced in the direction perpendicular to the one above or below.

"It was logistically challenging," says Auggy Chung, regional business development manager for Spancrete. The upper panel supports the flooring on the alternating side, requiring the upper-level panel to be set and braced to support the flooring below while it was welded into place. The panels had to be tied together by bracing two stories at once. "The erection was challenging but was necessary to achieve the architectural look."

The erection was complicated by the tight site, which required careful planning to maneuver the crane into the proper position for each lift. The components were erected on a just-in-time basis. This system allowed the construction to move quickly despite the busy streets surrounding the project and erecting the components through one of the coldest recent Chicago winters. "We kept going, whereas it would have crippled cast-in-place concrete," Chung notes. By spring, the envelope was completed and interior trades began their work.

The architect's work on this project, and the slightly earlier Burnham one on the south side, encouraged it to use the precast system more often. "We're looking at using this system on other affordable housing projects now," says Brown. "These decisions are often driven by cost, and pricing it out shows that the advantages are pretty clearly to precast concrete. It adds so much in helping with fire resistance, sound attenuation, construction speed, and other conditions."

BENEFITS OF PRECAST CONCRETE DESIGN
Two levels of panels had to be erected to support the balcony in between. A large window opening alternated on each level with the balcony. Photo: Landon Bone Baker Architects.

RESILIENCY
The precast concrete shell provides high resiliency, which was required at this location along a river near salt water and in a high-hurricane-wind zone. Photos: Finfrock.

HYATT HOUSE NAPLES/5TH AVENUE

Finding a developer willing to install a new concept in precast concrete flooring presented a daunting challenge for the manufacturer. Finfrock overcame this obstacle by serving as both developer and design-build team on a new Hyatt hotel in Naples, Fla., that features a total–precast concrete structural framing system. Their concept overcame the franchise administrators' skepticism and helped complete the project nearly one year earlier than other franchises.

The waterfront hotel features 183 extended-stay rooms, mostly one- and two-bedroom suites with balconies. Amenities include meeting spaces, indoor/outdoor cocktail bar and restaurant, resort-style swimming pool, docks, and 211 structured-parking spaces. The hotel, with a British West Indies-themed ambience, is located in an upscale community noted for the arts, fine dining, and resort-style living.

Knowing that getting a designer to specify an unknown system would be difficult, Finfrock decided to serve as its own customer. The firm performs most construction services, including contracting, engineering, and manufacturing of precast concrete components. The firm decided to serve as developer and hire its own crews for design and construction. "This project is about as Finfrocked as it could be," explains Bill Finfrock, president of the firm.

A developer acquaintance had unused land, so Finfrock purchased the lot and approached Hyatt with his plan. Hotel officials were skeptical of the schedule, but they approved it. "They said they expected it would take us a year longer than we outlined, the same as another project they approved then," he says. "We showed them differently."

FLOORING SYSTEM FEATURES VOIDS

The flooring system, which had been in development for 10 years, features two 2½-in.-thick wythes of concrete with a series of steel angles and bars through the center acting as joists. The void lessens weight, allowing longer spans. The slabs can be cast up to 12 ft wide and 68 ft long, depending on the depth of the void. The 68-ft-long slab, for instance, requires a void of 19 in., so the floor's full depth would be 2 ft.

Plumbing runs and other mechanical systems can be placed into the void prior to finishing, with blockouts created for penetrations. "Trades don't have to measure and cut holes, they just install their hookups," Finfrock explains.

The system was designed in 3-D using building information modeling (BIM), integrating the structural and subsystem designs into one common 3-D model, explains Jorge Arboleda, director of architecture for Finfrock. "Conflicts were noted and solved in the model by project designers rather than in the field," he says. "Resolution of conflicts at this level eliminated errors and change orders, considerably reducing the on-site schedule." Adds Stan Jones, COO at Finfrock, "There were several thousand penetrations in the

HYATT HOUSE NAPLES/5TH AVENUE

LOCATION
Naples, Fla.

PROJECT TYPE
Franchised hotel

SIZE
205,283 ft^2

COST
$31 million

DESIGNER
Finfrock Design Inc., Apopka, Fla.

OWNER
Naples 5th Avenue Hotel LLC, Apopka, Fla.

STRUCTURAL ENGINEER
Finfrock Design Inc., Apopka, Fla.

CONTRACTOR
Finfrock Construction Inc., Apopka, Fla.

PCI-CERTIFIED PRECASTER
Finfrock Industries Inc., Apopka, Fla.

PRECAST SPECIALTY ENGINEER
Finfrock Design Inc., Apopka, Fla.

PRECAST COMPONENTS
991 components, including spandrels, double tees, litewalls, columns, beams, curbs, spanning members, flat slabs, stairs, and wall panels.

THE FLOOR SYSTEM
The floor system offers spans of up to 68 ft, providing open spaces on the first floor while offering needed support for upper-story wall dividers. Photos: Finfrock.

building, and we had to manipulate only six of them at the site."

The precision was aided by the company's laser-guided layout system in the plant. The BIM coordinates were fed into the system, and lasers outlined precisely where blockouts and partition layouts should be located. The products then have lines marked on them for field installation of partitions, further speeding construction. "This approach eliminated the need for shop drawings, because the detailed drawings showed just where penetrations needed to be," Arboleda said.

Such precision helped with layouts, which had to combine precast's capabilities with Hyatt's strict requirements, he notes. "Hyatt has set sizes and layouts for hotels, and those can't change to ensure consistency between markets," he explains. "We had to use Hyatt's placement requirements and fit it into the precast concrete shapes. The flexibility of precast concrete ensured we had few problems achieving that."

The load-bearing wall panels that support the flooring system feature solid walls with rigid foam sprayed on the interior side to provide continuous insulation. The panels interior face was used for many interior walls, although along the perimeter they were furred out and drywalled, says Zach Horvath, architectural project manager. "You really can't tell the difference in the spaces, because the finish was very smooth."

The floor system was set on the tops of the walls and is buried in its width. The erection moved quickly, as the floor system had form-finished sides for floors and ceilings. Floors required no topping, and ceilings were painted with minimal preparation. The building was erected in 20 zones for its full three-story height, erecting the panels vertically. This format allowed interior trades to gain access to follow quickly behind the shell erection. As a result, the building's construction was completed in 11 months.

SOUND CONTROL CRITICAL

The hotel is located below the flight path to a local airport, so sound control was critical. "The precast concrete provided a strong base, but the windows were a weak link," says Finfrock. To counter that, designers specified double-pane units with a 7-in. thermal break to dampen sound. "Typically you get noise from outside in a hotel room," says Jones. "It's a weird sensation to stand at the window in one of the rooms and hear nothing from outside."

The precast concrete shell provides high resiliency, which was required at this location along a river near salt water and in a high-hurricane-wind zone. "Precast provides excellent durability and wind resistance while minimizing the effects of corrosion due to salt water, as well as mildew resistance due to humidity," Arboleda says. The building's low profile helps with hurricane protection, Finfrock notes, with connections geared to code requirements in that zone. "It's well protected and sturdy. It's a concrete box."

Reaction to the building's design and speed of construction has been gratifying, Finfrock says. "It definitely set a record for Hyatt. They were blown away by our ability to complete the project on time." Travelers too have taken note. The hotel quickly moved to the number-one hotel in its market just six weeks after opening, Finfrock says.

"We knew the system's benefits, but we were relieved to have it go so smoothly on the first try," Jones says. The project now serves as a showcase for other designers—and a chance for the fabricator to improve its system. "We definitely learned some tweaks," Finfrock says. One such involved redesigning the end beams with a new pick hookup, which will save 20 minutes per piece. End pieces also will be welded, to lessen grouting needs.

"It was our first use, so we knew there would be a learning curve," says Arboleda. "We knew there were great benefits, and now we know how to cast it to get the most out of it." Adds Jones, "Nobody wants to be a guinea pig, so we took that on ourselves. Now we can get people in to see it and the benefits it provides."

These projects show some of the ways that precast concrete structural systems and architectural panels can aid housing projects. Their ability to meet functional and aesthetic needs while offering high-performing resiliency capabilities ensure precast concrete designs provide attractive appearances, efficient designs, and cost-effective structures.

AN INTEGRATED SOLUTION FOR

Insulated Precast

Photos courtesy of U.S. Department of Energy

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SPOTLIGHT

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PRECAST OFFERS Safe Haven

Standards for FEMA storm shelters—required in some parts of the country—have been revised and upgraded. Precast concrete helps meet these needs with quick, economic construction

— Craig A. Shutt

KICKAPOO HIGH SCHOOL
The new Kickapoo High School safe room, seen at the far right, connects seamlessly to the existing school building on both the exterior and interior. Photo: BKDC.

School administrators in many parts of the country, especially through the Midwest's "Tornado Alley," have added safe rooms to their buildings to protect faculty and children against the damaging impact that storms can create. The 2015 International Building Code (IBC) requires such rooms in certain educational facilities, leaving it up to districts to conform to those standards. Many designers have turned to precast concrete systems to meet the needs for safe, protected spaces with economical, functional, and attractive designs.

"It's only a matter of time until a major tornado strikes while a school is in session," says Brian M. Orr, a principal at Toth and Associates Inc. in Springfield, Mo. Toth has been designing safe rooms for 15 years and is on the technical steering committees for updates to Federal Emergency Management Agency (FEMA) publications P-320, P-361, and P-431 that govern requirements. The firm has designed more than 100 safe rooms that encompass more than 1 million ft^2 and protect nearly 150,000 occupants.

MORE STRINGENT STANDARDS

Toth notes that the latest edition of the FEMA standards make more stringent distinctions between a "FEMA safe room" and an "ICC (International Code Council) 500 storm shelter," which has fewer requirements. Safe rooms offer more versatility for schools, as they can be used for other functions, such as a gymnasium. The ICC 500-2014 upgraded a number of provisions for these rooms, and includes key structural features such as:

- Two-hour fire separation
- 100-mph missile impact resistance
- Resistance to pressure and uplift from 250-mph winds
- Tested and approved door assemblies or protected vestibules
- Design for collapse load of adjacent structures and a 100-lb/ft^2 rubble load.

Per the 2015 IBC, section 423.4, schools in an area that can encounter 250-mph shelter-design wind speeds are required to provide a safe room, Toth notes. That has become easier as more manufacturers, especially of windows and doors, are offering better products targeted to meet the

upgraded needs. "Prices have dropped tremendously on these products, with more variety in larger sizes. The options are much better to meet any type of room need."

Toth normally prefers to use precast concrete for the structural system of the rooms, regardless of their location or function. "Precast offers a structurally consistent material, and its applications continue to grow." Those include capabilities to produce 50-ft-tall walls and new aesthetic options. "Precast concrete safe rooms don't have to be square concrete boxes," he says. "There are many architecturally pleasing designs that can be created with finishes and inset brick."

The benefits of using precast concrete components are varied, he says. They include ease of construction, consistent high quality of fabrication from certified plants, design flexibility through long spans and tall walls, integrated insulation, fast fabrication and delivery due to proximity of plants to sites, and short required lead times.

Some administrators and designers have shied away from incorporating precast concrete safe rooms into their facilities, owing in part to their belief in various myths that exist about the spaces (see sidebar p. 35). Education and awareness are key to ensuring schools receive the best protection at the most economical cost.

'Precast offers a structurally consistent material, and its applications continue to grow.'

KICKAPOO HIGH SCHOOL SAFE ROOM
Kickapoo High School in Springfield, Mo., recently built a safe room that doubles as the school's performing-arts center. Photo: BKDC.

STATE-OF-THE ART PERFORMANCE SYSTEMS
The Kickapoo High School safe room and performing arts center features state-of-the art performance systems, an orchestra pit, and a fly loft for lowering sets. Photo: BKDC.

DUAL-USE ROOMS

Integrating a safe room into the building by allowing it to perform another function, such as a gymnasium, band room, or even larger classrooms, provides the best approach, he says. "Dual-use safe rooms give a sense of comfort and familiarity to younger children during severe weather events, reducing stress," he points out.

The thick, insulated concrete walls assist in dampening sound transmission, adding benefits to cafeteria and band room applications, he notes. "With FEMA-rated window assemblies now available, classrooms can be used and still provide natural light and bright, airy spaces."

'Dual-use safe rooms give a sense of comfort and familiarity to younger children.'

They also can be integrated into new additions with transition to the safe room occurring seamlessly both on the interior and exterior. Precast concrete aesthetic designs can aid this, especially if the existing school features a traditional brick façade, by using similar inset thin brick or using formliners and stains to replicate the brick size and color.

Safe rooms also can be created for other facilities besides schools, he notes. Toth has designed them for parks and recreation buildings, fire and police stations, community centers, city halls, and hospitals. All can serve as safe havens for people in the vicinity when danger strikes.

TOTAL–PRECAST
A total–precast concrete structural framing system was used to construct most of the performing-arts center at the Kickapoo High School. Photo: Prestressed Casting Co.

KICKAPOO HIGH SCHOOL

A recent example of how precast concrete components can create successful designs is the Kickapoo High School safe room in Springfield, Mo. The facility serves as a performing-arts center and was built adjacent to the existing high school, connecting to the main building. In addition to offering state-of-the-art theater systems, an orchestra pit, and a fly loft for lowering sets, it serves as the school's safe room.

The structural system consists of a total–precast design, with a structural-steel fly loft diaphragm, used to shorten the fly loft structure while maximizing the interior clear height. Buxton Kubik Dodd Creative in Springfield, Mo., was the architect of record, while Prestressed Casting Co. in Springfield fabricated the precast concrete components.

The $9.9-million project features load-bearing panels with 4 in. of insulation sandwiched between an interior 6-in. wythe (the FEMA requirement) and an exterior 4-in. wythe. The panels were erected horizontally in a stacked configuration on the east and west faces of the fly loft, while the remaining wall panels were erected in a vertical format, with many serving as load-bearing walls. The panels on the north and south faces of the fly loft, which were erected vertically, feature 8 in. of insulation sandwiched between two 8-in.-thick wythes of concrete for a 2-ft thickness. That design was necessary to provide the required structural support at that height.

PRECAST RISERS SPECIFIED

Designers also specified precast concrete risers for the seating, which were part of the FEMA structure. The limited space required the panels to be erected with a crane inside the space, backing out and erecting the wall diaphragm as they went, with no shoring.

"The logistics of setting the seating were complex," says Dave Robertson, vice president of sales at Prestressed Casting Co., the precast producer and erector. The facility was built in two phases due to the large orchestra pit in the center, with one side erected after the other, after which interior trades did stage work and the erectors returned with a larger crane to button up the center.

That work was sped up by providing a steel-troweled finish on the interior sides, so they needed only painting to be completed. Exteriors also received a smooth finish that was painted.

CHALLENGES FOR THE ERECTION OF THE WALL PANELS
Precast concrete risers were installed for seating sections, creating challenges for the erection of the wall panels in the tight location. Photo: Prestressed Casting Co.

"This safe room worked only because we had precast concrete available to us and could hold a lot of preliminary design discussions with the precast producer to see if this could even be done," Toth says.

Safe Room Myths

Construction of safe rooms is sometimes delayed due to misconceptions about how they function and what is required. Here are some of the key myths that Brian M. Orr, principal, Toth and Associates Inc. in Springfield, Mo., hears:

Myth: Safe rooms have to be underground.

Fact: Above-ground safe rooms designed to FEMA standards can withstand the forces of an EF-5 tornado and provide near absolute protection.

Myth: It's cheaper to build underground.

Fact: Safe rooms can be built above-ground for less cost than below-grade options, eliminating many issues related to Americans with Disabilities Act (ADA) accessibility requirements and the potential for flooding.

Myth: They are single-use spaces.

Fact: Safe rooms can serve many roles, integrating into a building's everyday functions. Their capabilities can create benefits, such as dampening sound from gyms, band rooms, or theaters.

Myth: They can't have natural light.

Fact: New window products meet FEMA standards and natural light and a traditional appearance.

Myth: Hallways can serve as a safe room.

Fact: Hallways act as wind tunnels and do not have FEMA-rated doors to protect against flying debris.

Myth: Hurricane shutters provide sufficient protection.

Fact: Shutters are not designed for the higher wind speeds that a tornado can produce, and doors and roofs remain at risk.

Myth: Thick walls are all that's needed.

Fact: Thick walls will protect against debris and projectiles, but the entire envelope and its connections must work together to provide consistent protection.

NEOSHO HIGH SCHOOL IN NEOSHO, MO.
Neosho High School in Neosho, Mo., built a long, narrow safe room along the adjacent highway, presenting a new, signature look to passersby. Photo: Toth and Associates.

NEOSHO HIGH SCHOOL

Another challenging project was the Neosho High School in Neosho, Mo. The building, two stories tall and more than 300 ft long, with an 8:1 length-to-width ratio, was placed along the side facing the highway that was most prominent, due to a flood plain and bus routing on the other side.

"We had a very limited footprint and a long, skinny building to design, which created issues for a safe room," Toth says. The design incorporates multiple interior shear walls that act as room dividers to break down the scale. As shear walls, they were funded by a FEMA grant, which would not have been the case for interior divider walls, he notes.

The erection was complicated by the tight site and the need to work around existing trees and other obstacles. "It was a difficult location, especially with an active site," says Robertson, whose firm also fabricated these components. Sapp Design Associates Architects in Springfield, Mo., was the architect of record.

STRUCTURE FEATURES
The structure features load-bearing precast concrete walls and double tees that rest on haunches built into the panels. Photo: Prestressed Casting Co.

To create a signature look on the highway side (and to face the administration offices across the highway), three colors of brick were inset into the panels. "The new look makes a world of difference for the school," says Toth. "Precast concrete was the only material that could reach the goals that were set in an economical way."

'Precast concrete was the only material that could reach the goals that were set in an economical way.'

Funding for these projects from FEMA is available up to $3 million depending on the design, Toth says. Grants typically are given on a 75/25 ratio for the basic FEMA-approved shelter components, but construction costs typically work out to closer to 60/40. FEMA does not share costs for interior or exterior finishes and mechanical systems such as air conditioning.

The work already has paid off. The Neosho High School safe room withstood a tornado in February with no casualties. A school in Goodman, Mo., was struck on an April evening by a tornado, avoiding casualties but wrecking part of the building. Toth now is working on a design for their safe room.

"Both Neosho and Kickapoo are great examples," says Toth. "They show how engineers and PCI-certified precaster producers can work together from the preliminary stages to create designs that meet the architect and owners' requirements while resulting in buildings that have a major impact on their campuses."

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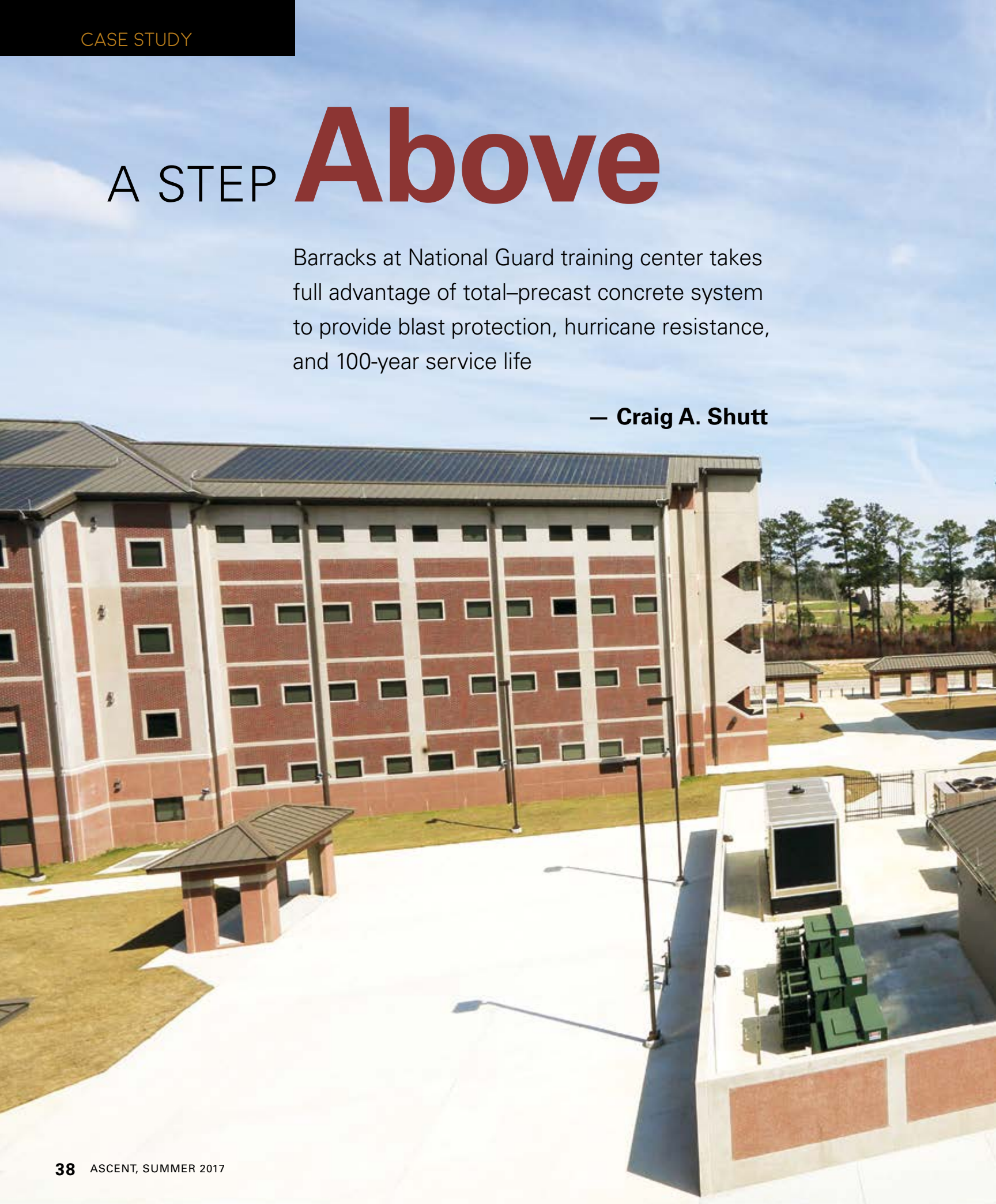
A STEP Above

Barracks at National Guard training center takes full advantage of total–precast concrete system to provide blast protection, hurricane resistance, and 100-year service life

— Craig A. Shutt



National Guard units set high standards for the buildings comprising their massive Operational Readiness Training Centers (ORTC), which transition soldiers from domestic duty to combat roles overseas and vice versa. The buildings must provide significant blast resistance as well as hurricane protection, energy efficiency, and a long service life to minimize maintenance costs. For the four-building barracks project built as part of Mississippi's new ORTC, designers found that a total–precast concrete system would help meet those needs.

The four four-story buildings comprising the barracks unit is the first phase for the development of the ORTC, which will be used by several states for guard training. The $50-million project encompasses 198,957 ft^2 and houses 1280 soldiers. The development also will comprise two officers' barracks, a dining hall, training facilities, eight company offices, a battalion office, a vehicle-maintenance facility, and storage buildings.

'We investigated alternative systems and determined the precast concrete design offered the best solution.'

THE FOUR-STORY BARRACKS BUILDINGS AT FORT SHELBY, MISS. The four-story barracks buildings at Fort Shelby, Miss., represent the first phase in the development of a new National Guard Operational Readiness Training Center (ORTC), which transition soldiers from domestic duty to combat roles. Photo: Johnson-McAdams.

INTERIOR SPACES
Long-span double tees provided open interior spaces. Walls consist of the interior face of the load-bearing precast concrete panels, which have a smooth troweled finish. Photos: Johnson-McAdams.

The new facilities replace outdated CMU buildings from the World War II era, essentially Quonset huts that offered simple sleeping quarters with no bathrooms or other amenities, explains Robin Henry, an architect and the project manager at Johnson-McAdams Firm, the ORTC designers. They created a master plan for the 12-building facility and will design each segment as they come on line.

"These spaces were just sleeping rooms, spread out over the base," Henry explains. "The new plan will significantly upgrade the facilities and condense them, adding space on the base by reducing the footprint needed for these functions."

TOTAL–PRECAST SYSTEM USED

The barracks feature a total–precast concrete structural system consisting of insulated sandwich wall panels, double tees, stair panels, stairs, and elevator panels. The designers specified the total–precast concrete system after the design development had begun, when the allotted square footage was reduced by 5000 ft^2 per building. The buildings had to still provide for all required functions and occupancy.

"This reduction without a corresponding reduction in occupant load or function created issues for us," Henry says. The designers value-engineered their concept for a structural steel frame with a typical veneered envelope to the total–precast structure. "The original concept wouldn't support the occupant load and the requirements for progressive collapse and other resiliency needs. The column placements we would need would interfere with the placement of beds. We investigated alternative systems and determined the precast concrete design offered the best solution."

The use of load-bearing exterior walls combined with long-span double tees eliminated the need

CAMP SHELBY ORTC

LOCATION
Camp Shelby, Miss.

PROJECT TYPE
National Guard barracks

SIZE
198,957 ft^2

COST
$43 million

DESIGNER
Johnson-McAdams Firm, Greenwood, Miss.

OWNER
Mississippi National Guard, Jackson, Miss.

STRUCTURAL ENGINEER
Johnson-McAdams Firm, Greenwood, Miss.

CONTRACTOR
Yates Construction, Biloxi, Miss.

PCI-CERTIFIED PRECASTER
Gate Precast Co., Monroeville, Ala.

PRECAST COMPONENTS
Total–precast concrete structural system consisting of load-bearing insulated sandwich panels in various sizes, double tees, stair panels, interior wall panels, interior wall panels with door and elevator openings, and stairs.

for additional structural columns, creating the flexibility needed to meet the occupancy requirements. The structural design was revised to feature precast concrete exterior and interior walls and partitions, with some nonstructural partitions made of concrete masonry. "Once this design path was taken," Henry says, "we looked at how we could utilize this system to improve the sustainability of the facility."

The total–precast concrete system had become familiar through the educational efforts of Gate Precast, which provided the components for the project. "We are working to get the military to change from block and brick construction to precast concrete," explains Mo Wright, marketing director for Gate and at the time sales director for the area. "We made several presentations in Savannah and Mobile, and they listened."

The concrete wall system features integral core insulation with a 4-in. interior structural wythe of concrete, 3 in. of insulation, and a 3-in. exterior architectural wythe. They provide the building with an *R*-value of R13.

The panels also provided the structural system, which is designed to resist progressive collapse. The panels are 14 ft 10 in. tall with a maximum width of 37 ft 8 in. and were designed to provide a counterlevered support for the structure above, acting as a counterlevered beam. "This was the beauty of using the precast concrete wall system for this design," Henry says. The double tees used for the floor structure feature a reinforced 4-in.-thick topping that ties the system together and provides additional counterlevered support benefits.

'The progressive-collapse calculations were higher than for any hurricane zone.'

TWO ARCHITECTURAL FACES

The panels were cast with architectural finishes on both the interior and exterior faces. The exterior face features a combination of thin-brick inlays and exposed aggregates with a sandblast texture to create a limestone-like finish for accents, while the interior face features a smooth troweled finish. Concrete used in the panels contained an integral color that eliminated the need for additional field painting. The panels arrived to the site already finished.

"The panels are architectural, although they perform structural functions," Wright notes. They were cast in a plant with C3A certification from PCI, which provides A1 architectural finishing as well as structural casting.

"Providing an attractive finish on the interior side was an important point for the base commander," he says. "The barracks have soldiers coming and going constantly, and they require a lot of durability, more than drywall could provide." The base has a small maintenance budget, he adds, so they wanted a material that could stand up to the requirements without needing constant attention.

EFFICIENCIES IN DESIGN
The erection process moved smoothly, with plenty of staging area. Efficiencies in design and construction brought the project in at $7 million below budget. Photo: Gate Precast.

The building's exterior look provides a dramatic step up from the existing "hut" buildings, Henry notes. We wanted to set a tone with these buildings we could carry through the remainder as they're built that would be attractive and economical." Adds Chris Ard, sales and marketing division of Gate, "These barracks definitely provide a step up in the aesthetic style of the current landscape of the Camp Shelby base, which is predominantly covered with single-story block buildings."

The progressive-collapse design aided with hurricane protection too, Henry notes. "We met to discuss the added requirements for wind protection, and we looked at the design and said, 'We're already there,'" he reports. "The progressive-collapse calculations were higher than for any hurricane zone, and we're in one of the highest there is, near the Gulf Coast."

In fact, barracks could potentially serve as temporary shelter for refugees during a hurricane. "All we had to do was specify high-quality connections to meet the wind-load needs, as the rest of the structure met the force requirements easily," Henry says.

LEED STANDARDS MET

The insulated walls helped the building meet LEED standards, although the facility won't be submitted for certification. It also features laminated solar panels on the roof that provide some of the building's electrical power. The thin panels were simply glued between

PRECAST MEETS CHALLENGES
The precast concrete structure helped the buildings meet a variety of challenges, including progressive-collapse requirements. Photo: Johnson-McAdams.

the standing seams on the roof system, with little structural loading required.

Additional LEED points were generated from the use of local materials being manufactured within 500 mi of the site, with fewer raw materials used for the thin bricks than for traditional masonry. Brick-firing costs were reduced and more brick fit onto flatbed delivery trucks, resulting in fewer trucks being needed and lower fuel costs. The panels also were cast and cured off-site, eliminating any dust or airborne contaminants from drying or curing compounds during construction, which improved construction site air quality.

"Using precast concrete meant very little construction waste," Henry says. "There were no leftover studs or materials." Low-VOC (volatile organic compounds) materials were used as well, and storm water is being captured, stored, and reused for soldier equipment wash.

The site offered plenty of space for staging components prior to erection, which moved smoothly. "Mississippi's military department was very pleased with the speed with which the precast concrete could be erected once the site was ready," Henry says.

The four buildings replicate each other, but they were turned on the site to create distinctions. "We didn't want to try to create mirror images or change them in other ways, so repositioning them on the site provided differences and avoided the appearance of the same façades in a row."

The positioning aided the overall budget, notes Ard. "It created quite a bit of repetition within the panels, ultimately reducing the amount of mold protection required."

The erection was aided by advance planning to create blockouts and conduit runs in the panels. Coordination meetings were held with the completed design team, contractors, and the precast producer's engineering team at the precast manufacturing plant to integrate the mechanical, electrical, and plumbing systems as much as possible into the panels. "There were several miles of conduit integrally cast within both the interior and exterior of the panels," says Ard.

"The system is basically an erection set," Henry says. "There were no mistakes in the field or adjustments needed. We could simply pull wires through the conduit and hook it up. Ductwork openings were blocked out so everything went in very quickly." The project had less than 1% change orders, which was unusual for a project of this size and complexity, he notes.

"This was a very positive experience all the way around, and the nicest military project I've ever been involved with," Henry says. "A lot of thought went into planning upfront to make the construction move very quickly. Bob Baylor, the Mississippi Military Department's project manager, is one of the most knowledgeable project managers I've ever worked with. His guidance and understanding of the industry is amazing."

The planning paid off where it matters most: budgeted at $50 million, the value-engineering and other efficiencies planned into the design and construction brought the project in at $43 million, a substantial savings.

With that success in place, Henry already has created plans for improving the next stage. Upcoming projects also will use the total–precast concrete structural system, with interior panels featuring a new concrete admixture that has shown great promise. The admixture creates a durable finish that protects against marks and stains, allowing even permanent marker to be wiped off. (For details, see the sidebar.)

"We're looking at what we've learned from this first experience to improve on later buildings," he says. "We can improve on our initial design concepts to make them more efficient in the future and create even better finishes. I can't wait for the next building to get started so we can improve on what we've done already."

Admixtures Offers Durability

A new concrete admixture offers potential for creating durable interior finishes that allow marks and scuffs to be easily wiped off. The E5 Concrete Slab System from Specification Products uses reactive co-polymer solids to internally cure concrete without the use of prewetted lightweight aggregates while reducing drying shrinkage, curling, and volume-loss cracking.

The E5 mixture can be applied topically or integrated into the concrete mix. It retains 95% relative humidity for many months, exceeding the requirements of ASTM D7234 *Standard Test Method for Pull-Off Adhesion Strength* only nine days after poured slabs. Perm tests at that time show relative humidity as low as 4.7% to 4.8%.

The material will be used on future precast concrete buildings at the Shelby OTRC and is currently being tested in a unique way: as part of a concrete monument for fallen soldiers designed by Robin Henry of Johnson-McAdams and constructed and installed by SP at Camp Shelby. The monument is being evaluated over time to determine how well the concrete retains its durability while exposed to the harsh southern Mississippi environmental elements.

To date, Henry has been impressed. "Based on the successful performance of the installed system and the high standards set forth by its developer, I plan on using the system on all of my projects," he says. "The E5 system sets a new standard for quality in concrete."

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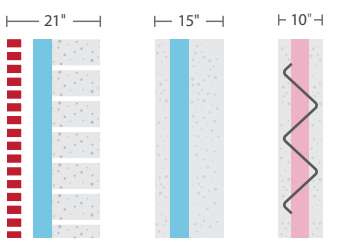

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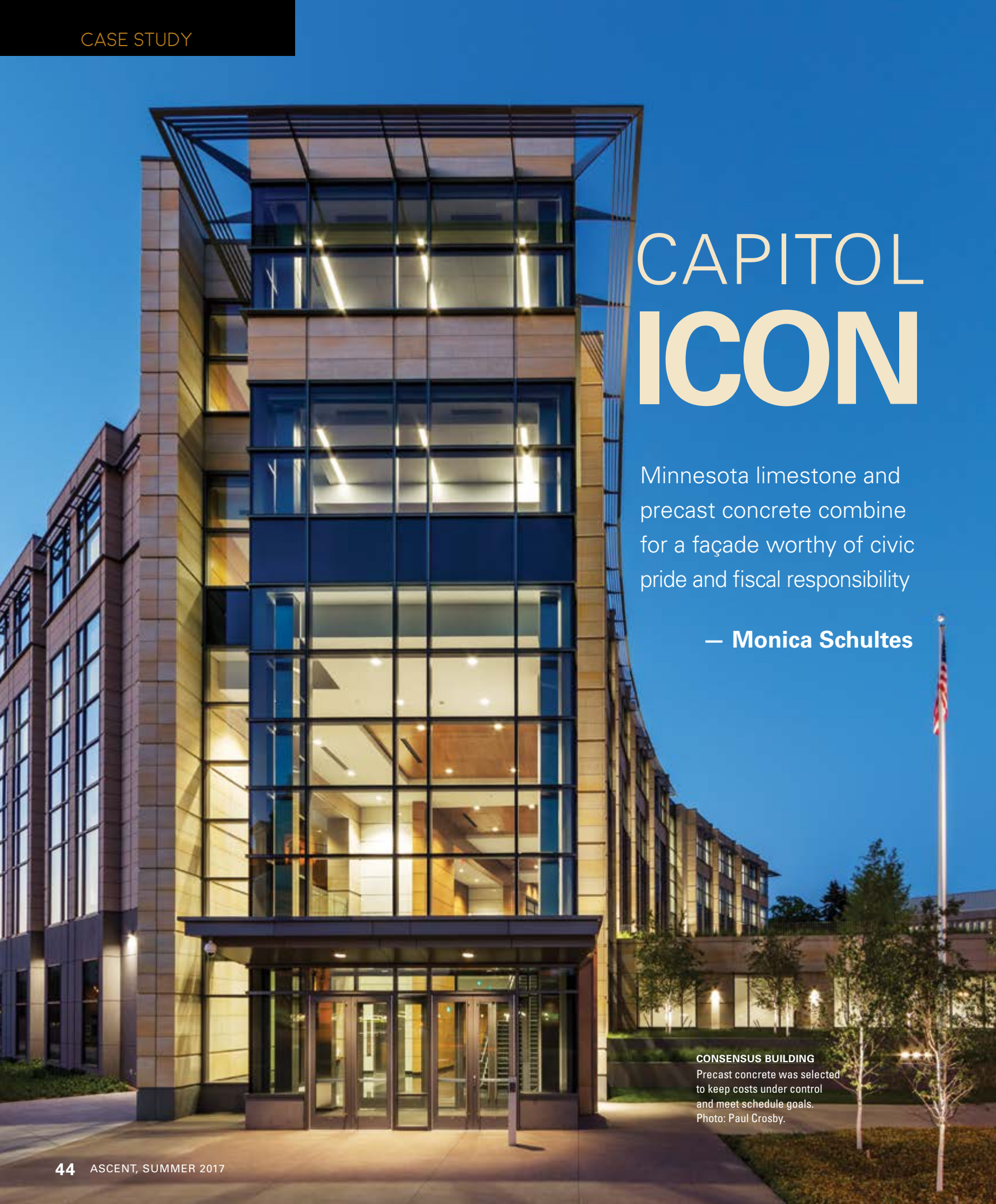
— **Monica Schultes**



CONSENSUS BUILDING
Precast concrete was selected to keep costs under control and meet schedule goals. Photo: Paul Crosby.

CRESCENT SHAPE
A radial design features prominently; the layout complements its historic neighbor. Photo: Paul Crosby.

In Minnesota's capital city St. Paul, the Capitol building has represented civic duty and Midwestern strength for more than a century. Across the street from it now sits another iconic structure that has become the new symbol of Minnesota politics and citizen involvement.

Standing next to a symbol of American architecture can be daunting, but the new Senate Building holds its own next to the iconic Minnesota State Capitol. The existing capitol building was designed by prominent American architect Cass Gilbert in the Italian Renaissance Beaux-Arts style. Work began in 1896 and featured a dome that was modeled after Saint Peter's Basilica in Rome, Italy. Gilbert is known for his design of the U.S. Supreme Court Building in Washington, D.C., and the Woolworth Building in New York, N.Y.

The Minnesota Senate Building pays deference to its historic neighbor yet fulfills the program requirements of the 21st century. It serves the needs of the public and state government within a functional yet beautiful structure that is an elegant and enduring representation of Minnesota civic architecture.

MINNESOTA SENATE BUILDING

LOCATION:
St. Paul, Minn.

PROJECT TYPE
Government and Public Buildings

SIZE
293,000 ft²

COST
$89 million

OWNER
Minnesota Department of Administration

EXECUTIVE ARCHITECT
BWBR, St. Paul, Minn.

DESIGN ARCHITECT
Pickard Chilton Architects, New Haven, Conn.

STRUCTURAL ENGINEER
Ericksen Roed & Associates, St. Paul, Minn.

CONTRACTOR
M. A. Mortenson Company, Minneapolis, Minn.

PCI-CERTIFIED PRECASTER
Gage Brothers, Sioux Falls, S.Dak.

PRECAST COMPONENTS
Architectural precast concrete panels: stone clad precast concrete pieces with granite or limestone

POLITICAL DEBATE

Design teams met for months with lawmakers and staff from both parties and both houses to discuss the new office space. To encourage open communication and gather input, BWBR Architecture, in collaboration with design architect Pickard Chilton, facilitated public workshops to build consensus among a very large group of people that had different requests. Steve Berg, the project architect from BWBR, explains, "From the very first workshop, all the different constituents from the state and the senate had input. With a high-profile project that neighbors the historic capitol, there were many critical voices that needed and wanted to be heard."

The drawings and models changed day-by-day based on cost limitations, tenant feedback, and site restrictions. The final design had to be approved by the House and Senate Rules Committee before construction could begin.

Early on it was evident that a top priority was the use of locally sourced materials. Another critical project goal was to complement and honor the capitol but not to replicate it. That led the designers toward Minnesota limestone for the warmth of the native stone. Due to budget constraints, there were no promises in the early stages that it would be a stone clad building.

"In the end we had a strong definition of the building design, the siting of the project and how the new senate building related to the capitol. It was an engaging and collaborative process to refine and develop the design," reflects Berg.

PRECAST FAÇADE MEETS CRITERIA

The wall assembly was one of the more challenging decisions to make because the state had high standards regarding building envelopes. The design team needed to prove to a third party reviewer that precast concrete was the best wall assembly. Cavity wall construction with traditional set masonry and brick with through-wall flashing is more commonly found in Minnesota. "This precast wall assembly meets all the criteria of the state requirements—but accomplishes them in a different way," states Eric West, project manager with BWBR.

Foam insulation was applied to the back of the precast concrete cladding panels that serve as barriers to both air and moisture. Atypical for the state of Minnesota, in the end they approved the design for a 100-year envelope using precast concrete.

The final iteration makes use of Minnesota stone embedded in precast concrete panels on the entire south façade that faces the capitol. A complementary architectural precast concrete panel with light sandblast is used on the other three sides. The end result honors the capitol while being judicious with the budget.

'This precast wall assembly meets all the criteria of the state requirements—but accomplishes them in a different way."

Vetter Stone and Gage Brothers Precast were added to the team to meet the unanimous goal of locally sourced materials. Berg commented, "We collaborated closely with Vetter Stone to select a tight range within the quarry that reflected a warm gray patina with a distinctive stone appearance."

Using a local stone vendor helped deliver the product in a timely fashion. The entire construction industry was busy at the time, so there was some concern about meeting delivery dates for stone and precast. Gage Brothers was able to save a slot in their production schedule.

Gage Brothers cast a large-scale mock-up panel (15 ft X 30 ft) to showcase every possible condition. The design team used it to study the type, grain, and strata of the stone, as well as every possible condition to determine how to accommodate it in advance.

Berg relates, "The mock-up allowed us to hone in on the finish of the stone and the precast before production began. It took a few iterations to achieve the appropriate level of sandblasting and to attain the softness and light quality desired."

Given the radial shape of the building, there were many L-shaped precast concrete panels and many with articulation, resulting in fairly complex forms. The mock-up allowed BWBR and Chilton to study the atypical panel shapes and end conditions to eliminate any potential spalling. The mock-up panel helped to resolve similar issues along the way.

Strong horizontal reveals in the precast concrete panels create shadow lines and reliefs around the building. The datum in the

precast concrete panels and those with dimensional stone extend into the interior detailing. The wood paneling in the interior follows the same rhythm as the exterior. "The end result is that most people can't distinguish between the precast and the stone as they walk by the building. There is a nice complementary quality to it," says Berg.

RADIAL DESIGN

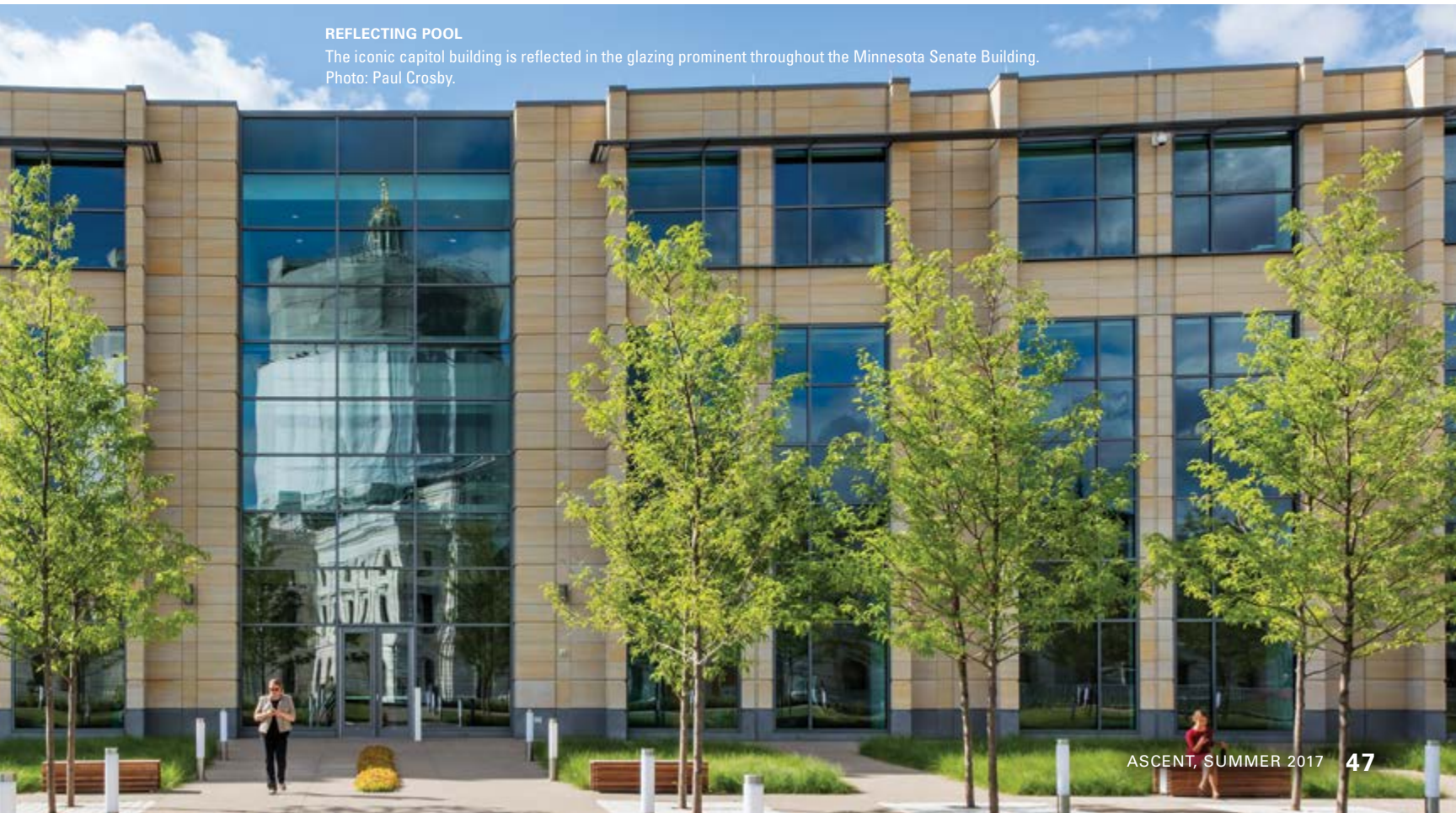
The layout of the new senate building is well conceived. "The radius is formed from the spring line or center point of the capitol rotunda. Chilton and BWBR considered several different configurations and this crescent shape connected itself in a strong way to the capitol. It frames your view as you walk through the building and is a reminder of its relationship to the capitol," notes Berg.

The new senate building houses all 67 senators under one roof and supports more than 360 staffers and state employees who are also officed in the facility. The new structure also contains critical technology and infrastructure, a broadcast studio, and a 250-seat theatre style hearing room. The design provides ample daylight, and senator offices on the upper two levels all have individual views of the capitol. From the main entrance to the public forum hearing rooms, everything radiates to the capitol and is even reflected in the design of the plaza landscape.

To optimize the efficient use of precast concrete throughout the building, there was much discussion about maximizing piece size. General contractor Mortensen created a 4-D model of the project, with the fourth dimension being time. West adds, "Mortensen wanted to ensure adequate coordination of delivery and installation. They reviewed that the crane could safely pick up all the precast pieces and could erect them in a timely fashion." He clarifies, "If it had been traditionally set masonry, it would have taken a lot longer with Minnesota winter conditions."

A critical aspect of the schedule was to accommodate the 2016 legislative term while the neighboring Capitol building was closed for a major renovation. There was a drop-dead date because of when the state senate had to hold sessions in the new building.

The precast concrete façade was selected to keep costs under control and to meet the schedule goals. Even with the design-build method and accelerated schedule, construction did not start until August 2014, but the precast was still completed in ample time for the interior fit out.



REFLECTING POOL
The iconic capitol building is reflected in the glazing prominent throughout the Minnesota Senate Building. Photo: Paul Crosby.

SENATE HEARING
Exterior courtyard reflects the warm Minnesota stone cast into the precast concrete façade. Photo: Paul Crosby.

FISCALLY CONSERVATIVE

Facing immense budget pressure to hit the targeted cost-per-square-foot goal, the design team responded with a building that was extremely efficient. "Throughout the whole process we were looking at cost-saving methods. We were trying to make efficient use of the materials and structure as best we could," says Mike Steenson, associate/division manager with Ericksen Roed & Associates.

The design team worked with B3 Guidelines ("Buildings, Benchmarks and Beyond") to manage and reduce energy costs. The B3 Guidelines contain detailed sustainable and resiliency goals that are specific to the state. Minnesota state buildings are expected to follow B3 policies for material selection, water usage, and other sustainable attributes. The intent is to benchmark energy consumption and compare data over the life of the building.

'The whole project was design-build to allow us to move at a faster pace but still make good decisions.'

Minnesota is known for its formidable winters and its location in the Upper Midwest means it experiences some of the widest variety of weather in the United States. Some parts of the state have experienced a 174°F spread. This extreme variation makes for some interesting weather reports and poses a challenge for building owners to withstand it efficiently.

A building that functions as it is intended is the underpinning of resilient design. In the planning stages, energy efficiency targets were identified. During the design stages, every effort was made to balance first cost with operating cost. Measures were taken to reduce long-term energy consumption. An energy model demonstrated that the building design exceeded that goal by 37% (energy consumption).

Steenson praises the whole design-build process on this project. "With the right players it works very well. There were weekly meetings set up near the project site where Mortensen had rented space. Design-build partners all had representatives there to work together as a team to get the best outcome." West agrees. "The whole project was design-build to allow us to move at a faster pace but still make good decisions."

The project was recently selected by Design Build Institute of America (DBIA) Upper Midwest Region as Project of the Year 2017. West believes that "having the owner, engineer, architects, precaster, and contractor all on the same page made it happen."

Chilton and BWBR wanted to foster connectivity and collaboration, bring the legislature together in a working collegial atmosphere, and give all Minnesotans access to the process. The result is a legacy building that exceeded expectations for budget and schedule and will stand the test of time.

REVEALING
The reveals and rustications on the 7-in-thick precast concrete architectural panels also translated into the interior layout. Photo: Gage Brothers.

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CIVIC Pride

Precast concrete hybrid moment frame supplies office with resilient, fast, beautiful solution

— Monica Schultes

PRECAST BY DESIGN
The City of Roseville wanted an attractive, durable low-maintenance structure.
Photos: LPAS Architecture + Design.

As the largest city in Placer County in the Sacramento, Calif., metropolitan area, the City of Roseville is undergoing a resurgence, common where shopping malls and suburban sprawl have drawn pedestrians away from the downtown. Slow and steady development under the Roseville City Council plan has seen tremendous improvements. Roseville's revitalization efforts are paying off with Vernon Street taking off as a destination. This wouldn't have been possible 20 years ago, but today residents want the authentic feeling and cool vibe that downtown districts can offer. With the addition of new restaurants and the completion of the Vernon Street Town Square, more foot traffic is common in and around the outdoor public plaza. Vernon Street Town Square attracts thousands of visitors annually for concerts, farmers markets, wine and beer events, movie nights, and parades. It is now the hub of activity and downtown Roseville has become a walkable community.

With the double-digit growth in population of Roseville in the last five years came a need for increased city services. A new location to house all the resources required to run a city of this size was conceived. Mike Isom, development services manager, for the City of Roseville, explains, "We have outgrown our civic center space. We only had a short time frame to get this building designed, programmed, and ready for occupancy."

The City Hall Annex located at 316 Vernon Street is the first precast concrete building constructed for Roseville. The new four-story office building, with a gross area of approximately 82,000 ft^2, provides space for the city's many departments, as well as office and classroom space for Sierra College. It consolidates the city's Information Technology Department, Fire Department Administration, Alternative Transportation Division, Parks and Recreation, and Library Services.

Two floors of the building are leased to the Sierra Joint Community College District, providing instructional classroom space

OPEN OFFICE PLAN
You can stand on one end of the building and see out the windows on the opposite end. Photo: LPAS Architecture + Design.

and bringing students and activity to this downtown location. The project also provides street-level retail and restaurant space. The college signed a 10-year lease, which will help pay down the debt service on the $26.5-million building.

CITY SERVICES

Isom explains the key drivers for the project. "As a public agency, we want to make sure that we're being efficient with the resources we have available. But also because we are a public agency, we hold our building forever. So long-term maintenance is very important to us. We wanted to make sure we had a design that was really attractive but also, from a long-term maintenance perspective, very durable."

The building was initially designed as a steel structure. However, during schematic design, the project team determined that switching to a precast concrete structure would result in key benefits for the city. The benefits of precast concrete include increased flexibility for space layout by removing interior columns, a shorter construction schedule, and improved performance.

"This is the most prominent building on the town square and it was important that we had an architectural look and finish that would stand the test of time and truly be a hallmark for our downtown," says Isom.

'This is the most prominent building on the town square and it was important that we had an architectural look and finish that would stand the test of time and truly be a hallmark for our downtown.'

Larry Jones, vice president of Buehler & Buehler Structural Engineers, and structural engineer of record for the project, describes the process. "We originally looked at a lot of different schemes and tried to come up with the most cost-effective approach. We landed on a steel frame structure with buckling restrained braced frames as the lateral system. The column grid was 28 ft by 28 ft square, which is typical for educational facilities and would work well for the university tenant."

VERNON STREET OFFICE BUILDING

LOCATION
Roseville, California

PROJECT TYPE
Government and Public Buildings, Office Building

SIZE
82,000 ft²

COST
$21 Million

ARCHITECT
LPAS Architecture + Design, Sacramento, Calif.

OWNER
City of Roseville, Roseville, Calif.

STRUCTURAL ENGINEER
Buehler & Buehler, Sacramento, Calif.

CONTRACTOR
DPR Construction, Sacramento, Calif.

PCI-CERTIFIED PRECASTER
Clark Pacific, West Sacramento, Calif.

PRECAST COMPONENTS
Precast concrete hybrid moment frame, double tees, columns, beams, hollow-core slab

The original budget was based on the steel system with plaster skin and work had begun on schematic design. The city wanted one more look at a concrete option. Buehler & Buehler considered tilt-up options, insulated panels, and precast, but the first cost of the steel system was the most economical.

Clark Pacific was asked to look at pricing the project and to present some value engineering ideas. They proposed a precast design that removed columns and used double tees to create 56-ft spans, with hollow-core slab for the remaining 28-ft span. That reduced costs and helped get precast within range of the steel system. There was a $200,000 premium in first cost over steel, but the long-term maintenance costs of a stucco façade would be eliminated.

Owners typically see things through a lens of fiscal responsibility. "How do we stretch our construction dollars the best we can, not just focus on first costs? It is the long-term maintenance that comes back to bite us," explains Isom.

After much consideration, Roseville selected the precast hybrid moment frame (PHMF) because it gave the architect flexibility in design, met the tight delivery requirements to meet tenant deadlines, and provided the city with reassurance that during an earthquake, critical operations and services would be housed in a resilient structure. By eliminating two lines of columns, the precast option opened up the interior and gave them more flexibility for planning. The precast concrete building also provided a higher performance of fire resistance, vibration, and sound attenuation.

'The precast system allowed us to create a structure with a sense of stability and permanence that is appropriate for an important civic building.'

"The precast system allowed us to create a structure with a sense of stability and permanence that is appropriate for an important civic building," says Curtis Owyang, vice president of LPAS Architecture + Design. "With the steel frame option there were columns and interior brace frames we had to work around, that the precast eliminated. The precast system created large areas of floor-to-ceiling glass between the columns and beams, which brings in lots of natural light and views throughout the work environment."

Clark Pacific was chosen to produce the precast concrete scope of work for the new office building. Precast concrete offered neighborhood-friendly construction methods of off-site prefabrication, while "just-in-time" delivery to the jobsite provided the schedule certainty that was so important. The city, which had promised to open the building on January 1 for Sierra College students, was a primary driver for the schedule.

The precast concrete panels used integral colored concrete with three different levels of sandblast that add depth to the precast concrete finish. The concrete mixture was chosen to relate to city hall and the rest of downtown. "Our building was not meant to overshadow city hall, but to complement it, which is reflected in the design and use of material," says Owyang.

STRONG FINISH

Precast concrete panels with three different levels of sandblast add depth to the exterior finish. Photo: LPAS Architecture + Design.

CUTTING COLUMNS
The precast design option removed columns and used double tees to create 56-ft spans. Photo: Ryan Colditz.

'Precast is an ideal solution because most of the work is done off-site and in 38 days we had a building shell ready to go.'

"Precast is an ideal solution because most of the work is done off-site. In 38 days we had a building shell ready to go," says Isom. Clark Pacific produced the architectural and structural framing system for the building, consisting of precast concrete hybrid moment frames, hollow-core slab, double tees, walls, spandrels, columns, and beams. A total–precast concrete system helped deliver value to the city and its residents by providing a cost-effective solution delivered on time and within the city's budget.

"The biggest selling point for the precast option was the shorter construction time. That whole building was put together in a little over a month," said Abe Sipes, project manager, DPR Construction.

Clark Pacific manufactured 538 panels off-site in 10 weeks, and erected the building structure in just over one month. The precast concrete panels included columns, beams, walls, and floor system accounting for 82,944 ft^2 of concrete. The precast installation minimized the disturbance to downtown. Steel construction would have had prolonged the noise and disruption to pedestrian and vehicular traffic. Given the infill nature of the project, with such a tight site there was no lay-down area.

"We wanted to get as much natural light into the building as possible and the furniture was purposely lower to allow for more light. You can stand on one end of the building (144 ft) and see out the window on the opposite end of the building—and that was the design intent," says Owyang.

How do you go from approval to proceed by the city council to an award-winning building in 15 months? The group embraced the philosophy of lean design to meet the aggressive schedule. Sipes recalls that there was a great team atmosphere. "It worked very well because everyone wanted this project to be a success; there was no one who wouldn't go above and beyond. From a design perspective, it was very tight schedule. It would have been nice to have had more time up front in the design phase to better coordinate the mechanical considerations."

Jones concurrs, "The weekly meetings at DPR were very well run and there were representatives from all the stakeholders at the table that made the process very transparent and very functional. As we ran into 'rocks in the road' the team coalesced and we reached decisions to keep the project moving forward."

RESILIENT BY DESIGN

The precast hybrid moment frame (PHMF) has been used successfully on projects since 1997.

The PHMF system offers the construction speed and relative simplicity of steel construction, the durability and mass-building benefits of concrete construction, and a seismic performance superior to many other systems due to its unique ability to self-right after a major seismic event, enabling faster reoccupancy of the structure. This benefit is invaluable to hospitals, government buildings, and other essential services structures.

Precast concrete provides high-end architectural finishes with low maintenance compared with a stucco façade that has to be painted and may be prone to leakage. "It was a no-brainer for the owner to pay the additional $200,000, which was still within the GMP," says Farid Ibrahim, director of preconstruction services at Clark Pacific.

The PHMF comprises high-quality precast concrete column and beam elements, produced under factory-controlled conditions, that are connected together using traditional construction methods and materials: reinforcing bars, posttensioning steel, and grout. Reinforcing bars and post-tensioning provide strength to the connection, with the reinforcing bars also acting to dissipate energy as in a traditional special moment frame.

Most seismic systems dissipate energy through yielding, and it is not unusual for a building to lean after a major earthquake. As a unique feature, the unbonded post-tensioning used in the PHMF system is designed to remain elastic and overcome yielding in the frame to pull it back to a righted position.

In an effort to educate owners and the design community who aren't familiar with PHMF, PCI and Clark Pacific conducted webinars along the west coast. "Once they see the benefit to the owner and they see the history (this is our 10th project using PHMF), the testing, and all the professional assessments regarding the system and how it performs in high seismic areas, you make a believer out of them," said Ibrahim.

PLATINUM RATING

The U.S. Resiliency Council (USRC) awarded its first-ever platinum rating to the City of Roseville and the design-build team of DPR Construction, LPAS Architecture + Design, Buehler & Buehler Structural Engineers, and Clark Pacific. The level of performance associated with the USRC platinum rating is not something every building can achieve, but this project met that standard because of several features and conditions. The architectural façade doubles as a redundant structural system, providing enhanced yet economical performance. The structural system incorporates a precast concrete hybrid moment-resisting frame that limits design level drifts to less than 1.25% and is designed to be self-centering after the design seismic event, therefore eliminating residual drifts, limiting damage, and providing for reduced recovery time. The greater Sacramento region has only a moderately high seismic risk (compared to much of the rest of California) so it is possible to achieve high seismic performance with only a nominal increase in construction cost.

The USRC is committed to helping establish and implement a building rating system to provide building owners with guidance on expected performance in natural and man-made disasters, and to educate communities about the vulnerability of the built environment. Evan Reis, executive director of USRC, explains, "It is often surprising to people that in a large earthquake, 70% to 80% of the building damage might encompass the architectural, electrical,

FAST FRAME
The entire precast concrete hybrid moment frame system was installed in just 38 days. Photo: Ryan Colditz.

PLATINUM RATING
The Vernon Street Office Building was the first project to win U.S. Resiliency Council platinum rating. Photo: Clark Pacific.

and mechanical systems, and not structural damage."

Buehler & Buehler Structural Engineers were instrumental in getting this project evaluated. Clark Pacific requested an analysis of the structure to measure its resiliency. "We knew that it was going to be a good solution," says Ryan Kersting, associate principal at Buehler & Buehler.

"One of the reasons the PHMF system was selected was for its high seismic performance," says Kersting. "But achieving a particular USRC rating was not an initial design requirement and therefore did not specifically factor into the selection of the system."

"In general, most structural designs are based on complying with the building code. From a seismic perspective, this performance is fundamentally focused on maintaining safety of the occupants during an earthquake. The USRC rating is a holistic system that is not totally focused on safety. It looks beyond the code and considers expected safety, amount of damage, and time to recover," says Kersting. He adds, "You need to have a broader and deeper understanding of the structural design from a high level. Getting a building permit or even a USRC rating doesn't mean that the building is going to be earthquake-proof. Instead, the concept of resiliency helps us consider the building performance in terms of the ability to recover from a disaster, how much it is going to cost, and how long it will take."

Having the platinum rating signifies that the building will perform well after an earthquake and Roseville city services should have limited interruption, if any. A building could potentially have a LEED rating for energy efficiency and sustainability (day-to-day operations) and a USRC rating for disaster recovery.

Kersting adds, "Getting a USRC rating for a prominent public building gives us the chance to demonstrate how resiliency works and that our communities should be more aware of how building performance will affect disaster recovery. Not every building is going to get platinum rating—we had a lot of things going for us on this project—but this is a perfect opportunity for the general public to hear about, and hopefully understand, how good building design affects them."

Reis shares the future of USRC: "We want to continue to get buildings rated and increase the visibility of these ratings. We are also working on developing rating systems for other hazards covering hurricane, wind, blast, flood, and fire. Ultimately, we want people to think about resiliency as much as sustainability."

LESSONS LEARNED

Brian Wiens, senior associate at Buehler & Buehler Structural Engineers, reflects that, "Some of the seismic attachments to precast are still being developed. We did spend some time working with Hilti and our reviewer to develop loading and acceptance criteria to attach equipment to the underside of the precast hollow-core."

Sipes from DPR Construction shares his thoughts on the fast-track schedule, "We had to do the whole thing in a few months—it was a fast adjustment for a complete redesign. When you think about it, it was pretty impressive. We tore down a building and rebuilt a new one in 14 months.

Wiens remarks, "This project was a success in seeing how the team worked well together. When everyone has a common goal and works hard toward it while looking out for each other's interests, the team can really achieve a remarkable project in a short amount of time. Projects like this make you appreciate the work that you do."

The old adage that the precast concrete industry preaches is true: The earlier we [as precast producer] can be involved, the better. "We try to be involved at the ground level, even at the conceptual level. If involved early, we are not doubling up on the design efforts to come up with the best solution," says Ibrahim of Clark Pacific.

"Looking back, if we had gotten involved early on with a precast solution, it would have streamlined the process. But in a way this was a blessing in disguise as it really highlighted the benefits of the precast system as compared to other solution," continues Ibrahim.

Sipes looks back on the job now that it is completed. "For me, I live in Roseville close to the job site and my children go to school there and they say 'my dad built that building.' I am proud to be part of the community and part of this project."

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DSDM TEST BUILDING
One-half scale test building shake table at the University of California–San Diego. Photo: PCI.

DESIGNING AND BUILDING FOR Earthquakes

New developments in precast concrete diaphragm design

— S. K. Ghosh

All 50 states have the potential for seismic activity. This is not news to residents of California, the Pacific Northwest, and the Intermountain West. What is changing, according to a report by the U.S. Geological Survey (USGS),[1] is that an increase in frequency and intensity of earthquakes is occurring in more areas of the country. Damaging earthquakes could happen in 42 of the 50 states, according to the USGS maps.[1] Recent research by the PCI, the National Science Foundation, and the Charles Pankow Foundation, on what is commonly referred to as DSDM (diaphragm seismic design methodology) gives new tools to designers and structural engineers looking to use precast concrete in seismic areas.

Damaging earthquakes could happen in 42 of the 50 states according to the USGS.

BASICS OF SFRS

The seismic force-resisting system (SFRS) of a building consists of a three-dimensional assemblage of elements that transmit loads and forces from the point of origin down to the soil underlying the foundation. This system typically consists of horizontal and vertical structural elements. When the building is subject to seismic excitation, the horizontal elements—roof and floor slabs—bend in their own plane, and act as diaphragms to transmit the forces horizontally from the point of origin to the vertical elements of the SFRS. The vertical elements (walls or frames) transmit the forces down to the foundation. Diaphragms also tie the vertical elements together to act as a system so that they respond to the seismic forces together, rather than individually. The diaphragms are an integral part of the SFRS of a building and deserve significant attention during the design process.

Seismic design forces for diaphragms are given in Chapter 12 of ASCE 7-10. The design of concrete diaphragms in general is addressed in the new Chapter 12 of ACI 318-14. Requirements for the seismic design of concrete diaphragms are given in ACI 318-14 Section 18.12. This article specifically addresses seismic design issues pertaining to precast concrete diaphragms with or without cast-in-place topping slabs.

ACI 318-14 Section 18.12 contains design requirements for cast-in-place composite topping and cast-in-place noncomposite topping slab diaphragms. The composite topping slab diaphragm transmits lateral forces to vertical elements of the SFRS through composite action of precast concrete double tees or hollow-core slabs and a topping slab. In a noncomposite topping slab diaphragm, the topping slab acting alone as the diaphragm transmits lateral forces to vertical elements of the SFRS. Although there is no specific provision that prohibits the use of an untopped diaphragm, such a design does not comply with the requirements of ACI 318-14 Section 18.12.

In a 2002 *PCI Journal* paper[2], Cleland and Ghosh suggested that it is possible to design untopped precast concrete diaphragms for buildings assigned to high Seismic Design Categories (SDC D and above) under the equivalency provision

currently in ACI 318-14 Section 18.2.1.7. The paper outlined how such equivalency could be achieved. However, designs based on the equivalency provision require project-by-project approval from the authority having jurisdiction.

Much broader applications of untopped precast concrete diaphragms in high-seismic applications, not requiring project-by-project approval, is now possible for the first time because of developments reported on in this article.

DSDM TESTING
One half scale double tees and hollow-core slab. Photo: PCI.

ALTERNATIVE DIAPHRAGM DESIGN FORCE LEVEL OF ASCE/SEI 7-16

ASCE/SEI 7-16 includes two significant items related to the design of diaphragms, which represent changes from the 2010 edition. First, ASCE/SEI 7-16 includes a new section entitled "Alternative Design Provisions for Diaphragms including Chords and Collectors". The new section provides for an alternative determination of diaphragm design force level, which is mandatory for precast concrete diaphragms in buildings assigned to SDC C, D, E, or F. The alternative is permitted to be used for other precast concrete diaphragms, cast-in-place concrete diaphragms, and wood diaphragms supported on wood framing. The new section does not apply to steel deck diaphragms. All diaphragms other than precast concrete diaphragms in SDC C, D, E, or F buildings may continue to be designed using the diaphragm design force level of ASCE/SEI 7-10, which is carried over into ASCE/SEI 7-16.

PRECAST CONCRETE DIAPHRAGM DESIGN OF ASCE/SEI 7-16

To go hand-in-hand with the alternative diaphragm design force level, ASCE/SEI 7-16 includes a precast concrete diaphragm design procedure in a new Section 14.2.4. The procedure must be used whenever the alternative design force level of ASCE/SEI 7-16 is used. The requirements are in addition to those found in ACI 318-14 Section 18.12.

The procedure presents the designer with three options for selecting the target performance of a diaphragm when subject to earthquake excitation. The Elastic Design Option (EDO) seeks to keep the diaphragm elastic in the Maximum Considered Earthquake (MCE). The Basic Design Option (BDO) seeks to keep the diaphragm elastic in the design earthquake while permitting controlled inelastic behavior in the MCE. The Reduced Design Option (RDO) permits controlled inelastic behavior even in the design earthquake.

The choice of options is not unrestricted, but depends on the Diaphragm Seismic Demand Level, which is a function of the seismic design category, the number of stories, the diaphragm span, and the diaphragm aspect ratio. The EDO is permitted for: (1) Low Seismic Demand Level, and (2) Moderate Seismic Demand Level, provided the diaphragm design force is increased by 15%. The BDO is permitted for: (1) Low Seismic Demand Level, (2) Moderate Seismic Demand Level, and (3) High Seismic Demand Level, provided the diaphragm design force is increased by 15%. The RDO is permitted to be used for all Seismic Demand Levels. For SDC D, E, or F buildings, the RDO will typically be the choice.

The EDO permits any type of diaphragm connector to be used.

The EDO permits any type of diaphragm connector to be used, including those classified as Low Deformability Elements (LDE). If the BDO is selected, connectors qualifying as Moderate Deformability Elements (MDE) need to be used as a minimum. Connectors qualifying as High Deformability Elements (HDE) need to be used exclusively if the RDO is chosen.

Hollow-core slabs in University of California, San Diego test building. Photo: PCI.

CONNECTIONS
Diaphragm to wall connections in University of California–San Diego test building. Photo: PCI.

A precast concrete diaphragm connector is assigned a deformability classification based on the measured deformation capacity in tension. The measurement requires testing, which is more generally required to establish the performance characteristics of strength, stiffness, and deformation capacity of the precast concrete diaphragm connectors under in-plane shear and in-plane tension. The testing must follow a protocol that is part of ASCE/SEI 7-16 Section 14.2.4.

ICC-ES ACCEPTANCE CRITERIA AND EVALUATION REPORT

The alternative design force level of ASCE/SEI 7-16 will automatically become part of the 2018 International Building Code (IBC) by virtue of its adoption of the seismic design provisions of ASCE/SEI 7-16. The 2018 IBC Chapter 19 will also specifically require precast concrete diaphragms to be designed using the provisions of Section 14.2.4, although ASCE/SEI 7 Chapter 14 is typically not adopted by the IBC. While these code changes will ultimately provide the basis for precast concrete diaphragm design without a field-cast topping, it may be many years before the 2018 IBC is adopted by a local jurisdiction.

To fill this gap, PCI applied for and received ICC Evaluation Service (ICC-ES) Evaluation Report ESR-3010, issued August 2016, based on ICC-ES Acceptance Criteria AC468, *Proposed Acceptance Criteria for Alternative Seismic Design of Precast Concrete Diaphragms and Qualification of Precast Concrete Diaphragm Connectors,* approved June 2016, which represents a cooperative effort of PCI and ICC-ES staff. ESR-3010 enables an engineer to design precast concrete diaphragms using the alternative diaphragm design force level and the precast concrete diaphragm design procedure discussed above in compliance with the 2015 or the 2012 IBC. Thus, a designer need not wait until adoption of the 2018 IBC.

PUTTING RESEARCH INTO USE IN DESIGN

These new developments in precast concrete diaphragm design are based on the DSDM research, which was awarded the prestigious 2016 ASCE Charles Pankow Award for Innovation. The award recognizes the contributions of organizations working collaboratively to advance the design and construction industry by introducing innovation into practice. Additional work to codify the research with ICC-ES ESR-3010 allows designers to implement the design methodology right now.

Additional work to codify the research with ICC-ES ESR-3010 allows designers to implement the design methodology right now.

2016 ASCE CHARLES PANKOW AWARD FOR INNOVATION
From left to right, Tom Smith, ASCE, Rik Kunnath, Charles Pankow Foundation, Clay Naito, Lehigh University, Robert Fleischman, University of Arizona, Roger Becker, PCI, Ned Cleland, Blue Ridge Design, Bob Risser, PCI, Mark Perniconi, Charles Pankow Foundation, Mark Woodson, 2016 ASCE President. Photo: PCI.

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Photo: Gate Precast Company.

PRECAST/PRESTRESSED CONCRETE

Design Resources

PCI develops, maintains, and disseminates the Body of Knowledge for designing, fabricating, and constructing precast concrete structures and systems. It is from this Body of Knowledge that building codes, design guides, education, and certification programs are derived. Please visit www.pci.org for all of these design resources and more.

Architectural Precast Concrete Color and Texture Selection Guide, 2nd Edition (CTG-10)

The "Architectural Precast Concrete—Color and Texture Selection Guide" has been reprinted with 12 new color and texture pages, plus identification pages with mixture designs. This includes nine new color pages with two new colors per page, two pages of new formliners, and one page of new clay brick-faced precast. The numbers in the guide have not been changed, so that there is no confusion between the old and the new versions. This is a visual guide to assist architects in the initial selection of color and texture for architectural precast concrete. Illustrating more than 500 colors and textures for enhancing the aesthetic quality of precast concrete panels, the guide is an extension of the information included in the architect-oriented Architectural Precast Concrete manual (MNL-122). Cements, pigments, coarse and fine aggregates, and texture or surface finish with various depths of exposure were considered in creating the 287 6.75- by- 11-inch color plates, the majority of which display two finishes on the same sample. The materials used to produce the samples are identified in the back of the guide for handy reference. The three-ring binder has removable inserts.

Architectural Precast Concrete, 3rd Edition (MNL-122)

This fully revised edition includes new sections on sustainability, condensation control, and blast resistance. You'll get extensive updates in the areas of color, texture, finishes, weather, tolerances, connections, and windows, along with detailed specifications to meet today's construction needs. Includes full-color photographs and a bonus DVD.

Precast Prestressed Concrete Parking Structures: Recommended Practice for Design and Construction, 3rd Edition (MNL-129-15; e-pub)

Decades of research have proven that precast, prestressed concrete is a cost effective, durable solution for parking structures. Over 140 pages present the latest concepts in design and construction, including 16 pages of full color photography and many details and design examples. This is the most comprehensive publication of its kind.

Designer's Notebooks – Free

The PCI Designer's Notebooks provide detailed, in-depth information on precast concrete relevant to specific design topics such as acoustics, mold, and sustainability.


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TPS Podium

PROJECT CONVERSION

All photos: Rachel Johnson.

A combined effort of the EnCon's companies is contributing to a new total–precast concrete podium structure in southwest Denver, Colo. This podium project encompasses a sophisticated total–precast concrete core and shell structure for a six-story residential building. With combined efforts, the companies are improving the performance of the building envelope for this parking structure with a diversified and targeted approach.

Total–precast structure (TPS) refers to a system of interior framing, floor systems, stair and elevator shafts, and perimeter load bearing elements. Located in Lone Tree, Colo., this four over one TPS podium project features a two-level parking garage with one level underground, a second elevated parking level with tuck-under units on two sides, and a roof featuring a pool and courtyard area. An interstitial concrete floor is used to create the concrete roof and courtyard, and to provide transition for four levels of wood framing that create living units above the podium. The multi-family facility is targeting the needs of a growing community, offering residents with direct access to the RTD light rail line, as well as Sky Ridge Medical Center and office locations in the area.

The Lincoln Station project process began with an initial meeting to introduce precast as a viable alternative to the planned cast-in-place model. The developer then contacted EnCon United and several meetings and site visits led to budget and design plan conversion discussions as shifting concerns arose due to labor shortages and scheduling. After these meetings with the project developer, precast was selected as the preferred option due to the ease of fabrication, an expedited erection schedule, and more economical pricing over conventional cast-in-place methods. Precast production and groundbreaking began in early 2017, with erection starting in May 2017. Throughout

the process, the project partners and the EnCon teams have used plans and strategies for achieving and meeting a fast-paced project schedule.

A primary reason for the conversion from cast-in-place to precast is the reduction of the project schedule from an initial plan of 32 weeks to 15 weeks. The entire precast schedule is projected to be finished in September 2017, and will continue to require heavy collaboration among the EnCon project teams.

Precast also provides an effective podium system while meeting desired project architectural features; primarily, the angled architecture and unique design. The precast concrete footprint is designed to maximize efficiency and space in a very tight and dense suburban location. Precast concrete was also chosen for its versatility, fire resistance, rapid construction, and for the ease in creating a total–precast concrete structure with a single-source supplier for the structure's podium.

The coordination of the three EnCon production plants, and the interrelated precast concrete parts provides several inherent advantages. The Lincoln Station project contains elements produced at EnCon Colorado, Stresscon Corporation, and Tpac, which are then shipped to the project site. The combined effort allows concurrent production to keep up with the piece demand of the project. The coordination of all precast concrete pieces ensures that all the project components are produced and expertly managed under one subcontracted trade. EnCon Design engineered and sealed the delegated design for the system and each of the prestressed components being produced by the three plants. EnCon Field Services and EnCon Construction are responsible for the installation and finishing of the precast, prestressed concrete components making up this TPS structure. The ability of EnCon's teams to be on site and manage the project reduces trade coordination, shortens the construction schedule, minimizes risk, and maximizes the assurance of a united team build.

The Lincoln Station project incorporates 2177 precast pieces, manufactured to PCI MNL-116 standards, serving as both the envelope design and structural support for the building. Precast components include columns, hollow-core, ramps, walls, beams, stairs, landings, flat slabs, and monolithic cores. A unique and challenging feature is the roof system that features recesses and an overall structural step in the building for the pool and courtyard area. The top podium is at one elevation, the courtyard has a 12-in. step-down in the entire outer section to account for

landscaping and pavers, and there is an 8-in. step on the outside for balconies. To accommodate the recesses and steps, the precast concrete beams are cast as block-outs and different sizes. The pool is at another elevation within the courtyard and is made with spandrels spanning column to column. Ramp walls and a hollow-core base are also integrated into this system, which is sloped to provide a secondary drainage system.

The project's total gross area is approximately 175,000 ft^2 and sits on a foundation system of drilled piers and pier caps. Precast concrete pieces in the project serve as both lateral and gravity systems. The lateral system is comprised of four stairwells and three elevator shafts with connections and reinforcements in the hollow-core flooring, as well as all exterior walls, serving as the building diaphragm. These lateral pieces are built to resist forces from wind and seismic events. The gravity system is comprised of the interior framing members that include beams, columns, and hollow-core.

The design process for the Lincoln Station project includes many welcome challenges, such as design angles and lack of design repetition, project layout to encompass parking below and living spaces above, conversion from cast-in-place using a design-build approach, and designing for a terrace with a rooftop pool. Because the project was designed as cast-in-place, the relative column layout and the conversion were all schematic. The design team did iterations of column and beam layouts and tried to insert double tees to reduce piece count, however a transition to hollow-core was necessary because of structural depth and podium loading requirements.

The podium project positions precast as an ideal alternative to cast-in-place design, and provides a high-performance structure with attributes of convenience, speed of turnaround, design flexibility, and cost savings. EnCon's full-service approach, from design and engineering through fabrication, production, and site administration, provides specialized experience and knowledge through a single supplier and direct access to the entire team.

Design, Technology, and Structures

UNIVERSITY OF WASHINGTON INTEGRATES LOCAL INDUSTRY INTO STUDIO'S SINGLE COURSE

— **Marty McIntyre**
PCI Foundation

Desk critiques by industry were an important part of working with students. Photos: University of Washington.

Tyler Sprague, assistant professor of architecture, is able to bring together his love of design and his training as a structural engineer through his precast concrete studio at the University of Washington in Seattle. "As a structural engineer, what I enjoyed the most was being in the architect's office and working through the building at the early critical stages where the design, technology, and structure comes together—I like those formative moments when the building takes off," says Sprague. "Now I am in the studio where I get to foster that environment directly. We take some things that are pretty high-end design, and make them realizable projects."

To make things more exciting, the students working with Sprague have only 10 weeks to kick off the projects, develop a concept, understand the structural system, and develop the plan. The program just finished its second year, and Sprague works closely with senior lecturer Jim Nicholls.

From day one, the students are surrounded by resources from PCI, and they connect early with the industry partners nearby. "We have a slew of industry partners," says Sprague," and they are a deep resource for us."

"In our second year we took a less, 'we talk, you listen' approach," says Catrina Walter of BergerABAM, who is the industry liaison for the program. "Instead it was more of an open forum during those first two meetings with the students. Our team sat down individually with the students, one on one, and talked with them about their plans for the projects. The students were able to show us both their computer and physical three-dimensional models and walk us through their thought process for how they arrived at their design concepts. We have offered tours at both Concrete Technology Corporation in Tacoma, Wash., and Olympian Precast in Redmond, Wash."

> "We encourage the students to think broadly about the problem"

CASTING EXERCISE TAKES HANDS-ON APPROACH

The students start the studio with the knowledge that their project will be precast and so the first thing on the agenda is to gain a working knowledge of concrete basics. Sprague starts with a small-scale casting exercise. Studios use the simple architectural diagram of the Maison Dom-Ino and develop a cladding system for it. They quickly come to understand both the importance of repetition in precast but also see how precast can take on many forms and designs.

"We encourage the students to think broadly about the problem, so we are not just looking for simple floor-to-floor panels that we can stack, we are asking them to engage the true nature of the problem and think about it in different ways," says Sprague. "The projects really take off in interesting directions. In one project the students looked at the warping of a fin and twisting of an airplane coil and how that might be created as a single, castable unit so that when you

passed inside and outside you would get different views from these fins, whether you are looking at it straight on or at an angle."

Other students researched more about the concrete and created a permeable façade, with the thought that a concrete screen could filter the water and runoff form the parking garage.

This initial study of placing precast concrete as a façade on a simple structure works well in helping students understand the freedom one can have in designing in precast. "I know a lot of ways to think about precast as an innovative material and as a means of executing their ideas," says Sprague. "We are not in the business of saying 'no you can't do that in precast.'" We are in the business of saying 'yes, and how' and really working with the students to figure out how to execute their ideas."

TOURS BRING NEW IDEAS TO LIGHT

To make that happen, the studio partners with a contingent of precast concrete industry professionals coordinated by Walter. Their first time with the students is when they come in and do desk critiques with each student.

"That is where the power of our studio really kicks in," says Sprague. "We are definitely pushing our industry professionals to think about precast in ways that they not have thought of before, and we are pushing our student to make their ideas real.

For student Sarah Chan, the desk critiques have been especially helpful. "It has been unique to this studio. And not only do we have those desk critiques with them, we invite them to our mid-term and final reviews so it creates an interesting dialog between the architect reviewers, and the industry reviewers. We get a chance to see how it comes out. They are always very interesting conversations with the different perspectives."

Students move out of the studio and into Seattle and the precast plants so they can see successful precast design and understand the fabrication process. "We have an interesting balance of precast producers in the Pacific Northwest. Concrete Tech is a heavy industrial producer who produces floating pontoons, bridge girders, and transportation products. Then we have a smaller producer, Olympian Precast, who is producing precast panels for buildings. We balance those two extremes as we take our trips," says Sprague.

A tour of precast projects around Seattle also gives students appreciation for some precast designs from the past. Sprague calls the 1960s and 1970s in Seattle a "golden age" of precast. A notable example is the Pacific Science Center designed by Minoru Yamasaki for the 1962 World's Fair, which is often referred to as "space gothic."

In addition to precast concrete industry personnel, local architects play an important role in nurturing student design.

PARKING STRUCTURE DESIGN USES NEW IDEAS IN PROGRAM

Finally, the students take on the design project: a modern day urban parking structure at a transit hub near the university. In addition to using precast concrete in the design, students are given another program element of modernizing the idea of how a parking structure is used.

As Sprague sees it, the parking structure of the future is less determined by current car sizes and more by speculation about future mobility trends. Students get on board with this because they are excited about thinking about the ways things could be in the future.

For one industry partner, Chuck Prussack previously with Oldcastle Precast, sitting down with the students and rolling up his sleeves was the most enjoyable part of the semester. "Anyone who knows me knows I like nothing better than sitting with architects, engineers, or contractors with a sketch pad or whiteboard to help show how to use our products," says Prussack. "I was amazed at the thought each student had put into their concepts and how much pride they had in their vision."

STUDENT DEVELOP IDEAS DURING SUMMER

Following the semester, Sprague will work with one or two students who want to develop their ideas further in a seminar. During the summer of 2016 students looked a thin concrete. "Thin concrete is material that used to be used in the 50s and 60s quite a bit, and now with new understandings of efficiency and all the different mix designs now, we are exploring how that might actually come back," says Sprague.

ALL-CAMPUS DESIGN COMPETITION

New for 2017 is a campus-wide design competition that is being held in addition to the Precast Studio. This is our effort to bring in designers from the art school, the engineering school, and from across the campus to think about precast concrete in an open-ended way. The students will be challenged to design a single, innovative precast concrete building element. The school is having information session across campus and will finish with a cash prize.

PCI Continuing Education

PCI is a registered continuing education provider with the American Institute of Architects (AIA), and the National Council of Examiners of Engineers and Surveyors (NCEES). PCI also has registered programs with the International Code Council (ICC). PCI's educational offerings include a variety of programs to fit your schedule and preferred learning environment, such as webinars, seminars, lunch-and-learns, and online education. To learn more, visit **www.pci.org/education**.

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September 26 and 28, 2017, "How Precast Builds-Floor and Roof Systems (Hollow-core)"
October 24 and 26, 2017 "PCI Handbook 8th Edition-What's New"

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The PCI eLearning Center is the first education management system dedicated to the precast concrete structures industry. This free 24-hour online resource provides an opportunity for architects and engineers to earn continuing education credits on demand. Each course includes a webinar presentation recording, reference materials, and a quiz. Visit this resource at **www.pci.org/elearning**.

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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 Structural Precast and Prestressed Concrete Products*
- MNL–117 *Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products*
- 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.

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 nonload-bearing wall panels, spandrels, beams, mullions, columns, column covers, and miscellaneous shapes. This category includes Category AT.

> GROUP B – BRIDGES

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.

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 (but 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 (but not certified to produce any products in 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.

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Gate Precast Company A1, C4, C4A
Monroeville, (251) 575-2803

> ARIZONA

Coreslab Structures (ARIZ) Inc. A1, B4, C4, C4A
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Green Fuel Technologies LLC dba Royden Precast B4
Phoenix, (602) 269-9206

Stinger Bridge & Iron B4
Coolidge, (520) 723-5383

Tpac, An EnCon Company A1, B4, C4, C4A
Phoenix, (602) 262-1360

> ARKANSAS

Coreslab Structures (ARK) Inc. C4, C4A
Conway, (501) 329-3763

> CALIFORNIA

Bethlehem Construction Inc. C3, C3A
Wasco, (661) 391-9704

Clark Pacific A1, C3, C3A, G
Fontana, (909) 823-1433

Clark Pacific C4, C4A
Adelanto, (626) 962-8751

Clark Pacific A1, B3, C4, C4A, G
Woodland, (530) 207-4100

Con-Fab California Corporation B4, C4
Lathrop, (209) 249-4700

Con-Fab California Corporation B4, C4
Shafter, (661) 630-7162

Coreslab Structures (LA) Inc. A1, B4, C4, C4A
Perris, (951) 943-9119

KIE-CON, Inc. B4, C3
Antioch, (925) 754-9494

Mid-State Precast L.P. A1, C3, C3A
Corcoran, (559) 992-8180

Oldcastle Precast Inc. B4, B4A, C2, C2A
Perris, (951) 657-6093

Oldcastle Precast Inc. C2
Stockton, (209) 466-4215

Precast Concrete Technology Unlimited dba CTU Precast A1, C3, C3A
Olivehurst, (530) 749-6501

StructureCast A1, B3, C3, C3A
Bakersfield, (661) 833-4490

Universal Precast Concrete Inc. A1, B1, C1
Redding, (530) 243-6477

Walters & Wolf Precast A1, G
Fremont, (510) 226-9800

Willis Construction Co. Inc. A1, C1
Hollister, (831) 623-2900

Willis Construction Co. Inc. A1, C1, G
San Juan Bautista, (831) 623-2900

> COLORADO

EnCon Colorado B4, C2
Denver, (303) 287-4312

Plum Creek Structures B4, C3, C3A
Littleton, (303) 471-1569

Rocky Mountain Prestress LLC Architectural Plant A1, C3, C3A
Denver, (303) 480-1111

Rocky Mountain Prestress LLC Structural Plant B4, C4
Denver, (303) 480-1111

Rocla Concrete Tie Inc. C2
Pueblo, (303) 296-3500

Stresscon Corporation A1, B4, B4A, C4, C4A
Colorado Springs, (719) 390-5041

> CONNECTICUT

Blakeslee Prestress Inc. A1, B4, C4, C4A
Branford, (203) 481-5306

Coreslab Structures (CONN) Inc. A1, B1, C1
Thomaston, (860) 283-8281

Oldcastle Precast B2, C2, C2A
Avon, (860) 673-3291

United Concrete Products Inc. B3, C3
Yalesville, (203) 269-3119

> DELAWARE

Concrete Building Systems of Delaware, Inc. B3, C4
Delmar, (302) 846-3645

Rocla Concrete Tie Inc. C2
Bear, (302) 836-5304

> FLORIDA

Cement Industries Inc. B3, C3
Fort Myers, (800) 332-1440

Colonial Precast Concrete LLC C2
Placida, (941) 698-4180

Coreslab Structures (MIAMI) Inc. A1, C4, C4A
Medley, (305) 823-8950

Coreslab Structures (ORLANDO) Inc. C2
Orlando, (407) 855-3190

Coreslab Structures (TAMPA) Inc. A1, B3, C3, C3A
Tampa, (813) 626-1141

Dura-Stress Inc. A1, B4, B4A, C4, C4A
Leesburg, (352) 787-1422

Finfrock Industries Inc. A1, C3
Apopka, (407) 293-4000

Gate Precast Company A1, B4, C3, C3A
Jacksonville, (904) 757-0860

Gate Precast Company A1, C3
Kissimmee, (407) 847-5285

International Casting Corporation C4
Hialeah, (305) 558-3515

Metromont Corporation A1, C3, C3A
Bartow, (863) 440-5400

Precast Specialties LLC C4
Pompano Beach, (954) 781-4040

Skanska USA Civil SE B4, C3
Pensacola, (757) 578-4147

Spancrete C2
Sebring, (863) 655-1515

Stabil Concrete Products LLC A1
St. Petersburg, (727) 321-6000

Standard Concrete Products Inc. B4, C3
Tampa, (813) 831-9520

Structural Prestressed Industries Inc. C4
Medley, (305) 556-6699

> GEORGIA

Atlanta Structural Concrete Co. C4, C4A
Buchanan, (770) 646-1888

Coreslab Structures (ATLANTA) Inc. C2
Jonesboro, (770) 471-1150

Metromont Corporation A1, C4, C4A
Hiram, (770) 943-8688

Spancrete C2
Newnan, (770) 252-8944

Standard Concrete Products Inc. B4
Atlanta, (404) 792-1600

Standard Concrete Products Inc. B4, C4
Savannah, (912) 233-8263

Tindall Corporation, Georgia Division C4, C4A
Conley, (404) 366-6270

> HAWAII

GPRM Prestress LLC A1, B4, C4, C4A
Kapolei, (808) 682-6000

> IDAHO

Forterra Structural Precast A1, B4, C4
Caldwell, (208) 454-8116

Teton Prestress Concrete LLC B4, C3
Idaho Falls, (208) 552-6606

> ILLINOIS

ATMI Precast A1, C3, C3A
Aurora, (630) 896-4679

AVAN Precast Concrete Products Inc. A1, C3
Lynwood, (708) 757-6200

County Materials Corporation B3, B3-IL
Champaign, (217) 352-4181

County Materials Corporation A1, B4, B4-IL, C4
Salem, (618) 548-1190

Dukane Precast Inc. A1, B3, B3-IL, C3, C3A
Aurora, (630) 355-8118

Dukane Precast Inc. A1, B3, B3-IL, C3, C3A
Naperville, (630) 355-8118

Dukane Precast Inc. A1, B3, B3-IL, C3, C3A
Plainfield, (815) 230-4760

ICCI Illini Concrete LLC B3, B3-IL
Tremont, (309) 925-2376

Illini Precast LLC B4, B4-IL, C3
Marseilles, (815) 795-6161

Lombard Architectural Precast Products Co. A1, C2, C2A
Alsip, (708) 389-1060

Mid-States Concrete Industries A1, B3, B3-IL, C3, C3A
South Beloit, (815) 389-2277

St. Louis Prestress Inc. B3, B3-IL, C3
Glen Carbon, (618) 656-8934

Utility Concrete Products LLC B1, B1A, C1, C1A
Morris, (815) 416-1000

> INDIANA

ATMI Indy, LLC A1, C2, C2A
Greenfield, (317) 891-6280

Coreslab Structures (INDIANAPOLIS) Inc. A1, C4, C4A
Indianapolis, (317) 353-2118

Hoosier Precast LLC B3, C1, C1A
Salem, (815) 459-4545

Precast Specialties A1, B1
Monroeville, (260) 623-6131

Prestress Services Industries LLC B4, B4-IL, C4, C4A
Decatur, (260) 724-7117

StresCore, Inc. C2
South Bend, (574) 233-1117

> IOWA

Advanced Precast Co. A1, C1, C1A
Farley, (563) 744-3909

Forterra Pipe & Precast B4, C4, C4A
Iowa Falls, (641) 648-2579

MPC Enterprises Inc. A1, C3, C3A
Mount Pleasant, (319) 986-2226

PDM Precast Inc. A1, C3, C3A
Des Moines, (515) 243-5118

> KANSAS

Coreslab Structures (KANSAS) Inc. B4, C4
Kansas City, (913) 287-5725

Crossland Prefab LLC C1
Columbus, (620) 249-1414

Fabcon Precast, LLC C3, C3A
Pleasanton, (913) 937-3021

Prestressed Concrete Construction LLC A1, B4, C4, C4A
Newton, (316) 283-2277

Stress-Cast, Inc. C3, C3A
Assaria, (785) 667-3905

> KENTUCKY

Bristol Group Inc. A1, B3, B3A, C3, C3A
Lexington, (859) 233-9050

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Owensboro, (270) 684-6226

Forterra Pipe & Precast B3, C3
Louisville, (800) 737-0707

Gate Precast Company A1, C3, C3A
Winchester, (859) 744-9481

Prestress Services Industries LLC A1, B4, C4, C4A
Lexington, (601) 856-4135

Prestress Services Industries LLC B4, C3
Melbourne, (859) 441-0068

> LOUISIANA

Alfred Miller Contracting C3
Lake Charles, (337) 477-4681

Atlantic Metrocast Inc. C2
New Orleans, (504) 941-3152

Boykin Brothers LLC A1, B4, C3, C3A
Baton Rouge, (225) 753-8722

dp Concrete Products LLC B2, C2
Vinton, (337) 433-3900

F-S Prestress LLC B4, C4
Princeton, (318) 949-2444

Fibrebond Corporation A1, C1, C1A
Minden, (318) 377-1030

> MAINE

Superior Concrete LLC B2, C1
Auburn, (207) 784-1388

> MARYLAND

Atlantic Metrocast Inc. B2, C2
La Plata, (301) 870-3289

Larry E. Knight Inc. C2
Reisterstown, (410) 833-7800

> MASSACHUSETTS

Oldcastle Precast Inc. B4, C3
Rehoboth, (508) 336-7600

Precast Specialties Corp. A1
Abington, (781) 878-7220

Unistress Corporation A1, B4, C4, C4A
Pittsfield, (413) 629-2039

Vynorius Prestress, Inc. B3, C2
Salisbury, (978) 462-7765

> MICHIGAN

International Precast Solutions LLC A1, B3, C3, C3A
River Rouge, (313) 843-0073

Kerkstra Precast Inc. A1, B3, C3, C3A
Grandville, (616) 224-6176

M.E.G.A. Precast Inc. A1, C3, C3A
Shelby Township (586) 294-6430

Mack Stress-Con LLC A1, B4, C3, C3A
Kalamazoo, (269) 381-1550

Peninsula Prestress Company B4, C1
Grand Rapids, (517) 206-4775

Mack Stress-Con LLC B3A, C3
Saginaw, (989) 755-4348

> MINNESOTA

Crest Precast Inc. B3, B3A, C3, C3A
La Crescent, (800) 658-9045

Forterra Pipe & Precast B4, C2
Elk River, (763) 441-2124

Fabcon Precast LLC A1, B1, C3, C3A
Savage, (952) 890-4444

Molin Concrete Products Co. C3, C3A
Lino Lakes, (651) 786-7722

Molin Concrete Products Co. A1, C1, C1A
Ramsey, (651) 786-7722

Taracon Precast C3, C3A
Hawley, (218) 216-8260

Wells Concrete A1, C3, C3A
Albany, (320) 845-2229

Wells Concrete C3
Rosemount, (507) 380-6772

Wells Concrete A1, C4, C4A
Wells, (800) 658-7049

> MISSISSIPPI

F-S Prestress LLC B4, C4
Hattiesburg, (601) 268-2006

Gulf Coast Pre-Stress Inc. B4, C4
Pass Christian, (228) 452-9486

J.J. Ferguson Prestress-Precast Inc. B4
Greenwood, (662) 453-5451

Jackson Precast Inc. A1, C2, C2A
Jackson, (601) 321-8787

Tindall Corporation A1, C4, C4A
Moss Point, (228) 246-0800

> MISSOURI

Coreslab Structures (MISSOURI) Inc. A1, B4, C4, C4A
Marshall, (660) 886-3306

County Materials Corporation B4
Bonne Terre, (573) 358-2773

Mid America Precast Inc. A1, B1, C1
Fulton, (573) 642-6400

Prestressed Casting Co. C4
Ozark, (417) 581-7009

Prestressed Casting Co. A1, C3, C3A
Springfield, (417) 869-7350

> MONTANA

Missoula Concrete Construction A1, B3, C3, C3A
Missoula, (406) 549-9682

Forterra Pipe & Precast B4, C3
Billings, (406) 656-1601

Forterra Building Products B4
Montana City, (406) 442-6503

> NEBRASKA

American Concrete Products Co. B1, B1A, C1, C1A
Valley, (402) 331-5775

Concrete Industries Inc. B4, C4, C4A
Lincoln, (402) 434-1800

Coreslab Structures (OMAHA) Inc. A1, B4, C4, C4A
LaPlatte, (402) 291-0733

Enterprise Precast Concrete Inc. A1, C2, C2A
Omaha, (402) 895-3848

> NEVADA

Western Pacific Precast B4, C2
Sloan, (702) 623-4484

> NEW HAMPSHIRE

Newstress Inc. B3, C3
Epsom, (603) 736-9000

> NEW JERSEY

Boccella Precast LLC C2
Berlin, (856) 767-3861

Jersey Precast B4, C4, C4A
Hamilton Township, (609) 689-3700

Northeast Precast A1, B3, C3, C3A
Millville, (856) 765-9088

Precast Systems Inc. B4, C4
Allentown, (609) 208-1987

> NEW MEXICO

Castillo Prestress B4, C4
Belen, (505) 864-0238

Coreslab Structures (ALBUQUERQUE) Inc. A1, B4, C4, C4A
Albuquerque, (505) 247-3725

Ferreri Concrete Structures Inc. A1, C4, C4A
Albuquerque, (505) 344-8823

> NEW YORK

David Kucera Inc. A1, G
Gardiner, (845) 255-1044

Lakelands Concrete Products Inc. A1, B3, B3A, C3, C3A
Lima, (585) 624-1990

Oldcastle Precast B3, C3, C3A
Selkirk, (518) 767-2116

The Fort Miller Company Inc. B1, B1A, C1, C1A
Greenwich, (518) 695-5000

The L.C. Whitford Materials Co. Inc. B4, C3
Wellsville, (585) 593-2741

> NORTH CAROLINA

Coastal Precast Systems LLC B4, C2
Wilmington, (910) 604-2249

Gate Precast Company A1, C3
Oxford, (919) 603-1633

Metromont Corporation A1, C3, C3A
Charlotte, (704) 372-1080

Prestress of the Carolinas B4, C4
Charlotte, (704) 587-4273

Utility Precast Inc. B3, B3A
Concord, (704) 721-0106

> NORTH DAKOTA

Wells Concrete C4, C4A
Grand Forks, (701) 772-6687

> OHIO

DBS Prestress of Ohio C3
Huber Heights, (937) 878-8232

Fabcon Precast LLC A1, C3, C3A
Grove City, (952) 890-4444

High Concrete Group LLC A1, C3, C3A
Springboro, (937) 748-2412

Mack Industries Inc. C3
Valley City, (330) 483-3111

Mack Industries Inc. B3A,C3
Vienna, (330)638-7680

Prestress Services Industries of Ohio LLC (I-Beam) A1, B4, C3
Mt. Vernon, (740) 393-1121

Prestress Services Industries of Ohio LLC (Box Beam) B3, C3
Mt. Vernon, (740) 393-1121

Rocla Concrete Tie Inc. C2
Sciotoville, (740) 776-3238

Sidley Precast Group A1, C4, C4A
Thompson, (440) 298-3232

> OKLAHOMA

Arrowhead Precast LLC A1, C3, C3A
Broken Arrow, (918) 995-2227

Coreslab Structures (OKLA) Inc. (Plant No.1) A1, C4, C4A
Oklahoma City, (405) 632-4944

Coreslab Structures (OKLA) Inc. (Plant No.2) B4, C3
Oklahoma City, (405) 672-2325

Coreslab Structures (TULSA) Inc. B4, C4
Tulsa, (918) 438-0230

> OREGON

Knife River Prestress A1, B4, C4, C4A
Harrisburg, (541) 995-4100

R.B. Johnson Co. B4, C3
McMinnville, (503) 472-2430

> PENNSYLVANIA

Architectural Precast Innovations Inc. A1, C3, C3A
Middleburg, (570) 837-1774

Brayman Precast LLC B3, C1A
Saxonburg, (724) 352-5600

Concrete Safety Systems LLC A1, B3, B3A, C3, C3A
Bethel, (717) 933-4107

Conewago Precast Building Systems A1, C3,C3A
Hanover, (717) 632-7722

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Dutchland Inc. C3
Gap, (717) 442-8282
Fabcon Precast LLC A1, B1, B1A, C3, C3A
Mahanoy City, (952) 890-4444
High Concrete Group LLC A1, B3, C3, C3A
Denver, (717) 336-9300
J & R Slaw Inc. A1, B4, C3, C3A
Lehighton, (610) 852-2020
Nitterhouse Concrete Products Inc. A1, C4, C4A
Chambersburg, (717) 267-4505
Northeast Prestressed Products LLC B4, C3
Cressona, (570) 385-2352
PENNSTRESS A1, B4, C4
Roaring Spring, (814) 695-2016
Say-Core Inc. C2
Portage, (814) 736-8018
Sidley Precast Group, A Division of R.W. Sidley Inc. C3
Youngwood, (724) 755-0205
Universal Concrete Products Corporation A1, C3, C3A
Stowe, (610) 323-0700

> RHODE ISLAND

Hayward Baker Inc. C2
Cumberland, (401) 334-2565

> SOUTH CAROLINA

Florence Concrete Products Inc. B4, C3, C3A
Sumter, (803) 775-4372
Metromont Corporation A1, C4, C4A
Greenville, (864) 605-5000
Metromont Corporation C3
Spartanburg, (864)605-5063
Tekna Corporation B4, C3
Charleston, (843) 853-9118
Tindall Corporation A1, C4, C4A
Spartanburg, (864) 576-3230

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Forterra Pipe & Precast (Rapid City) B4
Rapid City, (605) 343-1450
Gage Brothers A1, B4, C4, C4A
Sioux Falls, (605) 336-1180

> TENNESSEE

Construction Products Inc. of Tennessee B4, C4
Jackson, (731) 668-7305
Gate Precast Company A1, C3, C3A
Ashland City, (615) 792-4871
Mid South Prestress LLC C3
Pleasant View, (615) 746-6606
Ross Prestressed Concrete Inc. B4, C3
Bristol, (423) 323-1777
Ross Prestressed Concrete, Inc. B4, C4
Knoxville, (865) 524-1485

> TEXAS

Coreslab Structures (TEXAS) Inc. A1, C4, C4A
Cedar Park, (512) 250-0755
CXT Inc. B1, B1A, C1, C1A
Hillsboro, (254) 580-9100
East Texas Precast A1, C4, C4A
Hempstead, (281) 463-0654
Enterprise Concrete Products LLC B3, C3
Dallas, (214) 631-7006
Enterprise Precast Concrete of Texas LLC A1, C1
Corsicana, (903) 875-1077
Gate Precast Company A1, C1, C1A
Hillsboro, (254) 582-7200
Gate Precast Company C2
Pearland, (281) 485-3273
GFRC Cladding Systems LLC G
Garland, (972) 494-9000
Heldenfels Enterprises Inc. B4, C4
Corpus Christi, (361) 883-9334
Heldenfels Enterprises Inc. B4, C4
San Marcos, (512) 396-2376
Legacy Precast LLC C4, C4A
Brookshire, (281) 375-2050
Lowe Precast Inc. A1, C3, C3A
Waco, (254) 776-9690
Manco Structures Ltd. C4, C4A
Schertz, (210) 690-1705
NAPCO PRECAST LLC A1, C4, C4A
San Antonio, (210) 509-9100
Rocla Concrete Tie Inc. C2
Amarillo, (806) 383-7071
Texas Concrete Partners LP B4, C4
Elm Mott, (254) 822-1351
Texas Concrete Partners LP B4, C4
Victoria, (361) 573-9145
Tindall Corporation A1, C3, C3A
San Antonio, (210) 248-2345
Valley Prestressed Products Inc. B2
Houston, (713) 455-6098
Valley Prestress Products Inc. B4
Eagle Lake, (979) 234-7899

> UTAH

Forterra Structural Precast A1, B4, C4, C4A, G
Salt Lake City, (801) 966-1060
Harper Precast B2, C1
Salt Lake City, (801) 326-1016
Olympus Precast A1, B3, B3A, C3, C3A
Bluffdale, (801) 571-5041

> VERMONT

Joseph P. Carrara & Sons Inc. A1, B4, B4A, C4, C4A
Middlebury, (802) 775-2301
S.D. Ireland Concrete Construction Corp. B1, C1
Williston, (802) 863-6222
William E. Dailey Precast LLC A1, B4, B4A, C3, C3A
Shaftsbury, (802) 442-4418

> VIRGINIA

Atlantic Metrocast Inc. B4, C4
Portsmouth, (757) 397-2317
Bayshore Concrete Products Corporation B4, C4
Cape Charles, (757) 331-2300
Coastal Precast Systems LLC A1, B4, C3
Chesapeake, (757) 545-5215
Hessian Company LTD
t/a Faddis Concrete Products B2, C2
King George, (540) 775-4546
Metromont Corporation A1, C3, C3A
Richmond, (804) 665-1300
Rockingham Precast B4
Harrisonburg, (540) 433-8282
Smith-Midland A1, B2, C2, C2A
Midland, (540) 439-3266
The Shockey Precast Group A1, C4, C4A
Winchester, (540) 667-7700
Tindall Corporation A1, C4, C4A
Petersburg, (804) 861-8447

> WASHINGTON

Bellingham Marine Industries Inc. B3, C2
Ferndale, (360) 380-2142
Bethlehem Construction Inc. B1, C3, C3A
Cashmere, (509) 782-1001
Concrete Technology Corporation B4, C4
Tacoma, (253) 383-3545
CXT Inc., Precast Division B1, C1, C1A
Spokane, (509) 921-8766
CXT Inc., Rail Division C2
Spokane, (509) 921-7878
EnCon Northwest LLC B1, B1A
Camas, (360) 834-3459
Oldcastle Precast Inc. A1, B4, C4
Spokane Valley, (509) 536-3300
Wilbert Precast Inc. B3, C3, C3A
Yakima, (509) 325-4573

> WEST VIRGINIA

Carr Concrete a division of CXT Inc. B4, C3
Williamstown, (304) 464-4441
Eastern Vault Company, Inc. B3, C3
Princeton, (304) 425-8955

> WISCONSIN

County Materials Corporation B4, B4-IL
Janesville, (608) 373-0950
County Materials Corporation B4, C3
Roberts, (800) 426-1126
International Concrete Products Inc. A1, C1
Germantown, (262) 242-7840
KW Precast LLC B4, B4-IL, C4
Burlington, (708) 562-7770
MidCon Products Inc. A1, C1
Hortonville, (920) 779-4032
Spancrete A1, B4, C3, C3A
Valders, (920) 775-4121
Stonecast Products Inc. A1, C1
Germantown, (262) 253-6600
Wausau Tile Inc. AT
Rothschild, (715) 359-3121

> WYOMING

voestalpine Nortrak Inc. C2
Cheyenne, (509) 220-6837

> MEXICO

PRETECSA, S.A. DE C.V. A1, G
Estado de Mexico 52, (555) 077-0071
Willis De Mexico S.A. de C.V. A1, C1, G
Tecate BC, MX 52, (665) 655-2222

> CANADA

BRITISH COLUMBIA

APS Precast, a Division of
C&S Group Operations Ltd. A1, B4, C3, C3A
Langley, (604) 888-1968
Armtec Limited Partnership A1, B4, C3
Richmond, (604) 214-3243

NEW BRUNSWICK

Strescon Limited A1, B4, C4, C4A
Saint John, (506) 633-8877

NOVA SCOTIA

Strescon Limited A1, B4, C4, C4A
Beford, (902) 494-7400

ONTARIO

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

QUEBEC

Betons Prefabriques Trans.-Canada Inc. A1, B4, C3, C3A
St-Eugene De Grantham, (819) 396-2624
Betons Prefabriques
(Bombadier Plant), Alma A1, C2
Betons Prefabriques
(Papeterie Plant), Alma A1, C3, C3A, G
Prefab de Beauce Inc. A1, C3
Sainte-Marie-Dde-Beauce, (418) 387-7152

> UAE

Arabian Profile Company Limited G
Sharjah, 971(6) 5432624

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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 certified by the Precast/Prestressed Concrete Institute (PCI) prior to the beginning of any work at the jobsite. The precast concrete erector shall be 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.

> ARIZONA

Coreslab Structures (ARIZ) Inc. S2
Phoenix, (602) 237-3875

RJC Contracting, Inc. A, S2
Mesa, (480) 357-0868

Steel Girder LLC dba Stinger Bridge & Iron S1
Coolidge, (502) 723-5383

Tpac, An EnCon Company A, S2
Phoenix, (602) 262-1333

> CALIFORNIA

MidState Precast L.P. A, S2
Corcoran, (559) 992-8180

Walters & Wolf Precast A
Fremont, (510) 226-5166

> COLORADO

EnCon Field Services LLC A, S2
Denver, (303) 287-4312

Gibbons Erectors Inc. A, S2
Englewood,, (303) 841-0457

Rocky Mountain Prestress LLC A, S2
Denver, (303) 480-1111

> CONNECTICUT

Blakeslee Prestress Inc. S2
Branford, (203) 481-5306

> FLORIDA

Concrete Erectors Inc. A, S2
Altamonte Springs, (407) 862-7100

Coreslab Structures (MIAMI) Inc. A, S2
Medley, (305) 823-8950

Florida Builders Group Inc. S2
Miami Gardens, (305) 278-0098

Jacob Erecting & Construction LLC A, S2
Jupiter, (561) 741-1818

Pre-Con Construction Inc. A, S2
Lakeland, (863) 688-4504

Prestressed Contractors Inc. S2
West Palm Beach, (561) 741-4369

Specialty Concrete Services Inc. A, S2
Umatilla, (352) 669-8888

W.W. Gay Mechanical Contractor Inc. S2
Jacksonville, (904) 388-2696

> GEORGIA

Bass Precast Erecting Inc. S1
Cleveland, (706) 809-2718

Jack Stevens Welding LLP S2
Murrayville, (770) 534-3809

Precision Stone Setting Co. Inc. A, S2
Hiram, (770) 439-1068

Rutledge & Sons Inc. S2
Canton, (770) 592-0380

Southeastern Precast Erectors Inc. (SPE Inc.) A
Roswell, (770) 722-9212

> IDAHO

Precision Precast Erectors LLC A, S2
Post Falls, (208) 981-0060

> ILLINOIS

Area Erectors Inc. A, S2
Rochelle, (815) 562-4000

Creative Erectors LLC A, S2
Rockford, (815) 229-8303

Mid-States Concrete Industries S2
South Beloit, (815) 389-2277

> IOWA

Cedar Valley Steel Inc. A, S2
Cedar Rapids, (319) 373-0291

Industrial Steel Erectors A, S1
Davenport, (563) 355-7202

Northwest Steel Erection Inc. A, S2
Grimes, (515) 986-0380

US Erectors Inc. S2
Des Moines, (515) 243-8450

> KANSAS

Carl Harris Co. Inc. A, S2
Wichita, (316) 267-8700

Crossland Construction Company Inc. S2
Columbus, (620) 442-1414

> LOUISIANA

Alfred Miller Contracting S2
Lake Charles, (337) 477-4681

> MARYLAND

DLM Contractors LLC A, S2
Cheltenham, (301) 877-0000

E & B Erectors Inc. A, S2
Elkridge, (410) 360-7800

E.E. Marr Erectors Inc. A, S2
Baltimore, (410) 837-1641

EDI Precast LLC S1, S2
Upper Marlboro (301)877-2024

L.R. Willson & Sons Inc. A, S2
Gambrills, (410) 987-5414

> MASSACHUSETTS

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

> MICHIGAN

Assemblers Precast & Steel Services Inc. A, S2
Saline, (734) 368-6147

G2 Inc. A, S2
Cedar Springs, (616) 696-9581

Construction Specialties of Zeeland Inc. S1
Zeeland, (616) 772-9410

Midwest Steel Inc. S1
Detroit, (313) 873-2220

Pioneer Construction Inc. A, S2
Grand Rapids, (616) 247-6966

> MINNESOTA

Amerect Inc. S2
Newport, (651) 459-9909

Fabcon Precast LLC S2
Savage, (952) 890-4444

Molin Concrete Products Company A, S2
Lino Lakes, (651) 786-7722

Wells Concrete A, S2
Maple Grove, (800) 658-7049

> MISSISSIPPI

Bracken Construction Company A, S2
Ridgeland, (601) 922-8413

> MISSOURI

JE Dunn Construction A, S2
Kansas City, (816) 292-8762

Prestressed Casting Co. A, S2
Springfield, (417) 869-7350

> NEBRASKA

Moen Steel Erection Inc. A, S2
Omaha, (402) 884-0925

Topping Out Inc. dba Davis Erection–Omaha A, S2
Omaha, (402) 731-7484

> NEW HAMPSHIRE

American Steel & Precast Erectors S2
Greenfield, (603) 547-6311

Newstress Inc. S1
Epsom, (603) 736-9000

> NEW JERSEY

CRV Precast Construction LLC S1
Eastampton, (609) 261-7325

J. L. Erectors Inc. A, S2
Blackwood, (856) 232-9400

JEMCO-Erectors Inc. A, S2
Shamong, (609) 268-0332

Jonasz Precast Inc. A, S2
Westville, (856) 456-7788

Kenvil United Corp. S1
Kenvil, (973) 927-0010

> NEW YORK

Koehler Masonry Corp. S2
Farmingdale, (631) 694-4720

Oldcastle Building Systems Div./Project Services A, S2
Selkirk, (518) 767-2116

Tutor Perini Corporation Civil S1
New Rochelle, (914) 739-1905

> NORTH DAKOTA

Comstock Construction Inc. S2
Fargo, (701) 892-7236

Magnum Contracting Inc. A, S2
Fargo, (701) 235-5285

Midwest Precast Services A, S2
Fargo, (701) 893-0188

PKG Contracting Inc. S2
Fargo, (701) 232-3878

> OHIO

Precast Services, Inc. A, S2
Twinsburg, (330) 425-2880

Sidley Precast Group, A Division of R.W. Sidley Inc. S2
Thompson, (440) 298-3232

> OKLAHOMA

Allied Steel Construction Co. LLC S2
Oklahoma City, (405) 232-7531

> PENNSYLVANIA

Century Steel Erectors A, S2
Kittanning, (724) 545-3444

Conewago Precast Building Systems S2
Hanover, (717) 632-7722

High Structural Erectors LLC A, S2
Lancaster, (717) 390-4203

Kinsley Construction Inc. t/a Kinsley Manufacturing S1
York, (717) 757-8761

Maccabee Industrial Inc. A, S2
Belle Vernon, (724) 930-7557

Nitterhouse Concrete Products Inc. A, S2
Chambersburg, (717) 267-4505

> SOUTH CAROLINA

Davis Erecting & Finishing Inc. A, S2
Greenville, (864) 220-0490

Florence Concrete Products Inc. S2
Florence, (843) 662-2549

Steel Clad Inc. A, S2
Greenville, (864) 246-8132

Tindall Corporation A, S2
Spartanburg, (864) 576-3230

> SOUTH DAKOTA

Henry Carlson Company A, S2
Sioux Falls, (605) 336-2410

> TENNESSEE

Mid South Prestress LLC S1
Pleasant View, (615) 746-6606

> TEXAS

Coreslab Structures (TEXAS) Inc. A, S2
Cedar Park, (512) 250-0755

Derr and Isbell Construction LLC A, S2
Euless, (817) 571-4044

Gulf Coast Precast Erectors LLC S2
Hempstead, (832) 451-4395

Precast Erectors, Inc. A, S2
Hurst, (817) 684-9080

> UTAH

Forterra Structural Precast A, S1
Salt Lake City, (801) 966-1060

IMS Masonry A
Lindon, (801) 796-8420

OutWest C & E Inc. A, S2
Bluffdale, (801) 446-5673

> VERMONT

CCS Constructors Inc. A, S2
Morrisville, (802) 888-7701

> VIRGINIA

The Shockey Precast Group S2
Winchester, (540) 667-7700

> WISCONSIN

J. P. Cullen & Sons Inc. A
Janesville, (608) 754-6601

Miron Construction Co. Inc. A, S2
Neenah, (920) 969-7000

Spancrete A, S2
Valders, (920) 775-4121

The Boldt Company A, S2
Appleton, (920) 225-6212

SPECIFY PCI CERTIFICATION

THERE IS NO EQUIVALENT

Photo courtesy of USC/Gus Ruelas.

PCI
Precast/Prestressed Concrete Institute

The Precast/Prestressed Concrete Institute's (PCI) certification is the industry's most proven, comprehensive, trusted, and specified certification program. The PCI Plant Certification program is now accredited by the International Accreditation Service (IAS) which provides objective evidence that an organization operates at the highest level of ethical, legal, and technical standards. This accreditation demonstrates compliance to ISO/IEC 17021-1.

PCI certification offers a complete regimen covering personnel, plant, and field operations. This assures owners, specifiers, and designers that precast concrete products are manufactured and installed by companies who subscribe to nationally accepted standards and are audited to ensure compliance.

IAS ACCREDITED
Management Systems Certification Body

To learn more about PCI Certification, please visit

www.pci.org/certification

HIGH PERFORMANCE TOTAL PRECAST SYSTEMS AND ENCLOSURES

EnCon owns and operates nine entities dedicated to the construction industry, and serves customers in over 20 states through its manufacturing locations in Atlanta, Colorado Springs, Denver, Phoenix, Portland and Seattle. As a certified member of the Precast/Prestressed Concrete Institute, and a member of AltusGroup®, EnCon is recognized among the leading precast companies in the United States.

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An ***EnCon*** Company

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Email: sales@Atlanta-Structural.net
www.Atlanta-Structural.net

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Tpac

Architectural and Structural Precast Concrete
An **EnCon** Company

Phone: 602.262.1391
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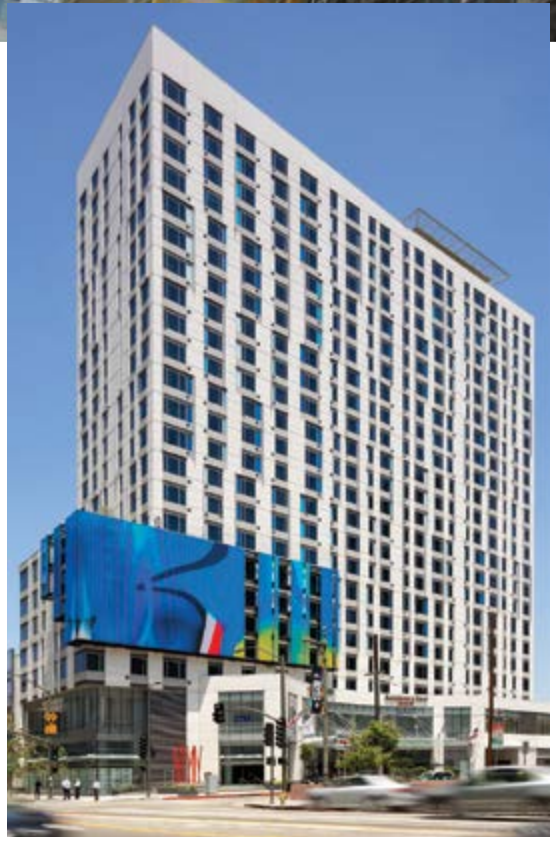

L.A. Live Marriott | Los Angeles, CA

2015 PCI Design Award Honoree

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PROVIDING TRUE OWNER VALUE.

The developer of the Courtyard and Residence Inn Marriott prioritized prefabricated systems for its new property in the heart of L.A.'s booming L.A. Live District. Clark Pacific's innovative envelope platform called C-CAPP (Clark Composite Architectural Precast Panels) provided the design-build team a great solution for the building enclosure. Pre-assembled at Clark Pacific's Fontana plant (complete with glazing, insulation, return air vents, and electrical fixtures), they were shipped to the jobsite as single modular units. Pre-assembly allowed for a safer site and a significantly enhanced construction schedule, providing true owner value.

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