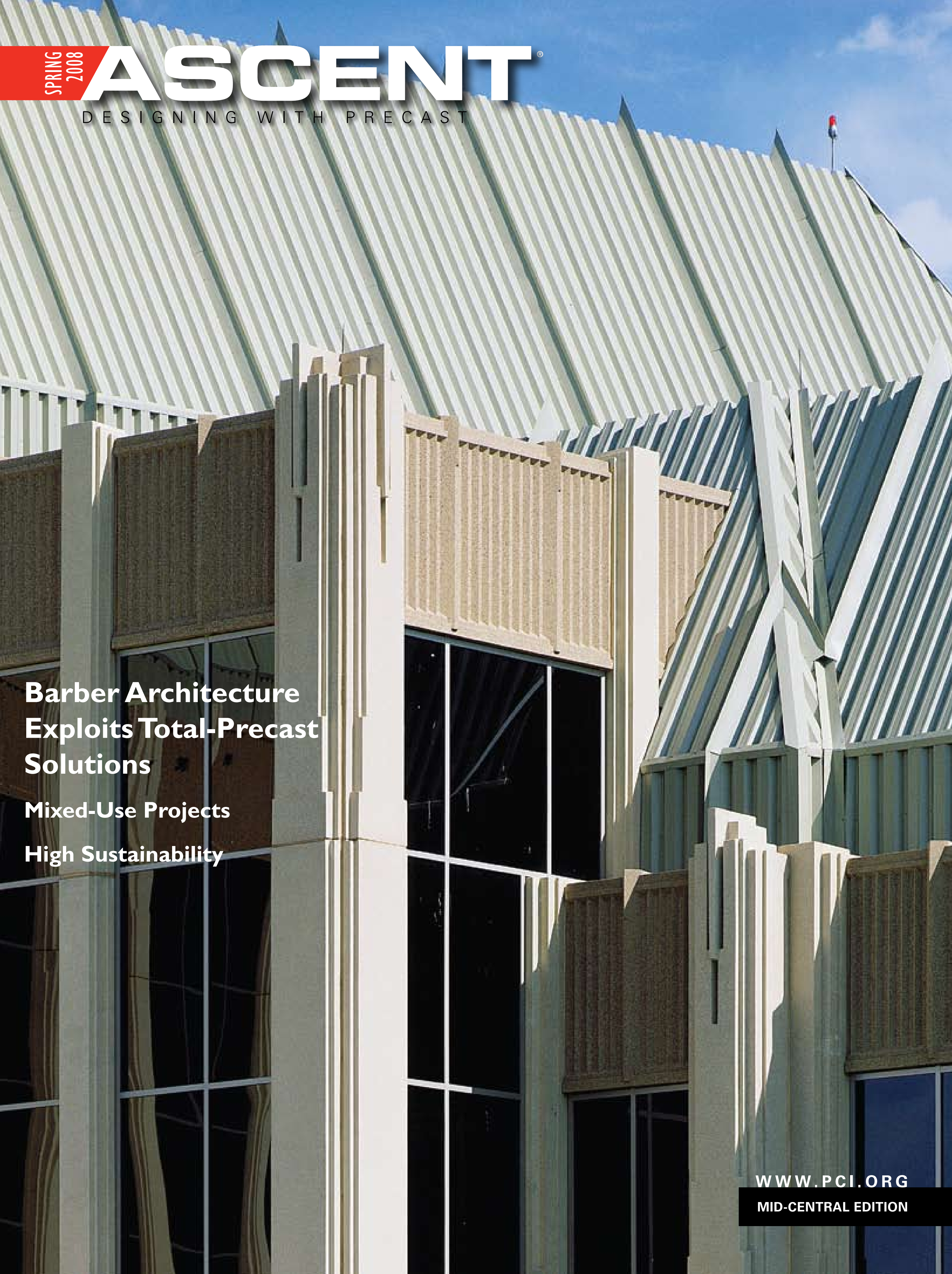


SPRING 2008

ASCENT®

DESIGNING WITH PRECAST

Barber Architecture Exploits Total-Precast Solutions

Mixed-Use Projects

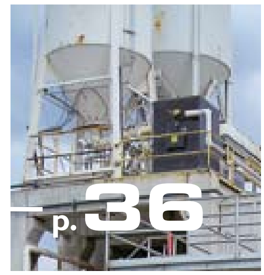
High Sustainability

WWW.PCI.ORG

MID-CENTRAL EDITION

CONTENTS

Features



Departments

PCI

On Call For You

PCI Headquarters
phone: (312) 786-0300 fax: (312) 786-0353
email: info@pci.org www.pci.org

Colorado Prestressers Assn. — Walter J. Prebis
phone: (303) 238-5674 fax: (303) 238-8734
email: wallycpa@aol.com
www.pci.org/host_sites/colorado/index.html

Florida Prestressed Concrete Association (FPCA) — Joseph Lord
phone: (813) 314-2458 fax: (813) 315-6026
email: info@fpcaweb.org www.fpcaweb.org

Georgia/Carolinas PCI (GCPCI) — Peter Finsen
phone: (678) 638-6220 fax: (678) 638-6221
email: peter.finsen@gcpci.org www.gcpci.org

Mid-Atlantic Precast Association (MAPA) — Monica Schultes
phone: (800) 453-4447 fax: (302) 235-1139
email: info@mapaprecast.org www.mapaprecast.org

Midwest Precast Association (MPA) — Mike Johnsrud
phone: (952) 806-9997 fax: (952) 806-9998
email: Mike@MidwestPrecast.com www.midwestprecast.com

New England Region PCI (PCINE) — Rita L. Seraderian, P.E.
phone: (888) 700-5670 fax: (617) 489-5810
email: contact@pcine.org www.pcine.org

PCI Central Region — Phil Wiedemann
(Indiana, Kentucky, Michigan, Ohio & West Virginia)
phone: (937) 833-3900 fax: (937) 833-3700
email: phil@pci-central.org www.pci-central.org

PCI of Illinois & Wisconsin (PCI-IW) — Marty McIntyre
phone: (708) 386-3715 fax: (708) 386-5922
email: martymci@pci-iw.org www.pci-iw.org

Precast/Prestressed Concrete Manufacturers Assn. of Texas (PCMA of Texas) — Chris Lechner
phone: (210) 633-6743
email: chrisjlechner@aol.com
www.pcmatexas.org

Precast/Prestressed Concrete Manufacturers Assn. of California Inc. (PCMAC) — Doug Mooradian
phone: (818) 247-6177 fax: (818) 240-3041
email: doug@precastconcrete.org
www.precastconcrete.org

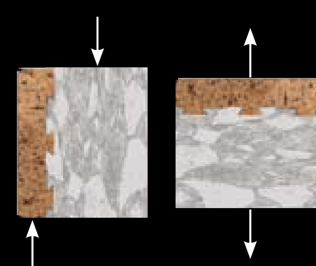
Prestressed Concrete Association of Pennsylvania (PCAP) — Heinrich O. Bonstedt
phone: (610) 395-2338 fax: (610) 395-8478
email: bonstedt@pcap.org www.pcap.org

endicott.com

Endicott Thin Brick

1st Mariner Bank – Canton Crossing, Baltimore, MD

Endicott's unique "keyback" design mechanically locks Thin Brick into the concrete for maximum durability and permanence.



The "keyback" design also provides advantages of increased shear values and pull-out strengths.

Beauty and Practicality

Thin Brick is one of the favored finishes for today's high-tech precast concrete panels. Endicott's specially designed "keyback" configuration creates a natural marriage between the desired look of brick and the practicality of precast.

Available in a full array of colors, five textures and four sizes, Endicott Thin Brick is a perfect fit for almost any design aspiration. When used with custom-made formliners, it brings concrete panel production into a new era – no longer are concrete panels limited to broomed, acid etched, sandblasted or exposed aggregate finishes.

And you'll be free to unleash your imagination with the unmatched quality of Endicott Thin Brick as your inspiration.

Endicott Tile LLC · P.O. Box 645 · Fairbury, Nebraska USA 68352 · 402/729-3323
endicott@endicott.com

ENDICOTT

Going for Platinum

Chuck Merydith
Executive Editor

Ascent is a publication of PCI (Precast/Prestressed Concrete Institute)

Designing a project that is certified by the U.S. Green Building Council under the Leadership in Energy & Environmental Design (LEED) program requires a strong commitment and an understanding that an investment today will pay off for decades to come. Achieving higher certification levels requires even more diligence, but more projects are meeting those challenges, as our article on page 26 indicates.

To reach those lofty goals, designers are turning to total-precast concrete solutions for the LEED-rated designs. These components offer a variety of benefits that help boost a project's efficiency. Precast concrete can assist projects in attaining credits in the following categories:

- **Sustainable Sites 5.1** (Site Development: Protect Habitat): By delivering components as they are needed, precasters help minimize site impact.
- **Sustainable Sites 7.1–7.2** (Heat Island Effect, Non-roof and Roof): Light-colored concrete for walls and roofs helps minimize heat islands.
- **Energy and Atmosphere 1** (Optimize Energy Performance): Precast concrete's thermal mass regulates peak temperatures.
- **Materials and Resources 2.1–2.2** (Construction Waste Management): Precast concrete's off-site production eliminates on-site construction waste and optimizes in-plant material use.
- **Materials and Resources 4.1–4.2** (Recycled Content): Precast concrete can use a number of recycled products, such as steel reinforcement, fly ash, and blast-furnace slag.
- **Materials and Resources 5.1–5.2** (Local/Regional Materials): Most precast concrete components are made with local materials, and they are typically transported less than 200 miles to the site.
- **Innovation & Design Process 1.1–1.4** (Exceptional Performance): Precasters can help create unique systems that aid sustainability goals.
- **Innovation & Design Process 2.1** (LEED Accredited Professional): More precasters have staff who are LEED accredited professionals to assist the design team.

A number of precasters are also incorporating green processes at their plants, as indicated by our feature on page 36. Some are even producing LEED buildings for their own use, as we report on page 6.

Precasters are sensitive to the needs of designers looking to create sustainable designs. Please talk with your local manufacturer as soon as the design process begins in order to ensure that precast concrete can assist your project team in reaching its green goals. ■

ASCENT

On the cover: American Family Insurance Co., Denver (page 19)

- **Executive Editor:** Chuck Merydith
- **Managing Editor:** Craig A. Shutt
- **Editorial Staff:** Roy Diez, Wayne A. Endicott, Donald P. Merwin, Daniel C. Brown, Rory Cleveland, Keith Ulrich
- **Editorial Administration:** James O. Ahtes Inc.
- **Art Director:** Paul Grigonis
- **Graphic Design:** Ed Derwent, Tressa Parks, Leader Graphic Design
- **Ad Sales:** Rob Brockley, Account Manager, Phone: (312) 203-3006, rbrockley@arlpub.com
- **Reprint Sales:** Mark Leader, (847) 564-5409, email: sales@leadergraphics.com
- **Precast/Prestressed Concrete Institute:** James G. Toscas, President
- **Industry Technical Review Team:** Sidney Freedman, Edward S. Knowles, Jason J. Krohn, Emily Lorenz, Brian Miller, Andy Osborn, Nancy Peterson, Jim Sirko
- **POSTMASTER:** Send address changes to *Ascent*, 209 W. Jackson Blvd., Suite 500, Chicago, IL 60606-6938. Periodical postage paid at Chicago, IL and additional mailing offices.
- *Ascent* (Vol. 18, No. 2, issn 10796983) is published quarterly by the Precast/Prestressed Concrete Institute, 209 W. Jackson Blvd., Suite 500, Chicago, IL 60606.

- If you have a project to be considered, send information to Chuck Merydith, *Ascent* Executive Editor, 209 W. Jackson Blvd., Suite 500, Chicago, IL 60606, Phone: (312) 360-3206, www.pci.org email: cmerydith@pci.org

Correction

The Project Spotlight for Miller Park in the profile article on Thornton-Tomasetti in the Winter 2008 issue of *Ascent* omitted the credit for the precast concrete specialty engineer for the architectural panels used on the Milwaukee stadium. That work was performed by **Precast Engineering Co.** in Waukesha, Wisconsin.

High Concrete's new maintenance building, which was designed to qualify for a Silver LEED rating, features the company's precast concrete architectural panels for its cladding.

High Concrete's Building Goes Green

DENVER, PENNSYLVANIA

High Concrete Group LLC is completing construction on a maintenance building at its plant that will incorporate sustainable-design concepts to achieve Silver certification from the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system. The single-story, 16,000-sq-ft building, with a 2,300-sq-ft mezzanine, features the company's precast concrete architectural panels as a key component.

The panels incorporate two colors of cement with a combination of light and heavy sandblasted finishes, coupled with an intricate reveal pattern, according to Francis S. Fox, president of **Greenfield Architects Ltd.**, who designed the facility. The insulated CarbonCast panels, which offer an R-value of 24, increase durability and thermal efficiency and provide a variety of other benefits, he notes. They incorporate concrete that includes locally harvested sand, cement, and aggregates and feature recycled materials such as fly ash and recycled water to aid in meeting LEED credit requirements.

Precast concrete tees are also being used for roofing, and they will feature 8 in. of insulation to achieve an R-value of 40.

A design-build process is being used to construct the project. "Having all team members—architect, engineers, manufacturers, and constructors—on board from the start helps facilitate and optimize the process to ensure a successful outcome," says Fox. "It aids in the evaluation of different systems, cost impacts, and the viability of meeting the credit criteria."

The team comprises MEP contractor Consolidated Engineers, structural engineer Raudenbush Engineering, civil/land-development engineer J. Michael Brill & Associates, commissioning agent Eastern Air Balance, and contractor High Construction Co.

Other sustainable-design concepts used in the project to earn LEED points include:

- Reducing water consumption by 20% using special faucets on lavatories, showers, and low-flow, double-flush toilets.
- Reducing energy costs an estimated 24.5% throughout the building.
- Beginning the commissioning process early in the design phase.
- Recycling and redirecting construction and demolition debris.
- Using certified wood products where applicable.
- Developing a plan for indoor air-quality management prior to occupancy.
- Using a variety of low-VOC materials.
- Using system controls to promote comfortable lighting levels.
- Integrating skylights, windows, and vision panels.

IPC has introduced the "2030 Panel" to improve energy efficiency in its insulated sandwich wall panel.

IPC Introduces High-Performance Panel

DES MOINES, IOWA

IPC Inc. has redesigned its standard architectural precast concrete wall panels to offer a high-performance version dubbed the "2030 Panel." The name references the 2030 Challenge issued by Architecture 2030 founder Ed Mazria and adopted by the American Institute of Architects and the U.S. Conference of Mayors.

The company is working with **Composite Technologies Corp.** of Boone, Iowa, which manufactures and distributes Thermomass Building Insulation Systems. IPC's panels will incorporate the system's fiber-composite connectors, which can eliminate thermal bridges and prevent vapor transfer and thermal leakage. The combination of the connectors and the panels' sandwich design, which includes a core composed of Dow Styrofoam brand polystyrene insulation, can reduce a building's energy cost by as much as 50%.

High Concrete to Make New Truss System
DENVER, PENNSYLVANIA

High Concrete Group LLC has gained exclusive rights to manufacture and sell the patented ER-Post precast concrete truss system in its territories in the Midwest, Northeast, and Mid-Atlantic regions.

The trusses span approximately 70 ft and are spaced at 40 ft on-center, allowing for large bays that are particularly suited for mixed-use residential buildings with parking underneath, the company says. Alternate levels require no structural elements, allowing flexibility in layout of interior walls and partitions. The truss bottom chord supports the floor below, while the truss top chord supports the open floor above.

Oldcastle Supplies Components for Prison
TELFORD, PENNSYLVANIA

Oldcastle Precast Modular Group is fabricating, outfitting, and erecting 864 precast concrete cell modules for a $230-million federal correctional institution being constructed in Berlin, New Hampshire. The facility comprises six housing units, administrative offices, and recreational space as well as healthcare, educational, and food-service facilities. It will house 1,280 inmates.

The Federal Bureau of Prisons awarded the design-build contract for the medium-security institution to Bell Constructors Inc. and Heery Construction Co., a joint venture in New York. **Edward Rowse Architects** of Providence, Rhode Island, in association with **KMD Architects** of San Francisco, California, is the architect of record.

Erection of the cells is to begin in July, with the project expected to take 37 months to complete.

Dukane Aids Green School Design
NAPERVILLE, ILLINOIS

North Central College has begun construction on a 198,000-sq-ft dormitory that has been designed to achieve a silver LEED rating. The specifications feature precast concrete wall panels and flooring units produced by **Dukane Precast Inc.**

The use of locally produced precast concrete materials will be a key aspect of achieving the certification, a spokesman for the college said. Other sustainable aspects include installation of a green roof, geothermal HVAC systems, and recycled materials.

The wall and flooring components will use Dukane's double-wall panel technology. Wall panels typically are 8 in. thick, comprising two 2$^{3}/_{8}$-in. wythes of concrete and a 3$^{1}/_{4}$-in. layer of insulation. Flooring panels typically are 10 in. thick with spans up to 30 ft in length possible. The bottom wythe of the double-wall floor panel is prestressed to achieve the span length and surface quality.

The center will house 265 students and will wrap around a new recreational center. The project was unanimously approved by the Naperville City Council following a rewrite of the city's design guidelines to allow alternatives to the mandate to build with brick, according to Brian Bock, vice president of sales and marketing at Dukane.

High Concrete to Clad 'Green' High-Rise
DENVER, PENNSYLVANIA

High Concrete Group LLC is producing precast concrete architectural panels for the 23-story Three PNC Plaza set to open in late 2008. The 752,000-sq-ft building combines office, retail, hotel, and condominium units. The $179 million project is designed to use a variety of sustainable-design concepts.

The 24,000 sq ft of precast concrete panels, consisting of 155 panels, will be produced at High Concrete's Springboro, Ohio, plant and erected this spring.

The project was designed by **Gensler** in San Francisco, in association with **Astorino** in Pittsburgh, Pennsylvania. It incorporates sustainable features such as daylighting, high-efficiency heating and cooling systems, and a minimum of 50% of construction products made from green and/or recycled materials. The building is expected to be LEED certified.

The company also announced that its Springboro plant will produce 1,200 precast concrete panels covering 156,000 sq ft for the 1.1-million-sq-ft C.S. Mott Children's & Women's Hospital in Ann Arbor, Michigan. The project, with a budget of $523 million, was designed by **HKS** of Dallas, Texas. The project is part of the University of Michigan Health System.

Shockey Plans Design Event
WINCHESTER, VIRGINIA

The Shockey Precast Group will host the third annual Design Professionals Education Event at its plant on September 25, 2008. The event will feature a 2.5-hour plant tour and an updated, AIA-registered presentation on precast concrete parking structural design, total-precast concrete systems, and CarbonCast brand carbon-fiber-reinforced precast, pretopped double tees for parking structures. Registered architects will qualify to receive 5.5 AIA LUs or PDHs.

A catered lunch, videos, and an exhibit area are planned. Architects can also register online at www.shockeyprecast.com. For more information, contact Terry Haney, marketing coordinator, at (540) 723-4190 or thaney@shockeyprecast.com.

– Brian Griffis

New Marketing Manager at Gate's Florida Plant
JACKSONVILLE, FLORIDA

Brian Griffis of **Gate Precast Co.** has been promoted to sales and marketing manager for the Florida territory. Griffis will be responsible for architectural precast sales and marketing efforts at the company's plants in Kissimmee and Sarasota. He has been with the company for 10 years.

PCI Undertakes Diaphragm Research

CHICAGO, ILLINOIS

The **Precast/Prestressed Concrete Institute** is in the final year of a five-year, $2 million-plus research program to develop an industry standard for the design and construction of diaphragms used with precast, prestressed concrete components. As part of that research, the researchers are simulating eight levels of seismic forces on a large-scale parking structure using the largest outdoor "shake table" in the world.

The high-profile research program is being carried out by a consortium of three universities, led by the principal investigator, Dr. Robert B. Fleischman, associate professor in the Department of Civil Engineering & Engineering Mechanics at the University of Arizona in Tucson. Researchers at the University of Arizona have been conducting comprehensive analytical research on the program, while full-scale static tests of reinforcing details and precast connections have been conducted at Lehigh University in Bethlehem, Pennsylvania. The shake-table testing will take place at the NEES/Englekirk Structural Engineering Research Center in San Diego.

The test structure was erected on a large shake table, measuring 25 by 40 ft, with a load capacity of 2,240 tons. Instrumentation located throughout the test structure will provide readings that will be evaluated following the testing period in May.

The testing began in April and will continue into May. It is using eight levels of seismic forces to gauge different responses. The test structure, measuring 17 by 58 ft, features one level each of three types of flooring components: untopped double tees, topped double tees, and hollow-core concrete slabs.

The program is funded with grants from the National Science Foundation (NSF), the Network for Earthquake Engineering Simulation (NEES), and The Charles Pankow Foundation (CPF), with substantial industry support from PCI. In addition, several PCI producer members, as well as associate and professional members, have made significant contributions.

The experimental results will be analyzed by the researchers and reviewed by PCI's Research & Development Committee, chaired by Professor Douglas Sutton of the School of Civil Engineering at Purdue University in West Lafayette, Indiana. The researchers have been guided by a committee chaired by Tom D'Arcy, principal and founding president of The Consulting Engineers Group in San Antonio, Texas.

Once the tests are completed and the results are evaluated, the group will work toward providing data and supplementary information that will allow the design approaches to be accepted into code documents. "Codification is necessary for the results to be useful to designers," explains Paul Johal, PCI's director of Research & Development. "We will scrutinize the results and prepare documentation to ensure these concepts are available to aid with future designs."

To view the construction of the test structure and to see the testing in progress, a Web camera has been established at the jobsite at http://137.110.165.19.

– Jason Woodard

– Jeff Winters

– Brian Koelsch

– Angela Harris

Metromont Expands Team

GREENVILLE, SOUTH CAROLINA

Metromont Corp. has named Jason Woodard vice president/general manager of its new precast, prestressed manufacturing facility in Tampa, Florida. Woodard will be responsible for sales, plant operations, and project management at the new plant.

The company also has hired Jeff Winters as vice president/general manager of its facility in LaVergne, Tennessee, where he also will be responsible for sales, plant operations, and project management. Brian Koelsch has been hired to fill a sales position at the facility, as well.

Angela Harris has joined the company's Atlanta sales team and will be responsible for sales out of the Hiram, Georgia, plant.

Photograph courtesy of Oldcastle Precast Building Systems.

Getting Started with Hollow-Core

Q. How do I get started creating a hollow-core design? What primary factors should I take into consideration for my project?

A. The primary consideration in developing a framing scheme using precast concrete hollow-core components is the span length. Create a list of loads and fire ratings and consult with your local precaster about optimizing the span lengths and slab thicknesses required to meet those needs.

You can also refer to a variety of published load tables. Copies of these can be found on most precasters' websites or in their product binders. The *PCI Design Handbook* recommends limits on span–depth ratios for hollow-core. A span–depth ratio of 45 is common for floors and roofs when fire endurance, openings, or heavy or sustained live loads do not control the design.

Other factors affecting the hollow-core thickness specification for a given span also must be considered. For instance, heavy superimposed loads would require a lower span–depth ratio. An example would be when the design includes heavy partitions or a large number of openings, which require higher load capacities to provide support.

Photograph courtesy of Oldcastle Precast Building Systems.

Once hollow-core thickness and spans are selected, the economics of the layout become important. Hollow-core ends can be cut at an angle, but it is more efficient to have the bearing perpendicular to the span; therefore, square-cut ends should be used whenever possible.

While it is desirable to have the hollow-core dimensions fit the bay size or module, the precaster can cast filler pieces to use as partial-width hollow-core if needed. Your precaster can aid with bay spacing and minimizing the need for partial-width hollow-core. The approach will depend on the precaster's techniques and regional availability.

Consider Camber

Camber must also be taken into consideration. As with all prestressed concrete products, initial camber can be predicted. Of particular importance is that differential camber can occur with hollow-core of unequal lengths. This must be recognized, so that any differential camber in the design layout and during placement in the field can be dealt with promptly.

When you are ready to create concrete drawings, feel free to contact a local precaster. Precasters can be especially helpful in the early stages of a project and can guide you through the process to maximize efficiency of pieces and design related to the precast concrete components.

Typically, the designer provides information on the drawings showing the span directions, loading requirements, connection information, fire-resistance requirements, topping requirements (for example, leveling coat or composite topping), and all the openings' locations and sizes (over 10 in. round or square) in the hollow-core.

More Information

This column answers frequently asked questions about designing, casting, and erecting precast concrete components. This issue's response was provided by the members of the Mid-Atlantic Precast Association (www.mapaprecast.org). If you have a question about precast concrete components, please send it to managing editor Craig Shutt at craigshutt@ameritech.net.

HAMILTON FORM CREATES FUNCTION

3 CASE STUDY

DALLAS COWBOYS STADIUM

'We've worked with Hamilton Form on a number of projects, including several stadiums. They evaluated our existing forms and developed a form plan that saved us time and money. We knew we could rely on them. Their experience is invaluable.

Kurt Schriefer
Vice President, Chief Estimator
Heldenfels Enterprises, Inc.
San Marcos, Texas

The Project:

The new Dallas Cowboys Stadium has a budget of $1 billion, a capacity of 100,000, and a retractable roof that duplicates the hole in the roof of the existing stadium.

The Precast:

Heldenfels Enterprises is providing close to 3,000 precast members for the project. Heldenfels needed forms, so they turned to Hamilton Form.

Hamilton Form inspected Heldenfels' existing forms to determine if they could be used or modified for the project, then designed several new, easily adjustable forms that cast several products to save costs and simplify production.

The Progress:

The precast work will be completed in 2008. When the stadum is completed, the Cowboys' new home will be the largest stadium in the NFL and the largest domed structure in the world.

Expect to hear more fanfare when the stadium opens for the 2009 season.

Hamilton Form Company, Ltd.
7009 Midway Road • Fort Worth, Texas 76118

Put Hamilton Form's experience to work for you.
Call 817 590-2111 or visit www.hamiltonform.com

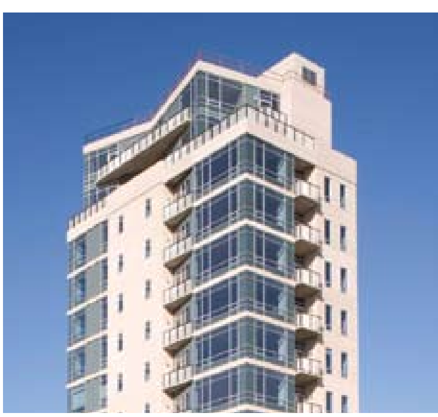
Jim Preskenis
Sika Corporation
Fairless Hills, Pennsylvania

Paul Ramsburg
High Concrete Structures
Denver, Pennsylvania

OUR PRECAST EXPERTS KNOW HOW TO STREAMLINE PRODUCTION.

As the market leader in precast concrete technology, Sika provides admixtures that improve quality, enhance performance and reduce costs. Sika® ViscoCrete® technology produces superior workability, higher strength and shorter curing. ViscoCrete self-consolidating concrete reduces vibration to deliver unmatched consistency. Our admixtures are perfect for fast turnaround of forms and architectural surface finishes. And with our expert support and expanding distribution channels, we'll give you the confidence to meet intense production demands, anytime, anywhere.

To get rock-solid support for your next project, visit **www.sikaconstruction.com** or call **1-800-933-SIKA (7452)**.



LIGHTER WEIGHT PRECAST MEANS MORE LEED CREDITS.

When LEED credits are important, Metal Stud Crete's lightweight architectural precast process provides multiple ways to achieve more LEED credits. This lightweight, curtain wall system contains a high recycled content and 65% less materials than traditional systems and can be fabricated at a plant close to your project, all with locally extracted materials. Discover how your project can achieve a higher certification level.

Metal Stud Crete®
... Best way to build a LEED.

Call (800) 796-3275 ext.62

www.metalstudcrete.com
metalcrete@earlcorp.com

Total Precast = Total Design

— Craig A. Shutt

Colorado architect has become leading proponent of total-precast concrete solutions

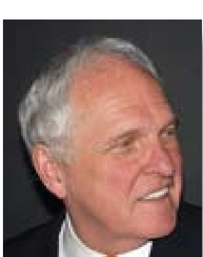
Barber Architecture Corp. has a long history of designing for corporate and governmental clients in Colorado and the Midwest. Today, in its 29th year, the company's designers are finding that the needs of those two markets are blurring together in more ways than ever before. Often, a number of the program goals, including budgetary ones, can be met with the use of a total-precast concrete solution that combines structural and architectural components.

"The markets are always changing and going up and down," says Michael Barber, principal. "Public and corporate architecture are our two key markets, and we are finding that more and more, they influence each other and are looking for common goals."

Public administrators, for instance, emphasize sustainability and durability, and are putting more emphasis on meeting LEED criteria. "Those concerns almost always well up within the public sector, but now we're seeing corporate and private-investment properties focusing on those, too." Meanwhile, the key criteria for corporate clients, including cost efficiency, flexibility in design, and workplace environment, are becoming more important to public clients as they understand the long-term savings that can be achieved.

"We are in a unique position, because as the markets rise and fall over time, we can benefit from the knowledge we gain in each market to help meet the goals in the other," he says. That's particularly helpful as clients discover during the design process that they have needs they didn't realize they had.

Barber just completed design work on a speculative Class A office build-



– *Michael Barber, principal, Barber Architecture*

'We are in a unique position, because as the markets rise and fall over time, we can benefit from the knowledge we gain in each market to help meet the goals in the other.'

The total-precast concrete solution for the Aurora Municipal Center in Colorado was completed in only 26 months, with as many as 55 pieces of precast concrete erected per day.

ing in which the developer had no interest in focusing on LEED certification. "But they discovered that the tenant market is very much influenced by the current cultural preoccupation with sustainability," he says. "Potential tenants are pushing to know what sustainable elements a project has, and developers must meet that need. That's an unusual situation to have unfold in the market."

Sustainable Expertise

The designers are well suited to the task, however, as they are steeped in using sustainable concepts. Barber Architecture produced the first LEED-certified projects in Colorado, the three-building CH2M Hill complex in Denver. Barber recently completed a fourth building in the complex, which received a silver LEED certification.

"Most companies are wary of aiming for LEED certification, because they fear there is a cost associated with that," says Barber. "And certainly, if you're aiming for elevated levels, there will be upfront costs associated with achieving that, so you need to perform a strict payback analysis to find the most effective approaches. But there are a variety of concepts you can use to gain LEED certification that have little or no cost impact."

Those include siting considerations to take full advantage of sunlight, as well as locating the building near public transportation. Other concepts, such as recycling water, won't impact the project's design or final appearance. "Much of this work focuses on the budget, and that's where we excel," he says. "It all goes back to the basics—clients establish a budget and look to us to deliver the best building with the highest quality and the most responsive design for that budget."

Total-Precast Solution Dominates

In about 85% of the cases, that analysis leads the designers to specify a total-precast concrete solution. "Early in the process, we examine a variety of systems for the structural frame and enclosure," he explains. "We owe the owner that level of evaluation. Markets change and material prices fluctuate, and owners sometimes have preferences for the expression of the building that may make different factors come to the fore." When the designers quantify structures, the key parameters will be cost, schedule requirements, and constructability, he notes.

"Precast concrete usually makes the most sense, although not always," he says. In most cases, those situations arise when the owner has an image in his head of the project's construction or demands specific types of materials.

Such was the case several years ago when Barber designed the RE/MAX headquarters in Denver after winning a design competition among four architecture firms. The design parameters required a steel-frame building clad with granite. Although the same appearance could have been achieved in a more cost-effective manner with precast concrete components, the owners plan was specific. Even then, the adjoining five-story, 288,493-sq-ft parking structure was built with precast concrete com-

PROJECT SPOTLIGHT

Aurora Municipal Center

Location: *Aurora, Colo.*

Project Type: *Municipal offices and parking structure*

Area: *Office: 286,000 sq ft; parking structure: 241,000 sq ft*

Designer: *Barber Architecture, Denver, Colo.*

Owner: *City of Aurora*

Contractor: *The Weitz Co., Denver*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *City officials needed to replace the outdated 1970s speculative office building where they were housed with a modern, efficient city hall that consolidated 26 city departments into one facility. Both the office building and parking structure feature total-precast concrete solutions, which combined architectural and structural components into one unit.*

Two five-story office wings feature acid-etched precast concrete panels that include punched windows. The panels connect to a glassy, six-story curving element with a sloping metal roof. The building's roof is accented by a large precast concrete cornice, projecting 3 ft and curving in two directions. Other precast concrete accents were provided throughout the project, including light bollards, signs, wall caps, and gateway walls at the main public-entry drive.

Floor plans were designed for maximum ease of use for both employees and the public. The clear-span space above the 300-seat city-council chamber features 10-ft-wide, 32-in.-deep precast concrete double tees.

(For technical information on this project, contact the precaster; see the Plant Certification directory.)

ponents that complement the granite on the corporate building.

"Typically, we will draw the building with two or three structural schemes and let those be bid," he explains. About 90% of the company's projects, he notes, are done with a construction manager and a general contractor, who is brought in early to create a proposal based on early documents. "That's where the real competition arises on designs." Often, those teams will receive input from the precasters in the area, and precasters from as far away as Utah and South Dakota have been involved with Barber projects.

"We end up a lot of the time with the total-precast system being the most effective and cost-efficient," he says. "It has advantages for achieving the architectural and qualitative goals, giving us more freedom for expressing architectural aspects than with other systems. And the scheduling is an advantage it always provides."

Contractors Prefer Precast

General contractors typically prefer to have a precaster on the project, he adds. "The precaster represents a large subcontractor that is essentially building the building. The contractors like having a precaster erecting the structure and setting the cadence and schedule for the project through their work. The general contractor can follow with other trades behind the precaster, who is essentially setting the scene of the construction."

Barber's designers spend a lot of time ensuring that each design is as cost efficient as possible. With precast concrete designs, that opens a lot of potential for saving money, he says. "Especially with investment-level office buildings, we are going back to basics and focusing on the fundamentals that make total-precast systems really economical." That includes minimizing the number of molds through repetition, maximizing the size of pieces to create the fewest that can be erected efficiently, and optimizing the span length for each structural element. "We study and research each component to optimize the system to take full advantage of precast's inherent characteristics."

That effort has resulted in some impressive cost savings, as shown in one recently completed speculative office building. The final cost of the precast contract was $23 per sq ft, compared to the mid-$30s for most projects in the region. "That total astounds people, especially in a market with rapidly rising construction costs," he says. "When they hear about it, they call us to ask how we did it, and we tell them that it was just a matter of going back to basics and working with the precaster to optimize everything to the fullest extent. We worked out the mold designs, repetition of elements, and the sizes of double tees to the inch. By doing that, we created a cost-effective and very handsome building."

Architectural Artistry

Architectural precast concrete also provides advantages as part of the total system, he notes. "Precast concrete, from an artistic side, gives us more

The striking rock-cut granite appearance of the Starz Encore Headquarters in Englewood, Colo., was achieved with load-bearing precast concrete panels cast with formliners created from actual stone.

PROJECT SPOTLIGHT

Starz Encore Headquarters

Location: *Englewood, Colo.*

Project Type: *Office building*

Area: *380,000 sq ft*

Designer: *Barber Architecture, Denver, Colo.*

Owner: *Starz Encore Group, Englewood*

Contractor: *The Weitz Co., Denver*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *Executives wanted to achieve a solid, permanent appearance for their new world headquarters while providing a distinct personality—and a cost-effective design. To achieve this, designers created a total-precast concrete solution using load-bearing exterior panels that simulate a rock-cut granite along the base course. The texture matches the granite design on a nearby smaller building, helping the buildings to blend together.*

Speed and economics were the key reasons why the total-precast concrete design was chosen, the designers say. The stone appearance of the precast panels was produced by creating individually sculpted form liners, with the panels turned to create more diversity in appearance. The precaster also had to match the color, texture and shapes of the granite as well as hide the joints between panels. In all, 46 different 1- by 1-ft samples were created using a variety of local aggregates to select the final option.

The building, three bays wide, is framed with 10-ft-wide double tees with precast concrete cores. To create the entablature at the front and back entries, round columns were cast vertically with horizontal joints to emulate historically correct Roman/Tuscan columns.

30 Years of History

Barber Architecture opened its doors on July 1, 1979, only a few blocks from its current location in Denver. Since that day, the firm has completed more than 750 projects ranging in size from 5,000 to more than 2.5 million sq ft, offering a full range of architectural and interior design services.

"Our goal has been to seek out projects that define communities and enhance the built environment," says Michael Barber, principal. "Regardless of the project type, we believe that good design is uplifting and benefits owners and users through positive architectural symbolism and effective, functional space. We maintain the philosophy that architecture and interior design must involve the continuous development of process and idea, a simultaneous movement that ultimately leads to inspired buildings and satisfied clients."

In October 1997, the firm was granted the highest level of recognition for quality design when it was presented with the Presidential Award for Design Excellence by the National Endowment for the Arts for its work on the Byron White United States Courthouse.

The company's staff of 25 employees has generated between $5 and $15 million annually during the past eight years, based on commissions. "We engage in only a few select projects each year," he explains. "We view each client and each project as unique. We are committed to nurturing these relationships, and the result is an extensive list of repeat clients."

possibilities. It has an inherent sense of permanence that is often important. We often are doing Neoclassical designs, especially for public clients and for high-profile corporate clients who are creating headquarters buildings. Those CEOs want to project an image, especially to investors, that this is a company that's going to be around for a while. Providing that strong masonry look is a key ingredient."

Owners today are emphasizing market flexibility over creating a unique appearance that is tailored to the company's distinct personality, he notes. "The after-market potential is more important than creating a personal touch, so there is less of a tailored look to the projects." Some owners do want to play up unique attributes or create an exceptionally employee-oriented design, he notes. Knowing the company's long-term goals and philosophy will impact the final aesthetic design.

That doesn't mean projects that want to enhance long-term market viability lack personality. The designers have achieved innovative looks, such as at the Starz Encore building in Denver, where formliners were created from rubber molds of cut rock to provide a unique texture to the panels. The formliners were turned to ensure that each panel had a different look.

"I don't want to brag, but in our area,

'We study and research each component… to take full advantage of precast's inherent characteristics.'

PROJECT SPOTLIGHT

Crescent Town Center

Location: *Denver, Colo.*

Project Type: *Office, hotel, and restaurant complex*

Area: *Five office buildings, plus a hotel and two restaurants*

Designer: *Barber Architecture, Denver*

Owner: *Denver Technological Center, Denver*

Contractor: *The Weitz Co., Denver*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *This eight-building complex was designed to serve as a dynamic urban gateway into the Denver Technological Center business park. A curving, dedicated vehicular traffic boulevard connects two corner parcels, allowing for the creation of eight development sites.*

To generate consistency among the office buildings, which were constructed in phases over several years, designers created a structural design featuring precast concrete load-bearing panels with an acid-etched finish. While each building maintains its own identity, the emphasis was placed on creating an overall look for the complex and the synergy among the multiple uses.

The designs showcase large glass areas to allow daylight to enter and include large vertical precast concrete elements to emphasize the projects' height. The office buildings vary in size from 30,000 to 135,000 sq ft, creating a dramatic low-rise complex with complementary designs offering a strong, classical image.

Although each building has a unique design, they all feature a basic three-bay structure with two 50-ft-long bays on the ends and a 20-ft-long bay in the center, which offered the most design flexibility. Two precast concrete elevator center cores provide additional support at the building's center.

Multiple colors were provided in some of the panels to create the unique design look for each project, creating additional challenges for the casting. The architectural panels received an acid-etched finish.

The Crescent Town Center complex of eight office buildings features total-precast concrete structural systems in complementary but distinctive styles.

The unique geometry of the TCI / AT&T Broadband World Headquarters in Douglas County, Colo., made designing the total-precast concrete structural system more challenging. The design features architectural load-bearing walls and double tees for flooring units.

PROJECT SPOTLIGHT

TCI / AT&T Broadband World Headquarters

Location: *Douglas County, Colo.*

Project Type: *Corporate office building*

Area: *270,000 sq ft*

Designer: *Barber Architecture, Denver, Colo.*

Owner: *AT&T Broadband, Douglas County*

Contractor: *The Weitz Co., Denver*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *This headquarters building represents the actualization of business goals through architecture. The goal was to create an environment of synergy, cooperation, and interaction, and spaces were designed to achieve those relationships. The project also was seen as an anti-corporate ego statement, to create the opposite of an architecture that expresses a hierarchy of individual status and department memorials.*

The unique geometry of the building produced challenges for casting the concrete panels. The main building is circular, and it connects to a support building shaped like a truncated cone. Close attention was paid to the load-bearing precast concrete panels to ensure the radius and other connections fit well. A particular challenge came in casting the 4 ft eyebrow that serves as a focal point at the top of the building.

The design features architectural precast concrete load-bearing panels, with double-tee and inverted-tee beams providing the flooring units. Precast concrete stair units serve as shear walls at the building's center.

> 'Today the most prestigious buildings in Colorado are being created with precast concrete.'

we've been leaders in innovating and developing new ideas with architectural precast," he says. "And that covers textures, colors, finishes, and sizes." The firm was responsible for the largest panels ever to be transported over the Rocky Mountains and for the largest panels to be erected in the state.

"We work hand-in-hand with the precasters, and as a result, today the most prestigious buildings in Colorado are being created with precast concrete. It provides an advanced aesthetic potential and allows us to design beautiful buildings." The company has yet to use much high-performance concrete or other high-tech mixtures, he notes, but that's not due to a lack of awareness. "There hasn't been much application for these technologies, but we always start our projects with a serious period of review of the available options to see how we can exploit them."

The volatility of the markets, especially the speculative-office portion, keeps Barber wary of what the future will bring. "My concern every day when I come to work is which project will really go ahead, and which will be placed on hold," he explains. "I've been through four or five cycles of growing intensity in developing investment projects, but only a small percentage actually gets built, because the market becomes flooded."

Colorado, and Denver in particular, is a strong market, he asserts, and the public side of the market remains consistent, offsetting some of the ups and downs from the corporate side. "But we have to be cautious about the future of each project because of the volatility," he says.

No matter how the market ebbs and flows, it's fairly certain that Barber Architecture's designs will ensure that clients receive cost-efficient, quickly constructed, and aesthetically pleasing buildings. No doubt many, if not most, of those projects will include total-precast concrete structural solutions. ■

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

PROJECT SPOTLIGHT

CH2M Hill Headquarters

Location: *Denver, Colo.*

Project Type: *Corporate headquarters*

Area: *503,000 sq ft (165,000 sq ft for corporate headquarters building and 113,000 sq ft apiece for the other three)*

Designer: *Barber Architecture, Denver*

Owner: *CH2M Hill, Denver*

Contractor: *The Weitz Co., Denver*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *As one of the leading engineering firms in the country decided to create a four-building complex to reflect its corporate identity, executives established goals for cost efficiency and high energy performance. To help achieve this, designers specified load-bearing precast concrete wall panels. The project, to which the fourth building recently was added, has been LEED certified.*

The project features 50-ft-long bays on each end, with a central 20-ft-long bay to provide open expanses that create layout flexibility. The structural system consists of load-bearing architectural precast concrete panels supporting double tees for flooring units. Two interior shear cores with elevator and stair access provide additional support at the center.

Two colors were provided in different panels to create contrast, and the architectural panels received an acid-etch finishing. A fifth building is now underway.

CH2M Hill's four-building complex features buildings with a total-precast concrete solution, consisting of load-bearing architectural panels and double tees for flooring.

PROJECT SPOTLIGHT

American Family Insurance Regional Headquarters

Location: *Denver, Colo.*

Project Type: *Corporate office building*

Area: *Four-story, 150,000 sq ft*

Designer: *Barber Architecture, Denver*

Owner: *American Family Insurance Co., Madison, Wis.*

Contractor: *M.A. Mortenson Construction Co., Minneapolis, Minn.*

PCI-Certified Precaster: *Rocky Mountain Prestress, Denver*

Description: *This regional headquarters building in Denver's Meridian International Business Center was designed to serve as a regional center for training that would also provide visibility in the community while offering substantial space for future growth. The design features a total-precast concrete structural solution that forms two office wings and a central pavilion.*

The building's design overall and the load-bearing precast concrete panels were tailored to fit the site while offering regional flavor and a unique manipulation of neo-Gothic style. Creating that style with precast concrete pieces required intricate forming, especially for the spires on top of the columns.

The building features a three-bay design with two 50-ft-long bays formed with double tees on the ends with a 20-ft-long bay in the center. The 50-ft-long bay produced efficient spaces that enhanced design flexibility for office layouts. Two different colors of panels were produced to create contrast, with an acid-etched finish adding texture.

The American Family Insurance Regional Headquarters building in Denver, Colo., features a four-story building constructed with a total-precast concrete structural system.

The District at Howell Mill
Phillips Partnership, Atlanta, Ga.

Bayshore Building N
Meacham & Apel Architects Inc., Dublin, Ohio

Precast Streamlines Mixed-Use Projects

Architects cite flexibility, economy, and speed of construction as key factors in choice of material for structure and cladding

— Wayne A. Endicott

Mixed-use projects, which combine several functions in one location (for example, retail, residential, office space, and parking) are fast becoming popular options for developers, due to the range of users they bring to the site throughout the day. But the trend also creates a key challenge: How do you combine the uses most efficiently to generate the most revenue?

A good answer often includes specifying precast concrete components for the building's shell and cladding, according to a number of architects who design such multi-use projects. Precast concrete provides multiple benefits for facilities that need to meet a variety of functions, says D. Brett Oaks, design principal with DMJM Design in Phoenix, Arizona.

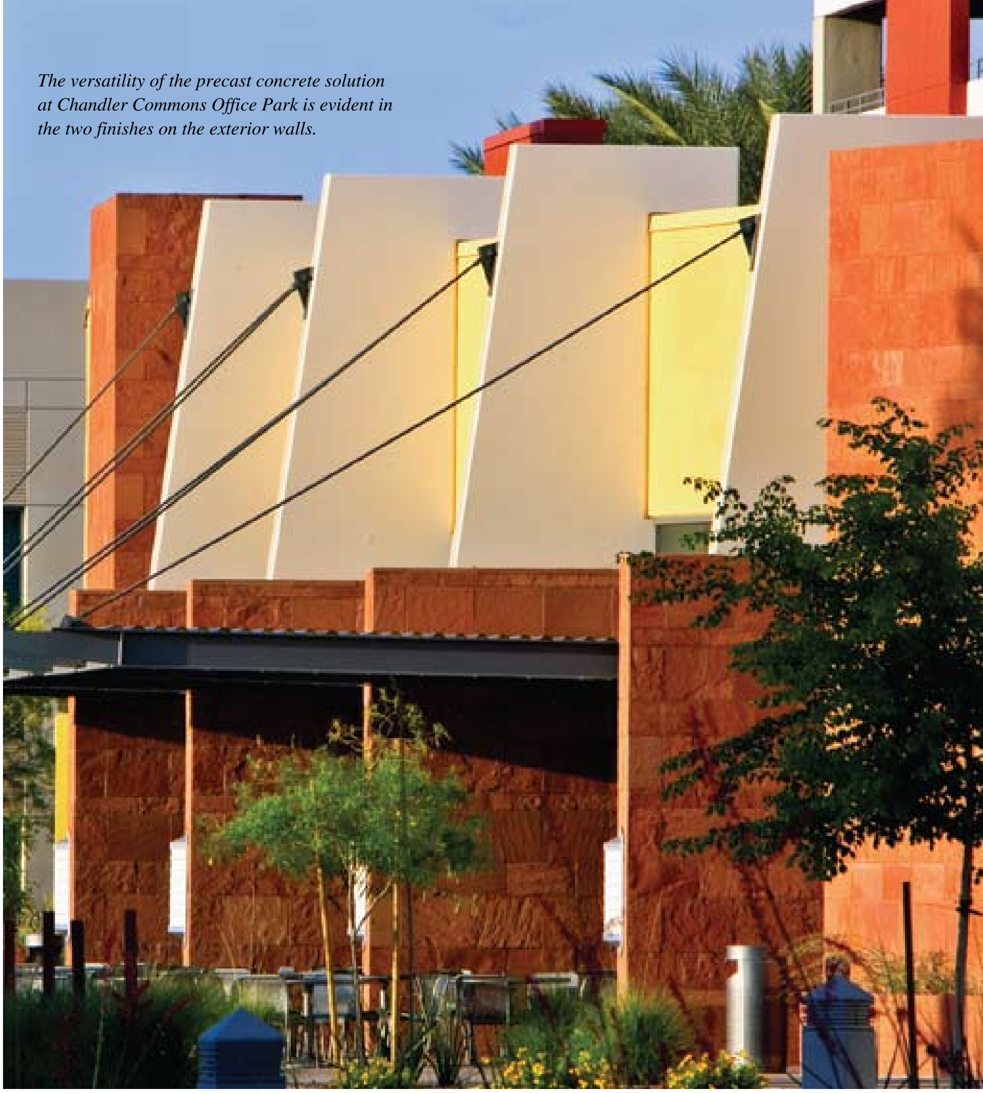
"Constructability and cost are two of the most important factors to consider in these projects, and precast concrete can help with both," he says. "Precast also offers scheduling advantages and aesthetic benefits, while also addressing functional issues such as fire safety." All were key reasons why standard precast concrete components were specified for the Chandler Commons Office Park Phase 2 in Chandler, Arizona. It combines an 850-car parking structure with a cafeteria and fitness center, meeting rooms, a shipping/receiving area, and storage space.

Dwight Bailey, a designer with Phillips Partnership in Atlanta, Georgia, echoed those sentiments. The senior project manager for The District at Howell Mill in Atlanta, Bailey adds that precast concrete can help reduce design time. "The precast design can take place simultaneously with the structural design, cutting planning time significantly."

Time is a major consideration for these projects, he says, and the ability to reduce planning time can have a significant impact on the completion date. Finishing quicker means revenues can be generated faster through rents, parking fees, special events,

Chandler Commons Office Park Phase 2
DMJM Design, Phoenix, Ariz.

The entrance to the ground-floor cafeteria is shown in the foreground at Chandler Commons, with the parking structure in the background.



The versatility of the precast concrete solution at Chandler Commons Office Park is evident in the two finishes on the exterior walls.

Fact Sheet

Chandler Commons Office Park Phase 2

Location: *Chandler, Ariz.*

Developer/Owner: *Countrywide Home Loans, Chandler*

Architect/Engineer: *DMJM Design, Phoenix, Ariz.*

Contractor: *Hunt Construction Group, Phoenix*

Precaster: *Tpac, a division of Kiewit Western Co., Phoenix*

Project Size: *324,240 sq ft*

Precast Concrete Components: *956 pieces, comprising twenty-four 20 in. double tees, four hundred twenty-five 24 in. double tees, 81 beams, 32 hollow-core slabs, 75 columns, 118 exterior spandrel panels, 23 exterior wall panels, 40 interior ramp-rail beams, 109 interior shear-wall panels, 20 stair/elevator walls, and 10 grade walls*

Project Cost: *$17 million*

'Constructability and cost are two of the most important factors to consider in these projects.'

and other activities. The Atlanta project, in the heart of the city, includes apartments and retail, as well as parking that serves both uses.

Balancing Functions

Determining the proper balance between the functions in a multi-use project creates a real challenge, Bailey notes, becoming a chicken-or-the-egg question that has to start with one given before providing supplemental needs. At The District at Howell Mill, for example, the retail space was the developer's key target. Once the amount of retail space was decided, planning for ample parking space fell into place. Finally, an adjacent residential component was factored in.

The process proved somewhat different in the case of Bayshore Building N in the Milwaukee suburb of Glendale, Wisconsin. There, the first consideration was the type of housing to be included in the town-square-style development, according to Michael Karpinski, an associate with Meacham & Apel Architects Inc. in Dublin, Ohio. "After that, making it work with the parking and retail components essential to the town center was the challenge."

Speed was a driving force in the selection of precast concrete for the structural system for Bayshore, he notes. "We were literally behind when we started, according to the developer's timetable." The lagging schedule dictated that much of the construction take place during winter, another situation in which precast concrete excels, as erection could continue even through the harsh Wisconsin winter. To keep the project on the tight schedule, it was necessary to hold early discussions with the precaster, Spancrete in Waukesha, Wisconsin.

In fact, all three of these projects brought the precast concrete producer into the process during the planning stages to take full advantage of that input. "The precaster was part of The District at Howell Mill from its inception," Bailey says about the participation by Tindall Corporation in Conley, Georgia. "It was important to have their input upfront. It reduced planning time, because they could develop their drawings while we focus on the building's design without having to worry about designing the precast concrete."

At the Chandler Commons project, Tpac, a division of Kiewit Western Co. in Phoenix, was also brought on early, notes Oaks. That participation allowed the design team to plan the structure with immediate feedback, including such considerations as the cost impact of proposed design concepts. As a result, the design team could better control the project budget. "The early selection of the precaster meant that precast shop drawings were developed as the architectural and structural construction documents were being completed," Oaks explains. That timetable shortened the overall project schedule.

Precast Provides Versatility

Although these three projects share the common bond of featuring precast concrete components, they are decidedly different, emphasizing the versatility of precast concrete systems.

The most extensive use of the material was in The District at Howell Mill in Atlanta, which blends upscale shopping with everyday needs and offers a 435,000 sq ft, pedestrian-friendly retail environment in a tight urban setting. The three-tiered structure includes a Wal-Mart at grade level, parking on a mezzanine level, and parking, retail, hardscapes, and truck delivery on the top level.

Constructed on a dense site, the development was limited to 9 acres sandwiched between Interstate 75, which carries 400,000 vehicles per day, and an operating grocery store/strip mall. To clear the site, an existing motel had to be removed. Then, due to the presence of a riverbed that would not drain, a 40 x 330 ft detention vault and a 30-ft-tall and 500-ft-long retaining wall had to be constructed.

The complex structure consisted of a total-precast concrete solution on the lower portion and numerous steel superstructures utilizing various lateral-force-resisting systems that carry height and loading criteria. The precast concrete components comprised field-topped double tees, bulb double tees, and W-beams, using precast concrete moment frames and shear walls for lateral stability.

The mezzanine level, which is subjected to standard parking loads, used standard precast concrete shapes, including inverted tee beams and double tees. The platform, however, at 31 ft above grade, features a 36-in.-deep W-beam system in areas that required continuity due to load and fire requirements.

Several engineering challenges arose in placing the Wal-Mart structure beneath the platform. This location resulted from the developer wanting the store as close to the retailer's standard as possible, which precluded the use of shear walls in the footprint. This was addressed by using a 60 x 30 ft, two-way moment frame. The upper floor was designed as the slab for retail stores and limited parking.

Retail structures bearing on the platform use structural-steel moment or braced frames, which required coordinating precast concrete and steel structures to account for large seismic forces and gravity loads. Because of the nature of the site, one corner of the precast concrete platform cantilevers in the horizontal direction approximately 12 ft while still accommodating the steel structure above.

Seismic Concerns Addressed

Another challenge met by the design team concerned the diaphragm torsion in the eastern side, at the Wal-Mart loading dock. The many solid, full-height precast concrete wall panels in the north-south direction were stiff enough that each could have acted as a shear wall. However, only a few were actually designed to be shear walls, and the non-shear walls would need to withstand significant seismic forces, so their lack of ductility could pose a problem. To resolve this, the architects designed the structure so these walls could slip, reducing the seismic force.

The design team determined that the best location for the loading dock was on the back side of the structure, where the building was as little as 25 ft from an interstate expressway ramp. To provide maneuvering space for tractor-trailer deliveries, Tindall designed free spans of up to 140 ft over the loading dock, an unprecedented span, Bailey notes.

The beams, varying in length from 67 to 147 ft, aid vehicle access on grade as well as support the 150 psf live loading above for the warehouse retail stores. Because a column support at the building edge was not

'Monster' Beams Meet Design Challenge

Heavy loads and long spans are typical in the construction of bridges, but in a commercial application, such "monster" beams or structural girders require a different approach.

For The District at Howell Mill project in Atlanta, Georgia, the decision was made to cast smaller standard pieces and then deliver them for on-site assembly. This approach can be used in structures where spans are longer than 60 ft with an upper span limit set by access and weight limitation. In the case of Howell Mill, the design called for spans running up to 140 ft with relatively heavy loads.

These beams featured standard precast concrete sections dependent only on the precaster's production capabilities.

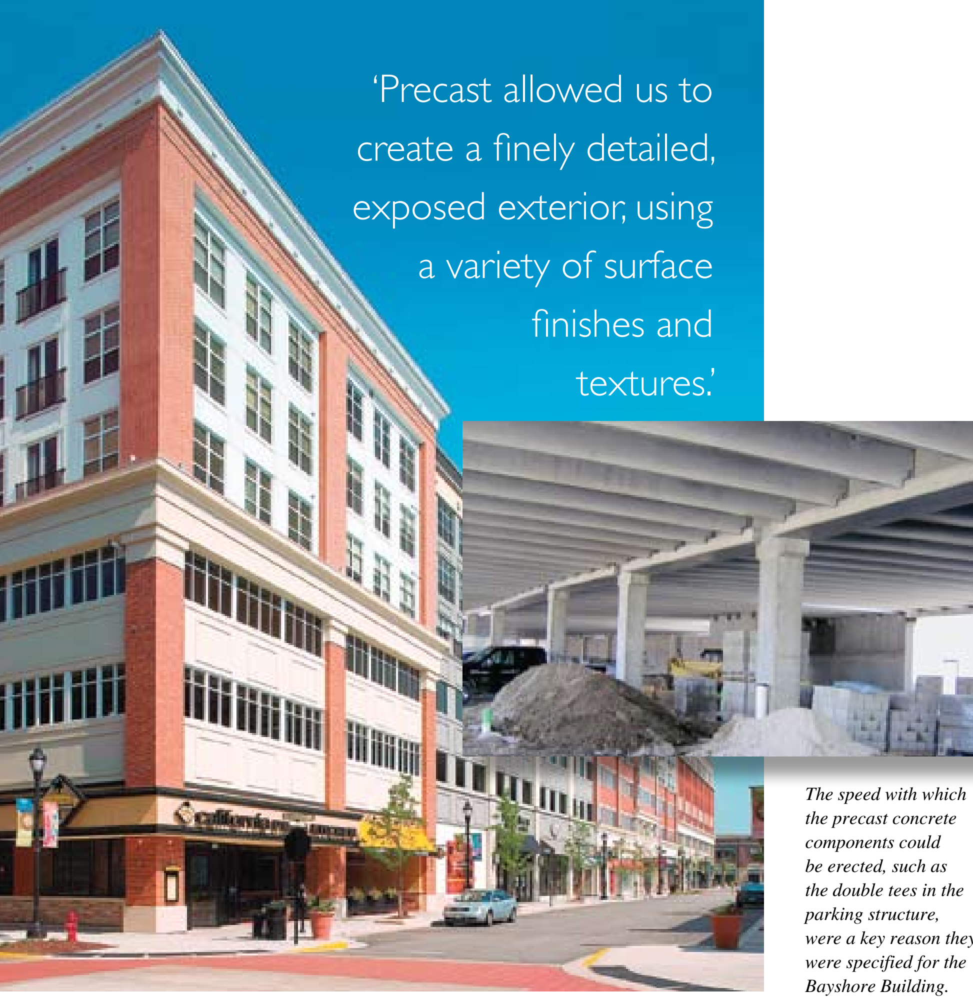
The long-span beams at Howell Mill varied in length from 80 to 140 ft and were up to 15 ft deep. As is readily apparent, they are too large to be created by a monolithic concrete placement or shipped by truck. To create these beams, they were designed and produced in components as standard shapes—a top flange, a web, and a bottom flange.

The top flange consisted of a 3-ft-wide, 25-in.-deep U-beam, similar to a W-beam. Concrete for the vertical web of the beam was placed on its side much like a wall panel and prestressed. The bottom flange is a 3-ft-deep, 3-ft-wide inverted-tee beam. The U-beams and flat panels were preassembled at the plant as panels.

The bottom of the web featured a saw-tooth panel that fit into a similar saw-tooth panel on the bottom flange. At the site, the beams were joined together using mechanical fasteners, then grouted together to form a monolithic structure.

The beams for the Howell Mill project were created in pieces that were then assembled on site.

‘Precast allowed us to create a finely detailed, exposed exterior, using a variety of surface finishes and textures.’



The speed with which the precast concrete components could be erected, such as the double tees in the parking structure, were a key reason they were specified for the Bayshore Building.

Bayshore Building N in Glendale, Wis., includes retail, parking, and services on the first floor, two additional levels of parking, and three floors of residential apartments.

Fact Sheet

Bayshore Building N

Location: *Glendale, Wis.*

Developer: *Bayshore Town Center LLC, Columbus, Ohio*

Architect: *Meacham & Apel Architects Inc., Dublin, Ohio*

Engineer: *Jezerinac Geers & Associates, Dublin*

General Contractor: *Corna/Kokosing Construction Co., Westerville, Ohio*

Precaster: *Spancrete, Waukesha, Wis.*

Precast Specialty Engineer: *Spancrete / Computerized Structural Design LLC, Waukesha*

Project Size: *638,838 sq ft (90,518 sq ft of retail and 70,950 sq ft of parking/services on the first level, two levels of parking of approximately 159,800 sq ft per level, and three floors of apartments of approximately 52,585 sq ft per floor)*

Precast Concrete Components: *106 columns, 134 beams, 525 double tees, 97 load-bearing spandrels, 36 non-load-bearing spandrels, 139 wall panels, 51 hollow-core slabs, and 76 stairs/landings*

Project Cost: *$41.5 million*

an option, a transfer girder spanning 50 ft was created as well (see the sidebar for more information).

To control vibration transmissions, the project was divided into seven independent structures with expansion joints isolating the vibrations of the automobile live loads from the retail structures. Each structure required a lateral analysis, which was affected by the retail, parking, or sidewalk on the top level. Seismic joints divide the mixed-use superstructure into four seismically detached structures, each of which was analyzed separately.

“What we supplied to The District was pretty much all standard precast—basic components,” notes Joe Golden, sales manager for Tindall. “That we were able to satisfy all of the needs with our standard products attests to the versatility inherent in the product.”

Creating a Town Center

Standard components also make up the Bayshore Building N, according to Karpinski. The structure includes 90,518 sq ft of retail space on the ground level, 70,950 sq ft of parking and services on the first level, two additional levels of parking space with 159,800 sq ft of parking per level, and three floors of residential apartments with approximately 52,585 sq ft per floor. In all, the 531 x 308 ft project includes 638,838 sq ft, of which the precast parking and retail encompass 481,000 sq ft on three levels. Parking space can accommodate about 1,000 vehicles.

Built under a design-build contract, the project features precast concrete for a variety of reasons, Karpinski says. The components meet specific bay-size requirements for retail, achieve the required spans for the parking decks, and meet the requirements for fire safety without needing additional fire-protection materials. Additionally, the precast concrete provided a transfer level for the erection of the residential floors and permitted construction to proceed during the winter months.

Design flexibility was a strong factor in the choice of precast concrete for the project, he says. “The precast allowed us to create a finely detailed, exposed exterior, using a variety of surface finishes and textures.” The wall panels could also be matched easily to surrounding structures. As well, the components could be designed to accommodate growth by reconfiguring existing interior spaces, thanks to designing the precast concrete beams with long spans, creating large open areas without obstructions.

Other traits that factored into the decision included the fact that the durable, fire-resistant material also lowers maintenance costs and insurance rates. The plant’s established quality-assurance program also ensured consistency in the finished product, requiring no worries about differences between panels. The design of repetitive panels and reuse of molds also saved production costs.

“We’ve participated in quite a few mixed-used development projects over the years,” says Kimberly Wacker, director of marketing and business development for Spancrete. “Precast concrete has inherent advantages that resonate in the building industry:

Precast concrete increased speed while providing a variety of aesthetic choices.

durability, fire resistance, design flexibility, and all-weather construction."

Spancrete was involved in the design of the project virtually from the beginning, she adds. "The earlier we can become involved in a project, the more input we can provide in the design to optimize construction efficiency." Bayshore was built even while the adjacent mall remained open and operating, another advantage to the use of precast concrete. Components were fabricated off-site, trucked to the erection site, and then rapidly lifted into place.

Blending with Neighbors

Of a somewhat different character is the Chandler Commons Office Park structure. It integrates parking, a cafeteria, and a fitness center under one roof. The design team at DMJM Design specified precast, prestressed concrete for several reasons, Oaks says. A key reason was its ability to match the context of existing buildings in the complex. The project includes double tees for most of the parking area with hollow-core panels used for shorter spans. Also included were spandrel panels for the structure's exterior walls.

A major advantage to using precast concrete, in addition to its versatility, was its capability for long life, says Oaks. Also, the variety of spaces, including the parking, cafeteria, and workout room, as well as meeting rooms and storage, required a variety of ratings for horizontal fire separation. "We could provide those requirements with precast concrete without needing to apply additional fireproofing materials."

The use of precast concrete not only aided speed in both production and erection of the building, but it also gave designers a variety of aesthetic choices. Another factor was that, due to the building's close proximity to existing office structures, there was minimal space to stage materials.

By bringing Tpac into the design process early, the design team received immediate feedback on aspects that included the cost impact of proposed design concepts. This provided better control over the project budget.

"We were not originally married to precast for this project," Oaks says, "but as various ideas were developed, it became apparent that it would give us more design options by offering us the capability to provide different surface textures, patterns, and reveals. That let us create an interesting building that fits well into the context of the office park." Production shop drawings also were created as structural documents were being completed, allowing the project to be built well within a tight schedule.

The precast concrete allowed the construction team to closely control costs and schedules. The project used standard precast concrete products, says Tpac's Randy Garmon. With the precaster's input, any potential problems were quickly identified and resolved with the designers and the company's engineering staff.

All three architects echoed the sentiment that precast concrete would receive prime consideration for any future mixed-use project they might design. Those projects no doubt will continue to grow as developers find that combining functions creates more useful and functional buildings that can be used all day long.

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

Construction workers prepare to hoist the top flange of one of Howell Mill's beams into place.

Fact Sheet

The District at Howell Mill

Location: *Atlanta, Ga.*

Developer: *Selig Enterprises, Atlanta*

Architect: *Phillips Partnership, Atlanta*

Engineer: *Haines, Gipson & Associates Inc., Lawrenceville, Ga.*

General Contractor: *Benning Construction Co., Smyrna, Ga.*

Precaster: *Tindall Corp., Conley, Ga.*

Precast Specialty Engineers: *Berger/ABAM Engineers Inc., Federal Way, Wash., and The Consulting Engineers Group Inc., San Antonio, Tex.*

Project Size: *450,276 sq ft (including 16,000 sq ft restaurant, 307,000 sq ft of retail space, and 336,000 sq ft of elevated parking)*

Precast Concrete Components: *251 square columns, 103 W-beams, 45 shear-wall panels, 59 stair/elevator panels, 39 rectangular beams, 10 wind beams, 33 spandrel beams, 6 spandrel panels, 7 long-span I- beams, 71 inverted-tee beams, 3 L-beams, 660 double tees, 224 bulb tees, 25 flat slabs, 50 architectural brick-tile panels, 21 brick-tile spandrel beams, and 61 spandrel panels*

Project Cost: *$47.5 million*

Achieving High Sustainability

— Craig A. Shutt

Photo courtesy of John Swain.

The precast concrete aided energy efficiency, provided a cost-effective system, and helped ensure that the center was finished on schedule. Photo courtesy of John Swain.

More projects are aiming high when they apply for LEED certification, and precast concrete is helping to meet those lofty goals

With owners and designers focusing more attention on energy conservation, "green" building, and Leadership in Energy and Environmental Design (LEED) requirements, more projects are not only looking to attain LEED certification but are hoping to achieve silver, gold, or platinum status. A number of those projects are using precast concrete components because of the assistance they provide in reaching that goal.

Achieving the "metallic" LEED ratings can be difficult because some of the credit requirements must be interpreted by the U.S. Green Building Council (USGBC). The owner and designer may determine that their approach achieves the credit requirements, but the USGBC may not reach the same conclusion. When the project goal is a higher LEED certification level, there is little room for error in credit interpretation, and every possible design element must be aligned to add to the total number of credits achieved.

There also is the need to overcome obstacles presented by highly specific programmatic needs in some facilities, such as hospitals or justice

Fact Sheet

Project: *Alameda County Juvenile Justice Center*

Type: *Courthouse and juvenile dormitory*

Location: *San Leandro, Calif.*

Architect of Record: *Hellmuth, Obata+Kassabaum (HOK), San Francisco, Calif.*

Associate Architect: *Beverly Prior Architects, San Francisco*

Engineer: *The KPA Group, Oakland, Calif.*

Construction Manager: *Vanir Construction Management Inc., Sacramento, Calif.*

Design-Build Contractor: *Hensel Phelps Construction Co., San Jose, Calif.*

Owner: *County of Alameda, Calif.*

Precaster (structural components): *Mid-State Precast LP, Corcoran, Calif.*

Precaster (architectural panels): *Willis Construction Co., San Juan Bautista, Calif.*

Project Size: *Three-story building, 379,000 sq ft*

Precast Concrete Components: *800 structural panels of various sizes, 112 architectural panels of various sizes, 260 slabs*

Project Cost: *$176 million*

centers, where function definitely comes first. "The United States Green Building Council's criteria for achieving a LEED-certified building for new-construction projects do not take into account the special operational and construction constraints of a juvenile justice facility," says Beverly Prior, principal in Beverly Prior Architects in San Francisco, California.

Her firm was the associate architect to HOK in the design of the award-winning Alameda County Juvenile Justice Center in San Leandro, California, which features a gold LEED rating and structural and architectural precast concrete panels. The facility was designed to create a more collaborative approach for supporting at-risk juvenile offenders by partnering county agencies with community-based organizations.

More High School than Prison

The plan was to create a building with a softer appearance, resembling a high school rather than a prison. Authorities also wanted to integrate environmentally sustainable architecture to educate visitors about the importance of environmental stewardship and to create a healthier building, Prior explains. The 379,000-sq-ft, $140 million facility features three buildings, including a three-story courthouse; a one-story, 360-bed dormitory; and a two-story support building. A large entry courtyard and an inviting lobby dominate the dormitory, which was designed with sleeping quarters surrounding a common social space and an adjacent outdoor recreation area.

The largest of the three buildings, the 162,000-sq-ft dormitory, was constructed entirely of precast, prestressed concrete structural panels and other components, she explains. The panels used for the exterior walls and interior corridor walls were 7 to 8 ft wide and 26 ft tall, while interior dormitory panels, which were Y-shaped to form individual sleeping rooms, were 16 x 10 ft. These panels supported floor slabs that were 10 ft wide and 22 ft long. It also incorporated 14-in.-thick insulated sandwich wall panels that were 10 x 30 ft.

The courthouse building features architectural precast concrete panels on structural-steel framing. The 27,696-sq-ft building uses a two-tiered panel system, with an upper tier of 11 x 14 ft panels with a smooth gray finish and a lower tier of 11 x 30 ft panels with an integral cream color and smooth finish, except at the 3-ft-tall rusticated base. "The two-tiered system provides an attractive appearance at the main entrance into the complex and creates a rhythm along the buildings' long façades with horizontal banding combined with a series of vertical reveals and inset storefront windows," she explains.

"The use of precast concrete on these buildings contributed an appealing aesthetic and a sense of permanence," Prior says. "It also provided numerous environmental benefits and contributed to several LEED credits." The structural concrete included fly ash, a pre-consumer material that also saved on the use of virgin materials.

"Precast concrete also reduces construction materials and waste by using reusable forms instead of wood formwork and recycling manufacturing waste materials," she adds. "It also uses regional materials and has a lower embodied energy than many other construction materials. Its thermal mass also contributes to higher energy performance, and the minimal VOC emissions create healthier indoor-air quality."

The precast concrete not only offered an affordable system, it also played a vital role in completing the center on "an extraordinarily tight schedule," she stresses. The facility was created in 31 months from design through occupancy. The exterior structural panels were fabricated in eight months and erected in five months, completing the shell that allowed interior trades to begin work earlier.

The facility was designed to maximize daylight and uses solar power for 60% of the building's electricity. It also was designed to outperform building-code requirements for energy and water by more than 40%.

Turning Silver to Gold

The justice center is an indication that government officials at all levels, and for all types of projects, are looking to minimize their environmental impact, both to save long-term maintenance costs and to set a good example for the public. Those were key factors in designing the California Department of Transportation's District 11 Headquarters in San Diego, California. The five-building, $72 million project

The use of precast concrete provided numerous environmental benefits and contributed to several LEED credits.

Photo courtesy of Chi Fang.

The Alameda County Juvenile Justice Center in San Leandro, Calif., which achieved a gold LEED rating, used structural and architectural precast concrete panels to reach a variety of goals.

Fact Sheet

Project: *California Department of Transportation District 11 Headquarters*

Type: *Government office complex*

Location: *San Diego, Calif.*

Designer: *Carrier Johnson Architects, San Diego*

Engineer: *John A. Martin & Associates, Los Angeles, Calif.*

Contractor: *Clark Construction Group, Costa Mesa, Calif.*

Owner: *Department of General Services, State of California, West Sacramento, Calif.*

Precaster: *Clark Pacific, Fontana, Calif.*

Project Size: *Five buildings with 300,000 sq ft plus 815-car parking structure*

Precast Concrete Components: *126 wall panels, 276 spandrel panels, 188 column covers*

Project Cost: *$72 million*

Community, sustainability, and location were the guiding factors for the new California Department of Transportation's District 11 Headquarters in San Diego. The five-building project features precast concrete panels and column covers for the solar grand trellis at the front.

'The way that the project fit within the context of its neighborhood was going to be our primary concern.'

Precast concrete column covers provide a complementary look for the grand trellis, which is supported by 70-ft-high tubular steel purlins.

features a variety of energy-efficient systems, including a dramatic solar grand trellis that prominently shelters drivers as they arrive and generates electricity for the site.

The project qualified for a silver LEED rating, but the state did not fund application for the rating, so it is not officially rated. State officials recently decided to apply for the rating, however, and are preparing paperwork for submittal. The state also plans to upgrade several existing systems to make them more efficient, thereby qualifying the project for a gold rating.

The project's design focused on "community, sustainability, and location," explains Edward Holakiewicz, project manager for Carrier Johnson Architects in San Diego. Bordered by the historic Old Town district, a railroad right of way, and a freeway exchange, the headquarters offered high visibility and a challenging site. But the designers used both the irregular, restricted site and the requirements for sustainability and security for their inspiration. "From the very beginning, it was clear that the way that the project fit within the context of its neighborhood was going to be our primary concern," says Holakiewicz.

Input from the Old Town community was a key ingredient in making the design work, he adds. "They helped us interpret the design guidelines so that we could give things back to the community, as opposed to just taking things away. One of the benefits for us was that they allowed us room on a couple of building elements to go higher than is normally allowed." This concession was critical, as the site's obstacles, including a small seismic fault, required that some areas be avoided. By building higher, the team could condense the floor plates and provide some landscaping for the site on the avoided spaces.

The buildings' height and positioning paid homage to the surrounding neighborhood, with the elevation closest to Old Town presenting a short, regimented, well-ordered façade. Meanwhile, as the buildings move farther back from the street, the shapes begin to fragment and become more angular. An 815-space parking structure, initially targeted for the front of the site, was placed in the rear so the complex would provide a more welcoming face to visitors.

Precast Panels Clad Buildings

The five buildings, including three primary office buildings and two ancillary structures, were clad with architectural precast concrete panels, covering the buildings in height from two stories along the Old Town side to five stories. The panels, produced by Clark Pacific in Fontana, California, were finished to replicate limestone to integrate the project with the Spanish architectural influence of Old Town.

Interior spaces were designed for departmental flexibility and were organized around central gathering spaces, which serve as access points for conference rooms, support amenities, and vertical circulation. Environmentfriendly aspects include recycled-content carpet, certified-sustainable wood products, and task and indirect lighting modulated by solar orientation. Work areas were located to maximize exposure to natural light and encourage interaction among staff.

Outside, the grand trellis dominates, providing a welcoming and functional focal point. The solar photovoltaic modules were a cost-effective approach to providing shading, as they will pay for themselves and offset other material costs. Clark Pacific was charged with designing and installing the massive precast concrete column system for the structure. The precast concrete columns cover 70-ft-high tubular steel purlins to form a trellis that reduces electric bills for the complex.

The trellis is among a series of design features that contribute to the project's fulfillment of California's Tier 1 and 2 Energy Efficiency and Sustainable Building Measures. The natural thermoplastic properties of concrete were exploited to help reach these goals, Holakiewicz says.

Thermal Mass Exploited

Concrete provides excellent thermal storage of cooler nighttime temperatures that are slowly released during the day, cooling both the building and the enclosed exterior courtyards. During the cooler desert nights, the panels release the accumulated daytime heat, eliminating the need for nighttime heating. The limestone-beige color for the panels also helps meet efficiency needs due to its high albedo and low reflectivity, which creates a soft, pleasing color that eliminates solar glare. "All these benefits contributed to a reduction in heat-island temperatures associated with building environments," he says.

In addition to the environmental benefits and the aid in visually integrating the complex, the use of precast concrete panels also helped to meet the state's requirements that the facility be built to last at least 100 years.

Precast concrete also helped to meet the state directive for ensuring public safety and occupant protection. By creating a hardened, secure building envelope, the reinforced concrete panels resist penetration while absorbing significant amounts of energy in the envelope and redistributing those loads across a broader area.

The building's proximity to a major highway interchange also influenced the specification, as the panels exceeded the sound-barrier requirements set by the state for resisting sound intrusion to office environments. "Extensive sound testing ensured that the building's orientation and use of precast panels reduced ambient sound exposure," says Holakiewicz.

Other environmental features include passive bio-swales that percolate water in the parking areas, an innovative water-recycling system, and a cool roof. "The campus organization, material selection, and resulting

'One of the greatest challenges was engineering the precast wall panels to accommodate all of the openings.'

Fact Sheet

Project: *Harm A. Weber Academic Center, Judson College*

Type: *Classrooms, library, and student activity center*

Location: *Elgin, Ill.*

Designer: *Burnidge Cassell Associates, Elgin, and Short & Associates, London, U.K.*

Engineer: *KJWW Engineering, Naperville, Ill.*

Contractor: *Shales McNutt Construction Co., Elgin*

Owner: *Judson College, Elgin*

Precaster: *Mid-States Concrete Industries, South Beloit, Ill.*

Precast Specialty Engineer: *Losch Engineering Corp., Palatine, Ill.*

Project Size: *88,000 sq ft*

Precast Concrete Components: *8 in. hollow-core slabs with attached insulation*

Project Cost: *$25 million*

A key challenge in designing the precast concrete panels was the number of penetrations required by the ventilation system, which produced a "swiss cheese" look for the components. Photo courtesy of Burnidge Cassell Associates.

The new academic center features three building segments clad with insulated precast concrete panels. Included are the library (square building at top), central academic wing (narrow shape in middle), and space for the Division of Art, Design & Architecture (sloped-roof structures in foreground).

energy benefits represent the finest in community-driven sustainable design," he adds. "The headquarters is a holistic composition of secure and sustainable architecture, building materials, and the people who will experience and enjoy it."

Teaching Tomorrow's Designers

Education administrators also understand the long-term value of incorporating sustainable measures, not just for the community the facility serves but for those who are learning in it as well. Nowhere is that more important than at architectural schools, such as the Harm A. Weber Academic Center (HWAC) at Judson College in Elgin, Illinois. The HWAC houses the library and the Division of Art, Design & Architecture (DADA) at the private Christian liberal-arts school, influencing the students' perspectives and inspiring future designs.

The 88,000-sq-ft, $25 million project was designed to greatly reduce the energy used by a baseline design through the use of natural ventilation and other efficient measures. The four-story building features three sections. The largest section forms a square enclosing the central atrium. The library is on the second and third floors, with architectural studios on the fourth floor. The first floor houses the building's mechanical systems and storage.

The library is joined to a central academic area that comprises the main concourse, art gallery, and lecture room on the main floor, with studios and classrooms are on the other levels. The DADA wing features a long, bar-shaped design that holds offices, a photo studio, a shop, and additional studio space.

To create the design, Burnidge Cassell & Associates (BCA) in Elgin, the architect of record, worked with Short & Associates in London, U.K., a design firm known for its innovative work with energy-efficient ventilation systems. The two design partners worked closely despite the challenge of integrating their work across the Atlantic Ocean. Short's team focused on the overall design while BCA translated the design into construction documents and worked on construction administration and submittal for LEED rating. A gold rating is anticipated.

The building's design relies on the stack effect, drawing air in at the lower level, circulating it up through the floors, and eventually exhausting it through roof vents. This natural-ventilation system is designed to operate primarily in the spring and fall months, while a traditional mechanical system provides heating and cooling in more extreme summer and winter conditions.

The precast concrete load-bearing panels and slabs that make up the structural system for the building played a key role in accomplishing the efficiencies in this ventilation system, explains Nanette D. Andersson, current project manager for BCA.

Insulated Panels Used

The 8-in.-thick solid panels, fabricated by Mid-States Concrete Industries in South Beloit, Illinois, feature 4 in. of insulation on their exterior side, which was finished with an exterior insulation finish in some places and a copper-colored metal panel in others, she explains. "This configuration allowed the panels to act as a large thermal mass, helping to passively regulate the indoor air temperature. They also were more cost efficient than cast-in-place or tilt-up concrete."

The floor/ceiling slabs were used on a 3.5:12 slope for an approximately 30 in. plenum that channels air out through the ventilation turrets at the roof. "One of the greatest challenges was engineering the precast wall panels to accommodate all of the openings required for the unusual ventilation system and large amount of glazing required for effective daylighting," she explains. "The south wall in particular was challenging; we joked that it looked like Swiss cheese."

The other challenge was engineering a solution to allow for the angled panels at the fourth-floor ceiling, which was accomplished with a special bracket. "The installers had to be very skilled to complete this work because the panels had to be handled delicately due to the large voids."

The interior sides of the panels also had to have a high-quality finish because they served as the interior walls of the structure with only a final coat of paint. "The whole building has a rather 'raw materials' aesthetic to it, and the precast panels fit into that aesthetic beautifully."

The result of the unique design and the precast concrete structure is a facility that has garnered high interest. "We had quite a few raised eyebrows during the construction process due to the innovative building techniques," she says. "However, the building's sustainability fits in well with the university's mindset that we are stewards of the earth. As a building meant to house a school of architecture, the daily exposure that the students have to this innovative design will influence their education and future careers." ■

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

Platinum Precast

Designers continue to push higher on the LEED spectrum, with more projects receiving the ultimate designation: LEED platinum. The first such project in Florida, now under construction, features architectural precast concrete panels as cladding.

The Conservatory at Celebration Place, a six-story, 170,000-sq-ft office condominium, is part of a complex of commercial buildings in Celebration, Florida. "This is the fifth and final project in the complex, and the others also feature precast concrete cladding," explains Robert Stack, project architect with Morris Adjmi Architects in New York. The panels, provided by Gate Precast Co. in Kissimmee, Florida, include an integral coloring and a washed, buff finish to complement the other buildings.

"The precast was not chosen specifically because of the desire for a LEED platinum designation, but it fit in beautifully with those needs," he adds. Precast concrete aids with LEED certification specifically through the use of recycled content, such as fly ash, and in using local materials and being produced locally, he says.

A variety of energy-saving attributes will help achieve the platinum level, including clerestory and atrium windows, photovoltaic lighting in common areas and hot-water heating in washrooms, operable windows and an underfloor fresh-air plenum, nearby public transportation, a green roof, waterless urinals, pervious paving, and gray-water recycling.

The project, which will be one of only 23 platinum buildings in the country, is expected to be completed in 2009.

Research Aids Designs to Prevent Progressive Collapse

— Donald P. Merwin

Federal officials join with PCI and other concrete groups to develop methods to protect against explosive forces

After the World Trade Center towers collapsed on Sept. 11, 2001, the federal government began developing building-code requirements to provide better protection for government buildings against any future attacks. This plan produced two design goals: resisting initial explosions from inside or outside a building and resisting the progressive collapse of a damaged building.

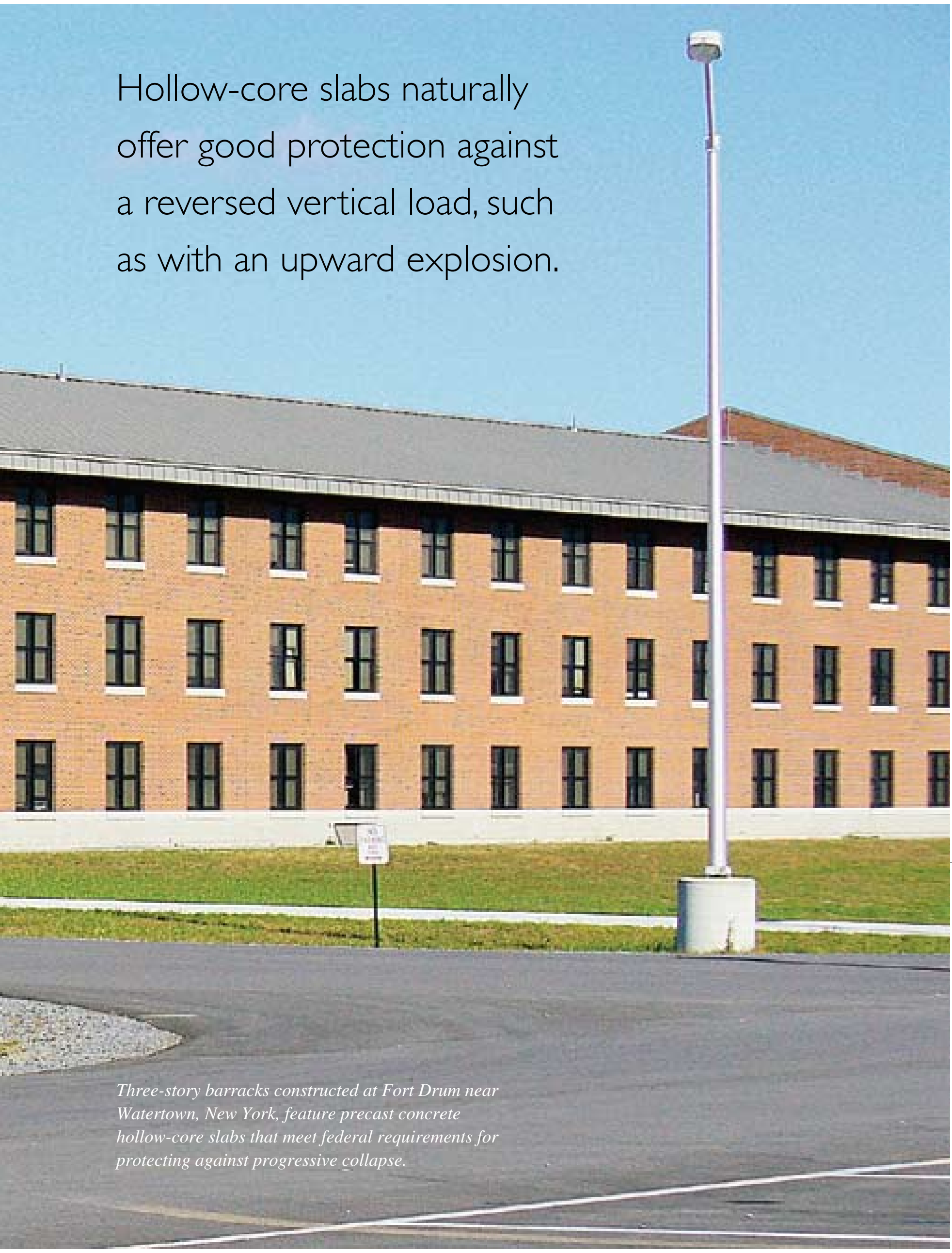
As part of that work, the Precast/Prestressed Concrete Institute (PCI) and other groups, under the organization of the Portland Cement Association (PCA), conducted research to aid in creating new designs. As a result of that research, four barracks were constructed using precast concrete hollow-core slabs at Fort Drum, near Watertown, New York, housing the Army's 10th Mountain Division Aviation Brigade.

The key to minimizing progressive collapse is to create a cantilevered design that does not rely on the outer wall for support, says David Wan, chief engineer for Oldcastle Building Systems of South Bethlehem, New York, which supplied the components.

The first bay of precast concrete slabs was designed as a 10 ft 8 in. backspan with a 10-ft-long cantilever rather than as a 20 ft 8 in. simple span. In the event of a blast in which the end wall (which normally supports the slabs) is destroyed, the precast concrete slabs will cantilever 10 ft from the interior bearing wall and not collapse.

The 8-in.-thick precast concrete hollow-core slabs will continue to be supported by an interior wall 10 ft inside the outer wall. The 10 ft overhang will have almost 3 in. of deflection, Wan says. "But the goal here is prevention of progressive collapse for the safety of individuals, not later serviceability."

To protect against an interior blast, "the use of a relatively heavy and dense material like hollow-core slabs naturally offers good protection against a reversed vertical load, such as with an upward explosion," Wan adds. The slabs are prestressed, adding four $^{1}/_{2}$-in. top strands in addition to the standard six $^{1}/_{2}$-in. bottom strands.



Hollow-core slabs naturally offer good protection against a reversed vertical load, such as with an upward explosion.

Three-story barracks constructed at Fort Drum near Watertown, New York, feature precast concrete hollow-core slabs that meet federal requirements for protecting against progressive collapse.

40 Years of Research

Studies of progressive collapse go back 40 years, to a 1968 gas explosion in a 23-story apartment building in London, U.K. The blast destroyed the load-bearing exterior walls, collapsing that unit and the four apartments above onto that level and then pancaking them all to the ground, destroying all the units beneath. Four people died in that disaster. (For more on that project and other information on progressive collapse, see the article in the Summer 2007 issue of *Ascent*.)

As a result of those disasters, research was conducted in the 1970s by PCA under sponsorship of the U.S. Department of Housing and Urban Development. The research was meant to develop new standards covering structural integrity and progressive-collapse resistance of large-panel buildings. In 1976, PCI published a summary of recommendations that were subsequently adopted by the American Concrete Institute, as part of *Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R).*

FACT SHEET

WSAAF–Barracks Expansion

Location: *Fort Drum, N.Y.*

Owner: *United States Army*

Architect/General Contractor: *Clark Construction Group, Bethesda, Md.*

Precaster: *Oldcastle Building Systems, South Bethlehem, N.Y.*

Components: *Hollow-core slabs, 81,000 sq ft for each building*

‘For economy and speed of construction, and structural requirements, precast was the natural choice for this sort of building.’

The hollow-core slabs could be erected quickly, thanks to the precaster’s ability to continue erection through cold winter weather.

The first bay of precast concrete slabs was designed as a 10 ft 8 in. backspan with a 10-ft cantilever, so if the end wall is destroyed by an external blast, the precast hollow-core slabs will cantilever 10 ft from the interior bearing wall and not collapse.

The code requires that “a structural floor system be designed for gravity and diaphragm loads resulting from lateral loads such as wind and seismic,” Wan explains. “The new Department of Defense design requirements also require that the floor system be designed for potential load reversal or an upward load caused by an internal blast.”

Ned M. Cleland, president of Blue Ridge Design Inc. in Winchester, Virginia, notes that, “In the early development of multistory buildings with large panels, the primary loads that were considered in the design process were gravity and wind. In today’s world the focus is on explosive bombings. Loading problems related to terrorist attacks and bombings have been conceived generally as a vulnerability to progressive collapse.”

Referring to the research conducted for more than 10 years after the London building collapse, Cleland adds, “The primary mechanism to develop an alternative load path for integrity (after an explosion) is the cantilever behavior of the wall assembly.”

Experiments on precast, prestressed concrete insulated sandwich wall panel assemblies were conducted early last year at the U.S. Air Force Research Lab in Panama City, Florida. They were said to have “performed well,” according to a government spokesman. Results continue to be analyzed at Lehigh University in Bethlehem, Pennsylvania, and at the University of Alabama at Birmingham.

The studies were assessed in greater detail in the November-December 2007 issue of *PCI Journal*, where it was recommended that experiments be conducted on floor assemblies to provide “validation of double-tee, hollow-core, and other precast concrete horizontal panels to facilitate effective blast-resistant design of precast concrete systems.”

“That recommendation was to be expected,” Wan notes. “On any new subject such as progressive collapse, engineers would want to have that happen. We do a lot of seismic and wind studies, but we don’t get an explosion to study every day.”

Economy, Speed Cited

Precast concrete wins plaudits from the contractor on the first two of the four barracks to be constructed at Fort Drum, each of which used about 81,000 sq ft. “For economy and speed of construction, and structural requirements, precast was the natural choice for this sort of building,” says Steve Maslen, project executive for Clark Construction Group in Bethesda, Maryland.

“Previously constructed barracks at Fort Drum were all two stories, extending from a hub with two long wings, and they weren’t subject to blast rules,” Maslen explains. “But once the design added a third story, as we did with these new barracks, the force-protection rules applied, and we went to the cantilever method.”

“The design team on this project showed that precast, prestressed concrete hollow-core slabs can be successfully integrated with other building materials, such as steel and masonry, to meet new Department of Defense anti-terrorism requirements,” says Wan. “The use of a precast-plank floor system also met tough budget limits and a fast-track construction schedule.” The masonry and precast concrete work were completed in January and February of 2006 in upstate New York, where the winter can be harsh on construction activity, he notes.

More Opportunities Arise

Recently, the U.S. Army announced plans to increase its size by 74,000 soldiers by 2010, a move that Wan views as an opportunity for more precast structures to be built. “I feel we have a competitive, economical product that will meet progressive collapse requirements.”

The Army’s plans call for basing new combat brigades (about 3,500 soldiers each) at Fort Bliss, Texas; Fort Carson, Colorado; Fort Stewart, Georgia; Schofield Barracks, Hawaii; Fort Leonard Wood, Missouri; Fort Lewis, Washington; and Fort Polk, Louisiana, plus moving two brigades to Fort Irwin, California, and to Fort Drum from other bases. The cost of building the 743 military construction projects is estimated at $66.4 billion. The projects include 69,000 new barracks spaces.

The cantilever method of construction offers a good solution not only for the construction of barracks but also for hotels and condominiums, Wan says. “Any multifamily or multistory structure will find advantages.” ■

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


P.O. Box 9240 Canton, Ohio 44711 1.888.325.3945 e-mail : info@ironrock.com www.metrothinbrick.com
METROBRICK® FITS YOUR NEEDS
MADE IN THE USA CANTON, OHIO
Dovetail Back
Serves as a fastener for sure bond.
Color Blending
Custom blending available.
Strict Sizing
Fits all liner systems.
Exacting Corners
All corners meet strict standards before shipping.
Office Building, Washington DC
From the Box...
to the Form...
to the Wall...
TBX GRADE
METROBRICK®
ARCHITECTURAL THIN BRICK


How to do it in Precast...
Q How is the moment connection made?
A All you need is an emulative detail, reconnect the concrete and rebar.
Q How do you connect the rebar?
A Use the... NMB Splice-Sleeve® System.
cross-section
cross-section
NMB SPLICE SLEEVE
SPLICE SLEEVE NORTH AMERICA, INC.
192 Technology Drive, Suite J • Irvine, CA 92618-2409
PHONE: 949-861-8393 • FAX: 949-861-8419 • e-mail: info@splicesleeve.com
WWW.SPLICESLEEVE.COM

Precasters Create Green Plants

— Craig A. Shutt

High-tech water conservation and material-recycling systems help precasters reduce costs and better serve the environment

Precast concrete provides significant benefits for designers looking to improve the environmental friendliness of their project, especially in assisting projects in attaining LEED certification. But precasters today are going beyond providing products with recycled-material content by improving their manufacturing processes. A number of initiatives, involving wastewater conservation, carbon-dioxide reductions, material reuse, and other efforts, are creating more efficient processes and enhancing the final product as well.

Metromont's new batch plant in Hiram, Georgia, for instance, incorporates upgrades that improve wastewater-recycling and aggregate-reclaiming systems. The improvements result from several years of research, including visits to European plants where the systems are already being used successfully, explains John Wenkel, facilities vice president and general manager. The equipment being used combines U.S. automation and controls with European-designed plant machinery.

The efforts updated an existing architectural-concrete batch plant that was transported from a North Carolina site to the Hiram location. The entire batching facility was upgraded with a precast, prestressed concrete superstructure, galvanized structural-steel components, and weatherproof enclosures for the production of structural and architectural precast concrete.

The two batch plants share a mixing-floor level with a common control room, located between the two batch plants. A twin-shaft SIMEM mixing system was installed for producing structural concrete and self-consolidating concrete (SCC). The OMG-Sicoma planetary, high-intensity mixer was installed for the architectural concrete mixture designs.

Equipment Upgraded

The plant additions have spurred additional sustainable-plant upgrades for the equipment for emission-control of concrete dust and processing concrete washout water. The facility also updated its wastewater-treatment system, borrowing a solids-separation process used by the textile- and food-processing industries. The system injects carbon dioxide into the water, followed by an acid treatment controlled by a magnetic-meter monitoring system. The process creates a semisolid byproduct that is chemically inert and clean, recycled water with a balanced pH, which is used throughout the manufacturing facility.

The inert semisolids are removed and transported to a nontoxic solid-waste landfill, where it can be used for their required daily cover or dried to a consistency that allows the material to be reintroduced into the fines storage (sand bin) in the batch plant. These fine, digested (inert, nonsetting) soils can be used to make SCC, which relies on the finest particulates to create the best reaction with ad-

Metromont has updated and relocated a batch plant to Hiram, Georgia, and improved its wastewater-recycling and aggregate-reclaiming systems. The changes reduced the plant's water bill by 90%.

The plant's water bill has been reduced by 90%.

mixtures to produce superior spread (flow) values. Metromont's quality-control department is developing and testing modified mixtures that will improve the properties of SCC.

The washout-recycling area provides easy access for drivers of concrete delivery vehicles. "Over the long run, the most business-savvy rationale is to recycle 100% of our slurry water and to reduce the amount of waste that needs to be sent to landfills, if cost-effective recycling methods can be installed on site," says Wenkel.

Substantial savings in water consumption can be achieved by recycling wastewater, balancing pH levels of water, and reclaiming aggregates, adds Jay Cariveau, director of business development and marketing. Costs to landfill-production byproducts can be reduced by 50% to 75% through recycling efforts, he notes. The plant's water bill has also been reduced by 90%.

Water-Reclamation System

High Concrete has also taken steps to lessen its impact on the environment. It recently implemented a water-reclamation program for the con-

At High Concrete's Denver, Pa., plant, the company screens washed sand and stone into two bunkers. The aggregate is separated to allow reintroduction of the material into the fine- and coarse-aggregate stockpiles.

Cool Climate Concrete

Cool Climate Concrete, run by The Climate Trust in Portland, Oregon, promotes climate-change solutions by providing high-quality greenhouse-gas offset projects and advancing sound offset policy.

Participating concrete producers submit documentation of concrete-mixture designs, truck tickets, bills of lading, invoices, and computer printouts of cement/concrete they have sold. When verified, producers receive $0.50 per metric ton of carbon dioxide saved.

To learn more about the program, visit www.coolclimateconcrete.com.

'[High Concrete's] $750,000 system has slashed water consumption and boosted process efficiencies.'

crete-batching operation at its Denver, Pennsylvania, plant. The $750,000 system has slashed water consumption and boosted process efficiencies, explains Mark Aho, vice president of operations.

The system uses vacuum filtration rather than standard settling-basin technology to conserve about 10,000 gallons of water each day that otherwise would be lost to evaporation. In the new process, all washout water is captured from transport mechanisms, batching-process mixers, and trucks. Coarse and fine aggregates are settled out, and cement and other particles are trapped for disposal. The vacuum filtration system also conserves valuable space, allowing it to meet site constraints.

The core of the vacuum system is a horizontal drum with a cloth medium coated with a filter cake of diatomaceous earth. As washout water is pulled through the rotating drum, a knife peels off deposits trapped in the earth. The precaster constructed a system of tanks and spillover devices called weirs to control the water through various stages of treatment and minimize the risk of contaminants escaping into the environment.

The initial challenge in setting up the system was to balance the processed water and then feed the system to ensure that it stayed in balance, Aho explains. "With this portion of the process stabilized, we're continuing to evolve practices to manage demand with a goal of increasing output without an associated increase in water consumption. The system also has the capability of segregating excess concrete aggregates for reuse according to concrete mix design."

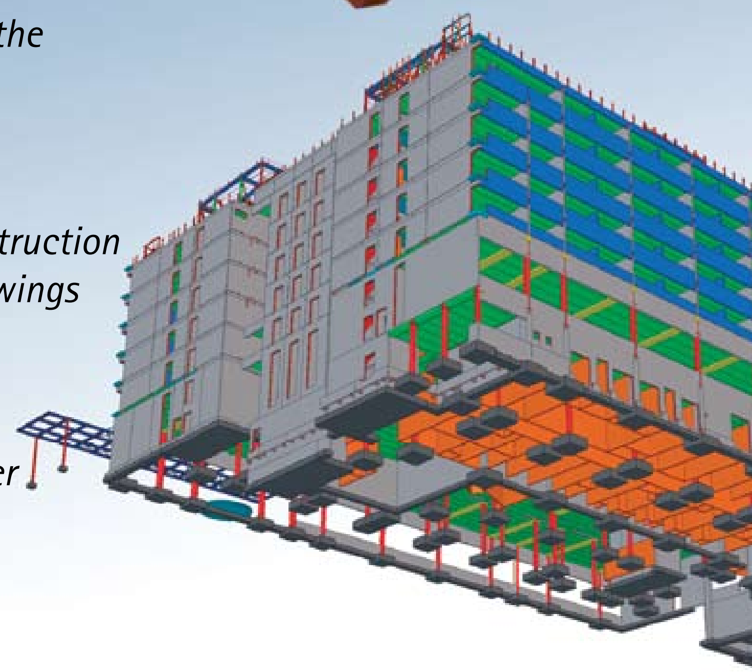
The company has also joined Cool Climate Concrete, an industry initiative to reduce the amount of portland cement used in concrete by introducing alternative materials to mixtures. The independently audited program is aimed at reducing emissions of carbon dioxide and other greenhouse gasses (see sidebar).

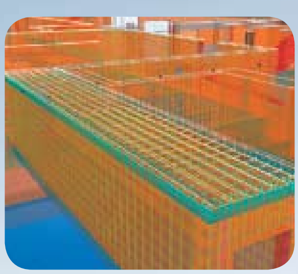
By reducing their use of ASTM C150 portland cement, precasters can help eliminate approximately 12,000 metric tons of carbon dioxide per year toward the program's goal of 200,000 metric tons by spring 2008 for the concrete industry. High Concrete uses supplementary cementitious materials such as slag and fly ash to maintain concrete quality.

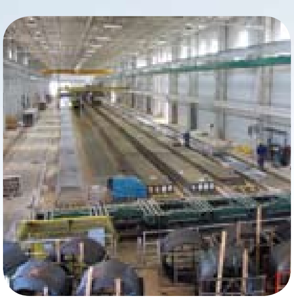
These efforts are but a snapshot of those being introduced around the industry. Architects and designers are finding it easier to specify precast concrete products that not only enhance their building's impact on the environment but lessen impact in the production process. ■

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

At High Concrete's plant, cement is removed by a vacuum-filtration process. The cement particles accumulate on the exterior of a rotating drum pre-coated with a layer of diatomaceous earth. The blade slices the cement off the drum, and it accumulates in a nearby hopper.

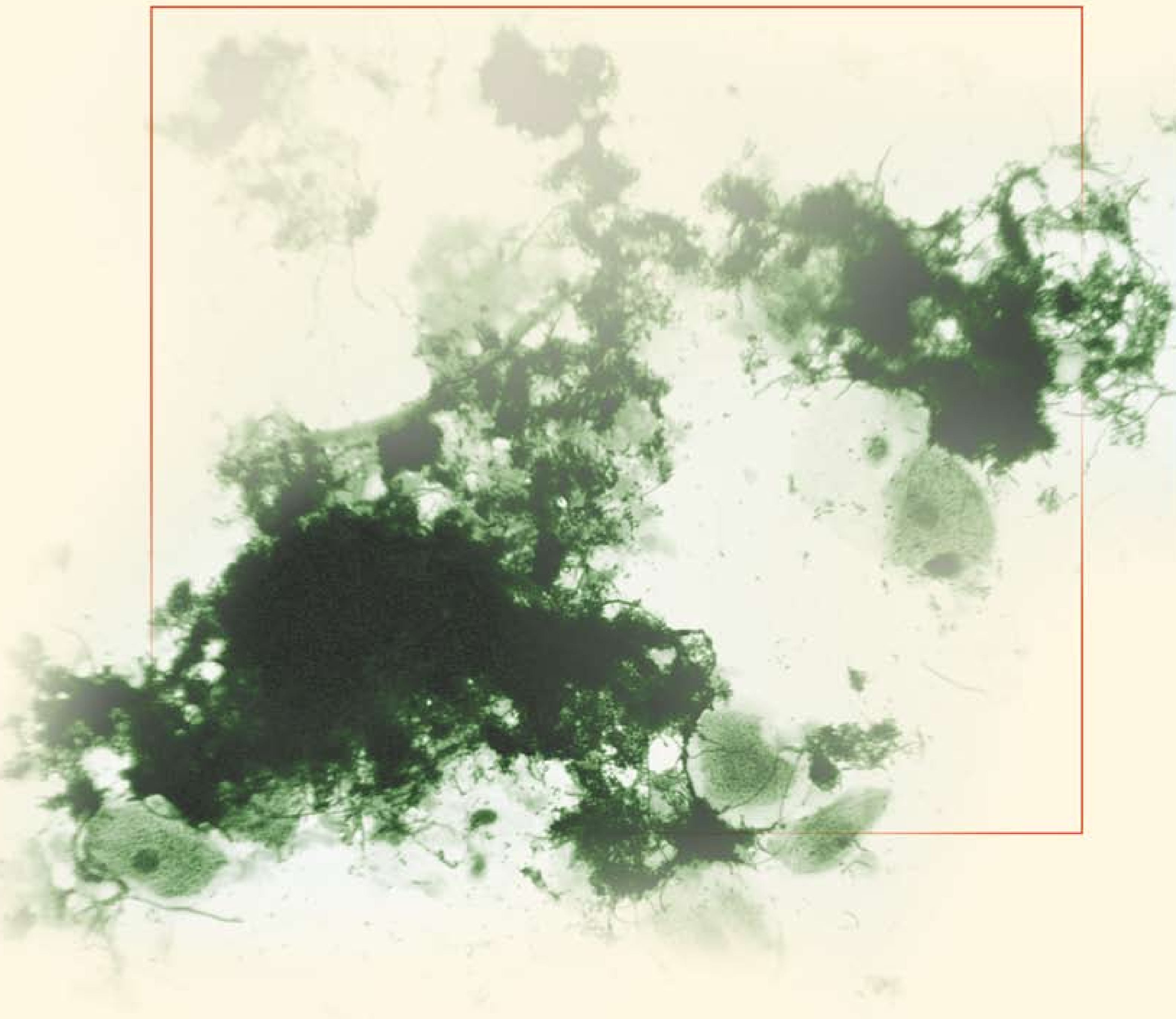






Hilton hotel, Finland

Designer's NOTEBOOK



AVOIDANCE OF MOLD

Introduction

Architects and engineers need to consider the potential for mold growth in all phases of building design, construction, operation, and maintenance. There is potential to develop some mold in any building and in any geographical area. Because of the possible health risks of mold and the enormous costs of mold claims and litigation, mold is a hot topic. Claimants have alleged negligent design and detailing, construction defects, or improper selection of materials susceptible to water damage or mold. The insurance industry generally excludes any property damage or bodily injury (health effects) coverage when defective design, construction, or operation of a building results in dampness or mold intrusion. The interface between construction defect litigation and insurance policies is complicated and highly fact specific, with courts in different states drawing radically different conclusions from similar policy language. Design professionals should take proactive measures to prevent water infiltration, excessive humidity, and condensation, which are the key factors in the development of mold. To this end, design firms need to educate themselves about how, why, and where mold grows, and what measures can be taken to reduce the threat of mold developing. Buildings in hot and humid climates have different problems and solutions related to mold from those either in cold climates or in areas with seasonal swings.

The owner and its design professionals should systematically consider the climate, temperature, relative humidity, type of envelope, dew points, outside air requirements, and intended occupancy of a structure when determining the probability of mold. With respect to building occupancy or type, single and multifamily housing, hospitality facilities, healthcare facilities, and schools pose the highest risk for mold growth for several reasons. First, opportunities for mold growth increase when there is a high turnover in occupancy, as often is the case in these property classes. These property classes also have uses and structural characteristics—many individually controlled HVAC systems, appliances, and plumbing systems, for example—that make them more susceptible to mold.

In order to reduce energy consumption after the oil crisis of the 1970s, buildings were being highly insulated (made airtight but without the benefit of adequate ventilation to control humidity). Insulation reduces the ability of a wall to dry after a water leak. It may also shift the dew point within the wall so that, if the condensation is not adequately drained or vented, mold growth and other water damage may occur.

When designing an energy-efficient building targeting longevity and sustainability, moisture and mold control should be part of the planning.

Mold in the Environment

Mold is a natural part of the environment. Molds are forms of fungi found year round both indoors and outdoors. Mold growth is encouraged by warm and humid conditions, although it can grow during cold weather. There are thousands of specimens of mold and they can be any color. Most fungi, including molds, produce microscopic (2 to 10 µm) reproductive cells called spores. These spores typically disperse through the air continually and settle on all building surfaces, where they can remain dormant for years. Given the right circumstances, they may begin growing and digesting whatever they are growing on in order to survive. There is no feasible or cost-effective method to completely eliminate fungal spores from the indoor environment.

Table 1 – Microbial Test Evaluation Criteria

Amount of Growth	% of Area Component Covered	Grade	Organic Substrates
None	0	0	Substrate is devoid of microbial growth.
Trace	1–10	1	Sparse or very restricted microbial growth and reproduction. Substrate utilization minor or inhibited. Little or no chemical, physical, or structural change detectable.
Slight	11–30	2	Intermittent infestations or loosely spread microbial colonies on substrate surface and moderate reproduction.
Moderate	31–70	3	Substantial amount of microbial growth and reproduction. Substrate exhibiting chemical, physical, or structural change.
Severe	71–100	4	Massive microbial growth or reproduction. Substrate decomposed or rapidly deteriorating.

Fig. 1 Appearance of mold on drywall.

Mold needs four favorable conditions in which to germinate and grow:

- **Temperature range:** Temperatures that are best for humans are also ideal for fungi. Because the comfort range for people is well within the comfort range for mold, modifying the interior temperature is not an option for controlling mold growth. Ideal conditions for mold growth are species dependent, but tend to be in the range of 40 to 100 °F (5 to 38 °C). Little growth occurs below 40 °F (5 °C) or above 122 °F (50 °C). Mold spores can survive, but mold cannot grow, outside this range. However, mold can remain dormant and growth can resume when conditions become favorable again.
- **Oxygen:** Oxygen is required for mold growth. Hence, mold will not grow underwater, but it can grow if starved of oxygen for only a few hours at a time. In all practical cases, the required level of oxygen is readily available in buildings, even in cases of low-permeance building materials.
- **Food source:** While all building materials can act as a substrate for mold to grow on, only organic materials provide a food source (nutrients) to sustain mold growth. In buildings the food source is generally wood, paper, paper-faced drywall (Fig. 1) or other cellulose- or carbon-based material, carpeting, or batt insulation. Materials such as precast concrete, metal, plastic, and so-called paperless wall board do not provide a ready food source for mold as they are not organic. Building-material samples were tested according to MIL-STD 810E (same as ASTM C1338) by Bodycote Materials Testing Canada Inc. to determine fungal resistance.

Five fungal cultures were used:

- **Aspergillus niger** (American Type Culture Collection ATCC 9642)
- **Aspergillus flavus** (ATCC 9643)
- **Aspergillus versicolor** (ATCC 11730)
- **Penicillium funiculosum** (ATCC 11797), and
- **Chaetomium globosum** (ATCC 6205).

The samples were examined at the end of a 28-day incubation period for the presence of fungal growth. The amount of fungal growth was rated according to the microbial test evaluation criteria in Table 1. The results of fungal-resistance testing are presented in Table 2.

Dirt and dust of an organic nature that accumulates on the surface of mold-resistive materials can sustain mold growth when the right temperature and humidity conditions prevail. However, dirt and dust can easily be removed from precast concrete through pressure washing

Table 2 – Microbial Test Evaluation

Description of Sample	Grade	Amount of Growth
Drywall with white paint on one side	1	Trace
Water-resistant drywall	3	Moderate
Piece of 3 ¼ in. (83 mm) tongue & groove wood	3	Moderate
10 in. (250 mm) clay brick	0	None
Concrete block - unsealed	0	None
Concrete block with white primer paint	0	None
Concrete piece - broken/uneven	0	None

Source: Masonry Canada. 2004. Fungal Mould Resistance Testing (FMRT) of Common Building Materials According to MIL-STD 810E. Technical bulletin. Ontario, Canada: Masonry Canada.

before shipment, making it an ideal substrate for inhibiting mold formation. The dust that collects in buildings is primarily paper dust, skin flakes, and fibers from carpeting and clothing. Basically, the food sources for mold are ubiquitous and attempts to control microbiological growth by limiting the food source are generally not successful. The alkalinity of the surface also plays a role in the viability of mold growth. Most fungi require the pH of the substrate to remain within the bounds of about 5 to 8 (neutral to slightly acidic). Concrete has a high pH (10 to 13) and can control fungal growth.

- **Moisture:** Moisture control is the most important strategy for reducing mold growth. Mold growth requires a certain level of moisture on the surface of the food source. Sources of moisture include wet building materials; plumbing; wall, roof, and window leaks; condensation associated with high humidity or cold spots in the building; infiltration of humid air through walls; and improperly operating heating, ventilation, and air-conditioning (HVAC) or humidification systems. In some cases, mold growth generates moisture itself to help the process proceed.

Fungi typically require a surface relative humidity (RH) to 70 to 80%. Some molds can grown at 20 to 40% RH levels, but these species are less important in building problems, and their growth is slow, even on nutrient-rich surfaces. The design objective should be RH levels below 40% during the heating season and in the range of 50 to 60% during the cooling season for indoor comfort during all load conditions, both occupied and unoccupied. These levels constitute a safe margin below the minimum values of RH that would initiate mold growth.

Condensation can occur within the walls or roof of a building as well as on interior surfaces. To prevent condensation, surface temperatures must be kept above the air's dew-point temperature. Mold growth can be reduced where RH near surfaces can be maintained below the dew point. This can be accomplished by reducing the moisture content (vapor pressure) of the air, increasing air movement at the surface, or increasing the air temperature—either the general space temperature or the temperature at a building surface. The dew-point temperature increases as the air's RH increases, that is, humid air will condense at warmer temperatures than will drier air. Therefore, controlling indoor humidity levels helps prevent condensation.

Condensation control focuses on preventing air flow (which can carry significant amounts of water vapor) through the building envelope; interrupting water-vapor diffusion, typically by using a vapor retarder; and maintaining temperatures above the dew point for surfaces exposed to moisture, typically by installing insulation or increasing circulation of warmer air. The first place condensation occurs is near a room's coldest surface. For example, a gap in insulation at the wall/ceiling interface results in a cold area where condensation is more likely to occur. Hence, ensuring the continuity of insulation and air and vapor retarders, if used, also helps prevent condensation.

Condensation can occur in either summer or winter, depending on climate and moisture conditions. A correlation exists between high outdoor dew-point temperatures (but not precipitation amounts) and incidences of mold. High mean dew-point temperatures (Fig. 2) are characteristic of most of the eastern United States, thus making these areas more susceptible to moisture-intrusion

Fig. 2 Mean dew-point temperature isoclines for July and August (1946–1965) from the Climatic Atlas of United States. Source: National Climatic Data Center 2003.

problems. Design strategies for moisture control under heating conditions often differ from those for cooling conditions, even though the basic principles of moisture transfer are the same. Recommendations for positioning air and vapor retarders relative to insulation and relative to each other depend on whether the building requires predominantly heating, cooling, or both. See Designer's Notebook (DN-15), "Energy Conservation and Condensation Control," at www.pci.org/publications for a complete discussion on condensation control and air and vapor retarders in precast concrete systems.

Mold control is primarily about controlling moisture to levels and durations appropriate for the material used. The general strategy is to construct and operate buildings in such a way that materials do not get wet enough to support mold growth, or to ensure that those materials that get wet will dry quickly, and to not provide sufficient food value to support mold growth. Usually, if moisture or high humidity is not addressed within 24 to 48 hours, mold can begin to grow exponentially. Precast concrete does not exhibit structural damage or deterioration from moisture. In addition, the site's natural ventilation will normally dry out concrete, eliminating moisture as a source of mold growth.

Without all of these four elements, mold cannot grow and spread. And of these, moisture is the easiest and only practical way to control mold growth because of the pervasive nature of nutrients and a temperature range suitable for mold growth. It is also the only one that can be controlled while maintaining comfortable operating conditions for humans.

Health Effects of Mold Exposure

Molds release microbial volatile organic compounds (VOCs), which cause mold's musty smell, and produce allergens and, under certain conditions, toxins. The allergens and toxins are not airborne themselves but can be carried in flight with the mold spores. It is these allergens and toxins that have the potential to cause medical issues for occupants.

Most building occupants experience no health effects from the presence of mold. However, some individuals with underlying health conditions may be more sensitive to molds. For example, individuals who have allergies or respiratory conditions such as asthma, sinusitis, or other lung diseases may be more easily affected. Similarly, persons who have a weakened immune system tend to be more sensitive to mold.

With mold growth, occupants may begin to report odors, and some may complain of a variety of health problems. The most common health effects associated with mold exposure include allergic reactions. Symptoms include sneezing, runny nose, skin and eye irritation, coughing, congestion, and aggravation of asthma symptoms. The types and severity of symptoms depend, in part, on the types of mold present, the extent of an individual's exposure, the ages of the individuals, and their existing sensitivities or allergies. Therefore, for people in general, it is not possible to determine safe or unsafe levels for airborne concentrations of mold or mold spores.

Even without substantial scientific data to establish a direct link between mold exposure and health effects, those particularly sensitive to certain types of mold can react so severely that claimants have litigated and obtain significant personal injury and property damage awards. Therefore, as long as there is a question regarding how mold may affect human health, claims will continue to arise and lawsuits will continue to be brought against anyone involved in the design or construction of a building that facilitates the growth of mold.

The building enclosure, the primary barrier to water intrusion, is often implicated in mold problems because it is exposed to a range of moisture sources, including rain and condensation. The decision to use a particular building-envelope system does not determine a building's likelihood of having moisture and mold problems. Many exterior envelopes are time tested (such as precast concrete) and will perform well when properly designed and installed.

Designers should evaluate the placement of fenestration, changes in plane, and the transition points of each material to determine if the proposed envelope system can be designed and installed to prevent water intrusion. Using multiple materials on the envelope multiplies the risk of water intrusion. Both the building-envelope and HVAC decisions made during the design process affect the amount of moisture and potential for mold. A design change in one system may have a dramatic effect on the performance of another system. For example, increased thermal insulation may change dew-point location with possible condensation in the wrong location. If both building pressurization and envelope are planned appropriately, future mold problems are unlikely.

Although the outer portions of precast concrete walls are exposed to wetting, mold is not a problem. Molds do not require sunlight (because they do not use photosynthesis) and in fact their growth is limited by sunlight (ultraviolet radiation [UV]). The UV intensity of bright sunlight typically slows or kills fungal growth both because the light warms (and hence dries) the surface, and because of the high UV intensity. In contrast, the inner portions of an enclosure are exposed to less wetting but are more prone to mold growth because they are kept warm year round. Interior finishes are often made of moisture-sensitive materials and are more affected by the interior environment.

Construction Phases

Moisture problems created by outside-air infiltration and vapor diffusion are negligible during construction. Other than rainwater leaks, moisture problems are generally not introduced until the building's air-conditioning (AC) system begins operating. Significant moisture and mold problems are often attributed to the so-called drying out of the building. In reality, however, such problems are rarely associated with moisture being released from new construction materials, unless the materials are not allowed to completely dry without being covered or hidden.

In the process of selecting building materials for a structure, consideration should be given to how a material reacts when exposed to free water or water vapor. Poorly chosen construction materials, often based on cost considerations or availability, may affect a building's integrity. Materials should be compatible with the regional environment and installed by knowledgeable workers. Contractors must take the initiative to refuse delivery of damaged, dirty, or moldy materials (in the case of timber and drywall).

Reducing the potential for moisture- and mold-related problems during construction generally requires a thorough understanding of moisture-related construction problems, proper attention to construction sequencing, effective temporary control of space conditions, and diligent testing and monitoring to identify problems before extensive damage has occurred. Typically, the most serious weather-related construction moisture problems result when the final stages of construction are completed in the summer or early fall. Because ambient humidity levels are higher during these times, materials are less likely to dry naturally before being enclosed in a structure.

There are three stages of construction: the exposed phase, the partially enclosed phase, and the controlled phase. If the goal is to achieve the lowest level of risk for mold formation, then the single most important point in the construction schedule may be the point at which the contractor seals the building envelope.

During the exposed phase, the foundation, the frame, and everything else are exposed to the elements but the natural ventilation of the site will normally dry out any materials that get wet. To minimize the potential for mold growth, it is important to develop a proactive plan to minimize the risk of water damage and wet surfaces due to external factors such as rain, snow, flooding, and high RH during the exposed and partially enclosed (contractor will normally begin to rough-in the interior and may install some of the finishes) phases. Appropriate construction sequencing avoids installing moisture-sensitive materials before the building is enclosed. The installation of protective barriers or temporary enclosures across building-envelope openings (walls, roof, and basement) and open areas to accommodate construction elevators/hoists and window installation is recommended. The use of water-resistant materials in areas susceptible to moisture also reduces the risk of mold growth. These decisions affect both the construction cost and schedule, and should be fully considered. Wet areas and materials should be dried within 24 hours of exposure.

Fireproofing materials for steel are normally installed during either the first or second phase of construction, even though this material may have a high potential for absorbing and retaining moisture and could serve as a substrate for mold. Precast concrete eliminates the need for and cost of additional fireproofing measures.

Installation of drywall or other interior finishes on or near cast-in-place concrete that is being cured, adjacent to spray-on fireproofing or insulation, or within an area of high humidity will result in water damage.

The contractor should not close in any areas that are not appropriately dried, or that are likely to become wet due to incomplete protection from moisture. Also, the contractor should take appropriate precautions to protect moisture-sensitive materials during storage and construction.

If the goal is to minimize the risk of mold formation, then the single most important point in the construction schedule may be when the contractor completes and seals the building envelope. At that point, the construction process enters the controlled phase and the contractor can begin to install drywall and other finishes.

It is particularly important that the owner and design professionals analyze the construction schedule. The earlier the construction schedule requires a contractor to begin work on finishing the interior (before the building is fully enclosed), the greater the risk of permitting water to enter or accumulate on porous or organic materials, or in places that accommodate mold formation. It also becomes important to pay particularly close attention to selected finishes. Materials that require long lead times or take longer to install will delay the completion of the envelope.

Prefabrication of precast concrete components allows vital construction elements to be manufactured early in the construction process as soon as drawings are approved, ensuring that units are ready for erection as soon as foundation work or the supporting structure is completed. The speed of erection of precast concrete systems also allows for faster completion of the building shell in almost all weather conditions, often cutting weeks and months from the schedule, allowing construction to get into the dry more quickly. This, in turn, allows interior trades to begin work earlier. The fast enclosure results in less weather or material damage during construction to mold-susceptible materials.

Sometimes contractors use drying techniques such as fans, natural ventilation, indirect fired heaters, dehumidifiers, desiccant dehumidifiers, or the HVAC system (if operational) to dry areas where they are installing or applying certain finishes, particularly if water is visible in those areas. Drying techniques may not control the temperature or humidity of the interior space. Thus, these techniques should be reviewed and used appropriately to reduce the potential of mold growth during construction.

Also, construction moisture should not be trapped in assemblies by the indiscriminate use of vinyl wall coverings (which may be impermeable). Vinyl wall coverings can cause the water vapor in drywall to condense and encourage mold to grow in wall cavities or in insulation. Foil-faced fibrous cavity insulation and foil-backed gypsum sheathing can also keep buildings from drying out when they get wet.

During the final stages of construction, the mechanical systems are usually not performing at optimal levels. It is critical that no additional moisture be added to the building during this time, especially from the outside. In addition, any temporary controls of the building HVAC systems must prevent the building from achieving negative pressurization. Maintaining positive (or at least neutral) pressure will help prevent moisture from intruding from outside air into the roof or ceiling and wall cavities. A plan for temporary controls may include statements such as the following:

- The contractor shall energize, operate, and maintain HVAC equipment before the interior finishes are installed. After the building or room is fully weatherized and before interior finishes are applied, the HVAC system shall be operated 24 hours per day for a minimum of three days, until a constant temperature of 75 °F (plus or minus 2 °F) (24 °C [plus or minus 1 °C]) and a constant humidity level of less than 60% can be demonstrated to the owner.
- Throughout the installation of finishes and until the owner's final acceptance, the HVAC system will operate 24 hours a day.
- If mechanical systems are not performing at optimal levels when interior finishes are installed, the HVAC contractor will provide additional temporary dehumidifiers (portable units) and heating or cooling units to meet required conditions. Instead of temporary dehumidifiers, an increased monitoring program may be acceptable.

If the project permits or requires the contractor to operate the permanent HVAC system during construction, it must be specified that the equipment be turned over upon project completion in a clean condition.

During construction, there can be increased pollutant load in a building because of heavy particulate load and off-gassing of formaldehyde and VOCs from newly installed products. There are various methods of controlling this additional pollutant load, such as additional air filtration, the use of temporary air handlers for heating and cooling, and flushing out the building with additional amounts of outside air.

Precast concrete has no outgassing that can cause deteriorated air quality. This has become a critical component in recent years as the need to enhance energy efficiency has tightened the "breathability" of buildings, preventing air from infiltrating and exfiltrating, which retains existing particulates in the air. Precast concrete will not add to outgassing that comes from VOCs and new materials brought into the structure. As proposed by USGBC LEED Credit 3.2, building flush-out can occur either late in the construction phase or after the building is occupied. While the use of outside air to flush out the building may reduce the concentration of off-gassed pollutants, it can also inadvertently cause moisture problems in buildings in many parts of the country during the summertime.

In a typical 100,000 ft^2 (9300 m^2) building, the amount of outdoor air required to meet the flush-out portion of this credit is 1,400,000,000 ft^3 (39,620,000 m^3). This amount of air volume in the eastern portion of the country during the humid summer months can be equivalent to over 200,000 gal. (757,000 L) of additional moisture introduced into the building. This moisture is in addition to the normal moisture load from construction activities, cleaning liquids, or construction-related moisture from curing concrete, paint drying, and similar activities.

One of the additional risks with conducting building flush-out (especially in an occupied building) is that it is usually done in the evening when the heat load (sensible) is the lowest and the moisture load (latent) is the highest. This can result in even greater RH levels in the building because the unfavorable ratio of sensible to latent load can cause overcooling of the building (resulting in flash condensation). This can cause moisture to accumulate in building materials such as gypsum wallboard, with subsequent material degradation and mold growth. The additional likelihood that the HVAC system might still be unbalanced at the time of the flush-out increases the potential for moisture problems as a result of this process. Infiltration of air with a high moisture load may also exceed the ability of the HVAC system to remove moisture from the supply air.

Moisture-related problems can be avoided if the building envelope adequately retards moisture, liquid, vapor, or air movement into the building and allows any accumulated moisture to either drain to the exterior or evaporate. Moisture comes from four sources, which have different impacts on a building depending on climate:

- ***Vapor diffusion through the building envelope.*** The vapor-diffusion mechanism does not typically induce significant moisture into a building and can generally be considered a negligible contributor to potential moisture problems. Nevertheless, it is a mechanism to consider in building design and construction, particularly in cold climates and in hot, humid climates, and especially as it relates to the construction of vapor retarders in walls.

  To control air and moisture flow through the wall, any air barrier or vapor retarder must have the proper air resistance or moisture permeability and must be installed at the correct location within the walls. The presence of multiple vapor retarders within a wall system is a common problem, and many architects do not recognize that common construction materials such as precast concrete act as effective barriers.

  Vapor diffusion is difficult to estimate because of microclimatic variables. The building envelope is subject to daily temperature extremes caused by shifting sunlight and shade on the walls or roof. However, using worst-case ambient temperatures in a steady-state analysis is usually sufficient for estimating vapor diffusion, especially if a vapor retarder is properly installed in the wall system.

  A vapor retarder is not required in all situations. Without one, the building envelope may still perform as an adequate barrier to vapor diffusion. Under many conditions, using an air barrier is more important than using a vapor retarder. However, if a vapor retarder is used, factors such as permeance, location, and use of multiple retarders become extremely important.

  The type and location of the vapor retarder can greatly affect moisture accumulation and mold formation. In hot, humid climates, for example, a vapor retarder located between a wall's thermal insulation and the building's interior could reach a temperature below the dew point (point of condensation) of the outside air. In cooler climates, an exterior vapor retarder could be located where the temperature is below the dew point. In both cases, condensation would form on interior surfaces or in interior cavities. To avoid such problems, the placement of vapor retarders is best determined early and with an understanding of the local climate.

Vapor-diffusion problems are accentuated by cold walls or building spaces, permeable exterior surfaces, and impermeable interior surfaces. For example, in hot, humid climates, if the exterior portion of the building envelope is porous—moisture absorbing and permeable—and the interior portion is porous as well as impermeable, the effect of vapor diffusion can be more significant. In cold climates, the opposite condition can cause problems (that is, when the exterior portion of the building envelope is porous and impermeable and the interior portion is porous and permeable). Vapor diffusion is discussed in chapter 25 of the *ASHRAE Handbook—Fundamentals* (ASHRAE 2001).

One advantage of insulation is that it keeps the primary vapor retarder (if one exists and is correctly located) from reaching the temperature at which condensation may occur. In a precast concrete wall system, a closed-cell nonhygroscopic insulation is recommended.

To avoid moisture problems, the design team must consider how direct contact with moisture-laden air affects wall structures. Thermal bridges that allow the structures to cool below the dew point of the ambient air may cause local condensation on the structural materials. For example, metal studs can act as a thermal short circuit or bridge, allowing condensation to occur on interior or exterior portions of the stud even though the wall may be well insulated.

Selecting an interior surface finish with the proper permeance is one of the most critical aspects of an exterior-wall-system design in any climate. Typically, the interior finish is selected for aesthetic appeal or ease of maintenance, with little regard for wall-system performance. An interior finish should have a high permeance rating in hot, humid climates to allow moisture vapor that enters the wall to migrate into the conditioned space, where the vapor will eventually be removed by the AC system. The opposite is true in cold climates. The mechanical engineer will use interior-finish-permeance ratings in performing the dew-point analysis on the wall system.

- ***Rainwater intrusion.*** Moisture can be present in building materials and on the site during construction, causing moisture problems in a building. Significant amounts of moisture can also result from water leaks within building systems or through the building envelope. In both hot, humid climates and temperate climates, rainwater leaks are a major source of building moisture and microbial growth problems.

Because of its panelized construction, fewer points of potential moisture penetration exist with precast concrete. This helps control moisture and eliminate the possibility for mold growth from water that penetrates the walls. Maintenance needs for precast concrete panels also are minimal, with panels requiring caulking only every 15 to 20 years to maintain their reliability. This limits the need to budget for repairs in annual maintenance budgets and reduces the potential for lapses to allow a problem to develop.

Rainwater can be drawn into a building by gravity, capillary action, surface tension, air-pressure differentials, or wind loads. The building envelope (exterior walls and roofing) should control water from all of these sources.

Weather-related moisture includes rainwater and groundwater, which can severely affect the building envelope. Rainwater rarely causes widespread problems in HVAC systems or building interiors; instead, it concentrates around window penetrations, roof lines, joints, and the base of exterior walls. It is important to understand performance criteria as they relate to moisture intrusion for fenestration components such as windows.

HVAC-induced moisture can equal or sometimes far exceed the amount of moisture attributable to rainwater leaks. Additionally, HVAC-induced moisture can mask or obscure rainwater leakage because it is often an envelope-wide problem. This misunderstanding can lead to misdiagnosis, which often results in expensive, unnecessary repairs to the building envelope when simply modifying the HVAC system would have been less expensive and more effective.

In all climates, the building skin must be the primary defense against rainwater and be designed to shed water quickly away from the building. The building envelope plays a vital role in minimizing uncontrolled moisture and air movement into a building and in preventing moisture entrapment within the wall.

Although the building envelope contributes to moisture-related problems in hot, humid climates, infiltration of humid outside air and vapor diffusion through the envelope is not usually as great a factor in more temperate climates. However, in temperate climates, the building envelope plays an important role in minimizing rainwater intrusion into the building, and in avoiding the subsequent mold growth that can result from such intrusion. In cold climates, vapor diffusion or exfiltration of humid indoor air during colder months can also be a problem in wall cavities.

- ***Internally generated moisture.*** After construction, occupant activities and routine housekeeping procedures can generate additional moisture, which can contribute to mold. Normally, if no other significant sources exist, well-designed and properly operating AC systems can adequately remove this moisture. Internally generated moisture is more likely to cause moisture damage inside a wall system in northern climates than in hot, humid climates.
- ***Infiltration of outside moisture-laden air.*** Whether introduced by wind or negative pressurization caused by the HVAC system, air infiltration can cause condensation on interior surfaces, including inside building cavities. Condensation and high RH are important factors in creating an environment conducive to mold growth and are primarily a problem in hot, humid climates.

No building is hermetically sealed. That is, all buildings have some degree of air leakage (openings inherent in the envelope construction) and this leakage carries a certain amount of moisture with it into, or out of, the building. Precast concrete construction allows minimal air infiltration or exfiltration, reducing the potential for moisture problems due to moist air migrating into a wall and building. The most critical areas of envelope air leakage are gaps around windows and doors; joint openings at roof, ceiling, or floor lines; and the intentional installation of soffit or wall vent systems. These areas provide the most likely openings in a building envelope and are convenient pathways for air leakage and moisture intrusion into the building. Although this air leakage can typically be overcome with positive building pressurization, a tightly sealed building envelope will minimize air leakage and reduce the amount of air required to achieve good pressurization with the HVAC system. Moisture contributed by air leakage is significant and should be a serious concern in the design of the wall system. In fact, the design of the building envelope for minimizing air leakage is more critical than the design of the vapor barrier.

The potential for infiltrated moisture to be deposited in the building envelope is directly related to the interior temperature of the building, the moisture content of the outside air, and the amount of outdoor air infiltrating the building wall systems.

An advantage to precast concrete construction is that an air barrier is inherent in its construction. Unlike a framed wall, a precast concrete wall usually provides a solid air barrier that is free from penetrations. This does not release the design team from designing a properly pressurized building envelope. A depressurized interior space will induce the intrusion of outside air, even through a precast concrete wall. And most wall systems will have openings for fenestration where possible air-infiltration pathways exist.

Nonconditioned air rarely should be the source of makeup air for a building. To preclude its introduction, the system should be designed and installed to eliminate negatively pressurized spaces (with respect to outside conditions) in the rooms, walls, or ceiling cavities. An exception to this recommendation applies to facilities that have higher internal moisture conditions than outdoors; forcing the moisture through the exterior envelope may allow moisture accumulation in the cavity. For example, natatoriums try to maintain indoor conditions of 82°F (28°C) and 60% RH to minimize pool surface water evaporation. In cold climates, forcing this moisture through the exterior envelope can cause condensation on cooled surfaces, ice formation, microbial growth, and degradation of wall or roof materials.

- ***Ventilation.*** Most buildings will bring in conditioned outside air to replace exhausted air, maintain indoor air quality (IAQ), and provide building pressurization (see ASHRAE 62.1). Providing enough ventilation to positively pressurize the building will reduce uncontrolled air leakage into the building. Ventilation moisture loads tend to be one of the highest moisture loads that need to be mitigated.

  If the HVAC system introduces moist outside air into the space for ventilation, the system must continuously dehumidify the air. *Under no circumstances should adequate dehumidification be sacrificed for ventilation.*

  In regions with high ambient dew-point conditions and elevated RH levels (which include much of the eastern half of the country during portions of the year), there is a direct correlation between the number of moisture problems (mold) and increased rates of mechanical building ventilation. This can occur for obvious reasons, such as the additional moisture load that is introduced into the building along with outside air. It is important to bring in the minimum amount of outdoor air possible (while meeting ASHRAE 62.1 and pressurization requirements) and dehumidify it directly and constantly.

  In ASHRAE 62.1-2004, a number of revisions were made that, on average, reduced the outdoor ventilation rate by about 15 to 20% when compared with the 2001 version. For designs in humid climates, this is a good design practice. Less air means less moisture. But some don't like the cut in the rate, which in an office environment reduces the rate from 20 cfm/person to an average of about 17 cfm/person.

The LEED rating system awards an additional credit (Increased Ventilation – Eqc2) for an increase in the rate of at least 30% over the 2004 calculated values. LEED went with 30% because the USGBC would actually prefer a number 50% higher than the 2004 rate (about 25 cfm/person), but a 30% bump was seen as a compromise between indoor air quality and energy efficiency.

This is a catch-22. If designing in a humid climate, you could actually be rewarded for increasing the potential for mold and moisture problems by bringing too much moisture inside. If the warm, moist air hits a cooler surface, such as the interior gypsum board of an air-conditioned room or the cold-water supply pipe in a ceiling plenum, the vapor from the moist air will condense and mold will form on the wallboard or on the ceiling tiles below the pipe.

A more progressive and safer approach would be to skip the LEED point and bring in the code minimum. Then, on projects that merit the added control complexity, apply a demand-control ventilation strategy to actually cut that quantity down further whenever possible. This might even earn a LEED point under the Optimize Energy Performance Credit (EAc1).

Considering both energy conservation and moisture-management goals in the design, construction, operation, and maintenance of HVAC systems can minimize the required energy use and resulting cost. However, the impact of mold proliferation suggests that energy-cost savings should not be achieved at the expense of sound moisture management in a building.

It is more difficult to maintain a specific RH than a specific temperature, which means it is easier to lose humidity control. To fully dehumidify the air flow, the HVAC cooling coils must be sized properly to meet the sensible and latent load. (Latent load is the moisture in outside air that is brought into the building and requires removal via dehumidification. Sensible load is the air temperature that is sensed and addressed by the HVAC system, either by heating or cooling the air, to reach the established set point.) This air flow, the combination of outside air and return air, must be brought to a temperature that causes the moisture in the air to condense. This is known as latent heat removal (or latent energy removal). Simultaneously, the cooling coil is reducing the sensible temperature of the air to offset the sensible energy generated in the space by lights, solar radiation, people, equipment, and so on.

AC units are typically sized according to the peak design cooling load. The cooling load is often standardized for a number of areas and sensed by a room thermostat. AC unit run time is typically controlled by temperature, instead of by humidity (humidistat). Run time is a critical variable in the ability of the unit to dehumidify the space. If the unit is sized properly to match the room sensible load and to maximize unit run time, the room will be dehumidified adequately. If the unit is improperly sized, however, when the room sensible load falls below the peak design load, the AC unit will run for a shorter period and could fail to dehumidify the room properly. The system should have control overrides to monitor air quality and force operation of the system independent of temperature conditions to achieve a balance of thermal comfort and RH in the building. Dehumidification needs to operate efficiently at peak and off-peak loads, and regardless of whether the building is occupied or unoccupied.

Chapter 26 of the *ASHRAE Handbook—Fundamentals* (ASHRAE 2001) contains a complete description of methods of calculating cooling loads from ventilation and infiltration. The outside humidity during a typical year may be quantified to determine annual moisture load before designing and sizing the mechanical system. Annual humidity information can be obtained from weather data that report mean frequency of occurrence of dry bulb temperatures with mean coincident wet bulb temperatures for temperature ranges and corresponding hours of occurrence per year. One such source is AFM 88 29 (U.S. Air Force [USAF] 1978).

The data as presented by ASHRAE work best for sensible load calculations but do not always apply for latent calculations. In humid regions, designers should know the highest vapor pressure likely to occur during the year. In most climates, the highest RHs are found during the morning and evening hours and occur at high values even during the winter. Also, the highest latent loads are usually found at lower dry bulb temperatures than the ASHRAE design data reflect.

ASHRAE outlines good practices for ductwork design, cooling for dehumidification, and proper installation of humidification systems to reduce moisture in ductwork and the likelihood of mold growth (see the 2001 ASHRAE publication *Humidity Control Design Guide for Commercial and Industrial Buildings*). In many cases the level of moisture control required to control mold is no more stringent than that required to ensure good performance and durability.

In any climate, the normal functioning of standard AC units can result in microbial growth. Just downstream of the cooling coils, the air is at or near 100% RH during the cooling season. The interior surfaces of the AC unit and ductwork immediately downstream of the cooling coils are often lined with insulation, generally for acoustical purposes. Dirt and fungal spores are often trapped in the lining. This environment is conducive to microbial growth and can lead to IAQ complaints because the conditioned air (and any microorganisms it carries) is distributed inside the building.

Building Layout Considerations for Proper Building Pressurization

Uncontrolled movement of nonconditioned moist air into a structure is an important source of unwanted moisture. Moist-air infiltration is often a bigger problem than rainwater leaks because water generally obeys the laws of gravity. By contrast, air movement can enter a building from any direction. While making a building watertight is a formidable task, making it airtight is an impossible one.

Maintaining proper pressurization in a building is the best way to prevent uncontrolled airflow, but this depends on a building layout that promotes interior air distribution. The uniformity of the layout from floor to floor, space usage, and construction style (atrium lobby areas or continuous slabs between all floors) affect air distribution and the degree of pressurization required. Atriums and a lack of between-floor air barriers provide portals for airflow that affect multiple levels, making pressure relationships more difficult to control. The building layout should be analyzed both vertically and horizontally for its effects on the pressurization.

HVAC systems that positively pressurize a building space by supplying unconditioned or only partially conditioned outside air will avoid infiltration of outside air through the building envelope. A positive pressure will cause air to generally flow out of the building through joints and cracks such as those found at windows and closed doors. However, even a well-pressurized building cannot prevent infiltration through large openings like door entrances. Unless a rate of air flow of at least 150 feet per minute (fpm) [0.8 meters/second (m/s)] can be achieved through these large openings, wind-induced air leakage into the building must be expected.

Mechanical Considerations

If improperly designed, constructed, and operated, building mechanical systems are likely to create moisture and mold problems. Therefore, particular attention must be paid to their design, equipment selection, installation, and start-up. The key factors to consider are pressurization and dehumidification.

Pressurization

Pressurization of buildings can work in all climates to eliminate uncontrolled air flows. In cold climates, pressurization during the winter forces moisture out through the building envelope and may allow moisture to accumulate if it does not have a pathway out, or if it reaches a vapor retarder that is below dew point. In hot, humid climates, outside air can contribute a large moisture load to the wall cavity and conditioned space. If outside air is drawn into the building envelope by negative pressure inside the building, it will travel through the wall and into the interior space, making it very difficult to maintain a set RH. Because airflow will always follow the path of least resistance, outside air can even get into any interior walls that intersect with an exterior wall. The potential for moisture accumulation increases with lower interior temperatures and with higher negative pressures. Proper building pressurization depends on control of mechanically induced depressurization and the proper distribution of makeup air within the building spaces. Even a properly designed and installed building envelope cannot compensate for a building under negative pressure. Achieving proper building pressurization is sometimes difficult because it must overcome any depressurization from stack, wind, and fan effects.

Building Operation and Maintenance

Operation and maintenance are no less important than design and construction to avoid moisture problems in a building. If the HVAC system is not properly operated, the relative humidity in the building may increase, or condensation may accumulate to the point where mold will begin to grow. For the most part, the HVAC system should be kept turned on. Among other things, the costs and benefits of humidistats should be considered.

Once construction is complete, designers should encourage the development of a detailed set of written procedures for scheduled maintenance and inspection programs for the prevention and early detection of mold. The first step in achieving timely and appropriate maintenance is to make sure visual inspections and component service-life monitoring are conducted regularly of the building envelope, windows, roofing system, HVAC, and drainage systems. Particular attention should be paid to flashings, counter flashings, and sealants. Attention should be paid to all plumbing and piping systems and to any water used to clean or otherwise maintain the interior of the building. Below grade, water infiltration through foundation walls should be avoided.

Sources of dampness, high humidity, and moisture should be eliminated and any conditions that could be causes of mold growth should be corrected to prevent future mold formation. Wet or damp spots and wet, non-moldy materials should be cleaned and dried as soon as possible (preferably within 24 to 48 hours of discovery).

Commissioning

A comprehensive continuous commissioning program should ensure that the building's energy-related systems provide optimal design performance at all times and produce expected comfort, reliability, and savings, and should analyze the building envelope's performance. It should also find and correct any equipment-installation mistakes. The HVAC designer should provide input on the operation and maintenance guidelines for the specified systems and equipment, and should actively participate in the commissioning process to ensure that building operators understand their role and responsibility in mold prevention.

To reduce the possibility of moisture and mold problems, the following should be included in building commissioning:

- During the design phase, a technical peer review of the contract documents should identify issues that will likely be a major cause of moisture and mold problems in the operating building. This review may need to be accomplished by someone other than the traditional commissioning agent because they may not have the requisite skill set to conduct this type of analysis. This review needs to specifically identify which building components and systems have a high potential for moisture problems and offer alternative solutions to the design team.
- The commissioning process needs to consider the interrelationship of the building envelope and the HVAC system. This area is often overlooked because it involves the dynamic interaction between two separate technology areas. The building should be properly pressurized and the HVAC system dehumidifying properly.

- The building envelope needs to be commissioned to ensure avoidance of rainwater leaks, excessive air leakage, and condensation problems. In cases where the envelope is commissioned, both individual envelope components (like windows) should be tested as well as assemblies of multiple adjacent components. Testing individual components does not address the connection points and intersections between various envelope components where most failures occur.

The sequence of commissioning is critical to avoid problems that may occur even with a properly designed and constructed building. For example, during the final stages of construction, a combination of events may occur that results in depressurization of the building despite the fact that the building will eventually operate as a fully pressurized building.

Remediation of Mold

Reliable sampling for mold can be expensive, and standards for judging what is and what is not an acceptable or tolerable quantity of mold have not been established. If visible mold is present, then it should be remediated by removing standing water and drying affected areas within 24 to 48 hours regardless of what species are present and whether samples are taken. In specific instances, such as cases where health concerns are an issue, litigation is involved, or the source(s) of contamination is unclear, sampling may be considered as part of a building evaluation, or to document that remediation efforts were successful at removing contamination.

Repair of the defects that led to moisture accumulation (or elevated humidity) should be conducted in conjunction with or prior to mold remediation. Specific methods of assessing and remediating mold contamination should be based on the extent of visible contamination and underlying damage. The simplest and most expedient remediation that is reasonable and properly and safely removes mold contamination should be used.

Nonporous (for example, metals, glass, and hard plastics) and semi-porous (for example, precast concrete) materials can be cleaned and reused. Cleaning should be done with a water extraction vacuum and using a damp wipe with water and a high-quality detergent solution, scrubbing as needed until all visible signs of mold are removed. The process is completed by rinsing the area with clean water, but in some circumstances, a disinfectant such as bleach may be used to complete the rinsing process. If a disinfectant is used, allow the area to dry overnight; otherwise, dry the area immediately. It is suggested that water not remain on the treated surface more than 24 to 48 hours to prevent the conditions necessary for mold to redevelop.

Porous materials, such as ceiling tiles and insulation, and wallboards with more than a small area of contamination (obvious swelling and seams not intact), should be removed and discarded. All materials to be reused should be dry and visibly free from mold. Routine inspections should be conducted to confirm the effectiveness of remediation work.

Precast concrete construction supports the scientific community's maxim to prevent or inhibit mold formation rather than attempt remediation of fungi in indoor environments. This, coupled with durability, fire safety, and all of the other outstanding attributes of concrete make it an excellent choice as not only an ideal mold-resistant material, but also one that mold simply won't consume.

— J. David Odom
Vice President, Senior Building Forensics Consultant
Liberty Building Forensics Group LLC
Orlando, Florida (d.odom@libertybuilding.com)

References:

1. Mold Litigation Task Force. 2003. Managing the Risk of Mold in the Construction of Buildings: Guidance for Building Owners, Construction Contractors, and Other Parties to the Construction Process. *Constructor,* May.
2. Odom, J. David, and George H. DuBose. 1996. *Preventing Indoor Air Quality Problems in Hot, Humid Climates: Problem Avoidance Guidelines.* CH2M HILL and the Disney Development Company.
3. Odom, J. David, and George H. DuBose. 1999. *Commissioning Buildings in Hot, Humid Climates.* Lilburn, GA: Fairmont Press.
4. Odom, J. David, George H. DuBose, Richard Scott, and Norman Nelson. 2005. *Mold and Moisture Prevention.* Washington, DC: National Council of Architectural Registration Boards.
5. Odom, J. David, Richard Scott, and George H. DuBose. 2007. The Hidden Risks of Green Buildings: Avoiding Moisture and Mold Problems. *Direct Connection,* V. 10, No. 2.
6. Ontario Association of Architects (OAA). 2003. *OAA Mould Control Practice Guide.* Toronto, Canada: OAA.
7. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). 2001. *ASHRAE Handbook—Fundamentals.* Atlanta, GA: ASHRAE.
8. ANSI/ASHRAE TC 4.3. 2004. *Ventilation for Acceptable Indoor Air Quality.* (Standard 62.1-2004). Atlanta, GA: ASHRAE.
9. ANSI/ASHRAE TC 7.6. 2004. *Energy Standard for Buildings Except Low-Rise Residential Buildings.* (Standard 90.1-2004). Atlanta, GA: ASHRAE.
10. Harriman, L.; G. Brundrett; and R. Kittler. 2001. *Humidity Control Design Guide for Commercial and Institutional Buildings.* Atlanta, GA: ASHRAE.
11. U.S. Green Building Council (USGBC). 2006. *New Construction & Major Renovation version 2.2 Reference Guide.* 2nd ed. Washington, DC: USGBC.

VIEW EVENT INFO ONLINE

WWW.PCI.ORG/CONVENTION

FOR MORE INFORMATION

2008 PCI 54th annual CONVENTION EXHIBITION

PCI NATIONAL BRIDGE CONFERENCE

october 4–7

ROSEN shingle creek

ORLANDO, FLORIDA

View Event Information Online at: www.pci.org/convention

- **LEARN** new knowledge at **40+ education programs** geared toward business owners, managers, engineers, specifiers, architects, and marketing and sales teams.
- **GROW** your professional experience with unparalleled professional development opportunities to earn HSW-LU & PDH credit.
- **CONNECT** at countless networking events and talk with **industry experts** and representatives about the latest developments, applications, and techniques throughout four exciting days!
- **DISCOVER** the newest innovations in an exhibit hall filled with the industry's major suppliers showcasing their products, materials, and services.

Thursday, October 2	Friday, October 3	Saturday, October 4	Sunday, October 5	Monday, October 6	Tuesday, October 7
Committee Meetings	Committee Meetings	Committee Meetings	Opening Session Breakfast & Awards Ceremony	Education Sessions	Education Sessions
Foundation Golf Tournament	Foundation Welcome Reception	Board of Directors Meeting	National Bridge Conference Welcome & PCI Bridge Design Awards Ceremony	Exhibits	Exhibits
		Membership Luncheon	Exhibits	Architectural Precasters Get-Together Session	Plant Tours
		Exhibit Grand Opening Reception	Education Sessions		PCI Design Awards Banquet (Event Closing)
			Professional Member Get-Together Reception		

EXPANDING OPPORTUNITIES IN A CHANGING WORLD

Cosponsored by:
U.S. Department of Transportation Federal Highway Administration

U.S. Department of Transportation
Federal Highway Administration

PCI
Precast/Prestressed Concrete Institute

PCI-Certified Plants

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

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

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

Guide Specification

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

"*Manufacturer Qualification:* The precast concrete manufacturing plant shall be certified by the Precast/Prestressed Concrete Institute Plant Certification Program. Manufacturer shall be certified at time of bidding. Certification shall be in the following product group(s) and category(ies): [Select appropriate groups and categories (AT or A1), (B1,2,3, or 4), (C1,2,3, or 4), (G)]."

Product Groups and Categories

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

MNL–116 ***Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products***

MNL–117 ***Manual for Quality Control for Plants and Production of Architectural Precast Concrete***

MNL–130 ***Manual for Quality Control for Plants and Production of Glass-Fiber-Reinforced Concrete Products***

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

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

GROUPS

GROUP A – Architectural Products

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

Category A1 – Architectural Cladding and Load-Bearing Units
Precast or precast, prestressed concrete building elements such as exterior cladding, load-bearing and non-load-bearing wall panels, spandrels, beams, mullions, columns, column covers, and miscellaneous shapes. This category includes Category AT.

GROUP B – Bridges

Category B1 – Precast Concrete Bridge Products
Mild-steel-reinforced precast concrete elements that include some types of bridge beams or slabs, sheet piling, pile caps, retaining-wall elements, parapet walls, sound barriers, and box culverts.

Category B2 – Prestressed Miscellaneous Bridge Products
Any precast, prestressed element excluding superstructure 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-Ts, stemmed members, solid slabs, full-depth bridge deck slabs, and products in Categories B1 and B2.

Category B4 – Prestressed Deflected-Strand Bridge Members
Includes all products covered in Categories B1, B2, and B3.

GROUP BA – Bridge Products with an Architectural Finish

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

GROUP C – Commercial (Structural)

Category C1 – Precast Concrete Products
Mild-steel-reinforced precast concrete elements including sheet piling, pile caps, piling, retaining-wall elements, floor and roof slabs, joists, stairs, seating members, columns, beams, walls, spandrels, etc.

Category C2 – Prestressed Hollow-core and Repetitive Products
Standard shapes made in a repetitive process prestressed with straight strands. Included are hollow-core slabs, railroad ties, flat slabs, poles, wall panels, and products in Category C1.

Category C3 – Prestressed Straight-Strand Structural Members
Includes stemmed members, beams, columns, joists, seating members, and products in Categories C1 and C2.

Category C4 – Prestressed Deflected-Strand Structural Members
Includes stemmed members, beams, joists, and products in Categories C1, C2, and C3.

GROUP CA – Commercial Products with an Architectural Finish

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

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

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

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

(as of March 2008)

ALABAMA

Gate Precast Company, Monroeville (251) 575-2803	A1, C1A
Hanson Pipe and Precast Southeast, Birmingham (205) 663-4681	B4, C4
Standard Concrete Products, Theodore (251) 443-1113	B4, C2

ARIZONA

Coreslab Structures (ARIZ) Inc., Phoenix (602) 237-3875	A1, C4A
TPAC, Phoenix (602) 262-1360	A1, B4, C4A

ARKANSAS

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

CALIFORNIA

Bethlehem Construction Inc., Shafter (661) 391-9704	C2
Clark Pacific, Fontana (909) 823-1433	A1, C3, G
Clark Pacific, West Sacramento (916) 371-0305	A1, C3
Con-Fab California Corporation, Lathrop (209) 249-4700	B4, C4
Coreslab Structures (L.A.) Inc., Perris (951) 943-9119	A1, B4, C4A
Fintech Precast Inc., Redding (530) 241-8397	C2
Hanson Structural Precast, Irwindale (626) 962-8751	C4
Hanson Structural Precast, San Diego (619) 423-9030	C4
Mid-State Precast L.P., Corcoran (559) 992-8180	A1, C3A
Pomeroy Corporation, Perris (951) 657-6093	B4, C2
Walters & Wolf Precast, Fremont (510) 226-5162	A1, G
Willis Construction Co. Inc., San Juan Bautista (831) 623-2900	A1, C1, G
Willis De Mexico S.A. de C.V., Tecate (011) 52-665-655-2222	A1, C1

COLORADO

EnCon Colorado, Denver (303) 287-4312	B4, C1
Plum Creek Structures, Littleton (303) 471-1569	B4, C3
Rocky Mountain Prestress Inc./Architectural, Denver (303) 480-1111	A1, C3A
Rocky Mountain Prestress Inc./Structural, Denver (303) 480-1111	B4, C4
Rocla Concrete Tie Inc., Denver (303) 296-3505	C2
Stresscon Corporation, Colorado Springs (719) 390-5041	A1, B4, C4A
Stresscon Corporation, Dacono (303) 659-6661	C4

CONNECTICUT

Blakeslee Prestress Inc., Branford (203) 481-5306	A1, B4, C4A
Coreslab Structures (CONN) Inc., Thomaston (860) 283-8281	A1
Oldcastle Precast Inc./dba Rotondo Precast, Avon (860) 673-3291	B1, C1A

DELAWARE

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

FLORIDA

CDS Manufacturing Inc., Quincy (850) 875-4651	B2, C2
Cement Industries Inc., Fort Myers (239) 332-1440	B3, C3
Coreslab Structures (MIAMI) Inc., Medley (305) 823-8950	A1, C4A
Coreslab Structures (ORLANDO) Inc., Orlando (407) 855-3191	C2
Coreslab Structures (TAMPA) Inc., Tampa (813) 626-1141	B3, C3A
Dura-Stress Inc., Leesburg (800) 342-9239	A1, B4A, C3A
Finfrock Industries Inc., Orlando (407) 293-4000	C4
Florida Precast Industries Inc., Sebring (863) 655-1515	C2
Florida Rock and Sand Prestress Precast Co. Inc., Florida City (305) 247-9611	B2, C3
Gate Concrete Products Company, Jacksonville (904) 757-0860	B4, C4
Gate Precast Company, Kissimmee (407) 847-5285	A1
Gate Precast Company, Sarasota (941) 957-0270	A1
South Eastern Prestressed Concrete Inc., West Palm Beach (561) 793-1177	B3, C3
Southern Prestressed Concrete Inc., Pensacola (850) 476-6120	C4
Standard Concrete Products Inc., Tampa (813) 831-9520	B4, C3

GEORGIA

Atlanta Structural Concrete Co., Buchanan (770) 646-1888	C4A
Atlantic Metrocast Inc., La Plata (301) 870-3289	B3, C1
Atlantic Metrocast Inc., Portsmouth (757) 397-2317	B4, C3
ConArt Inc., Cobb (229) 853-5000	A1, AT, C3
Coreslab Structures (ATLANTA) Inc., Jonesboro (770) 471-1150	C3A
Metromont Corporation, Hiram (770) 943-8688	A1, C4A
Standard Concrete Products Inc., Atlanta (404) 792-1600	B4
Standard Concrete Products Inc., Savannah (912) 233-8263	B4, C4
Tindall Corporation Corrections Division, Conley (800) 849-6383	C2
Tindall Corporation Prestress Division, Conley (800) 849-6383	C4A

HAWAII

GPRM Prestress, Kapolei (808) 682-6000	A1, B3, C4

IDAHO

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

ILLINOIS

ATMI Dynacore, Lockport (815) 838-9492	C2
ATMI Precast, Aurora (630) 896-4679	C3A
County Materials Corporation, Champaign (217) 352-4181	B3
Dukane Precast Inc., Naperville (630) 355-8118	A1, C3
Egyptian Concrete Company, Salem (618) 548-1190	A1, B4, C4
High Concrete Group LLC, Paxton (217) 379-9790	A1, C3A
J. W. Peters Inc., Rochelle (815) 562-4136	A1, B4, C4A
Lombard Architectural Precast Products Co., Alsip (708) 389-1060	A1
Prestress Engineering Corporation, Blackstone (815) 586-4239	B4, C4
Spancrete of Illinois Inc., Crystal Lake (815) 459-5580	C2
St. Louis Prestress Inc., Glen Carbon (618) 656-8934	B3, C3

INDIANA

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

IOWA

Andrews Prestressed Concrete Inc., Clear Lake (641) 357-5217	B4, C4
IPC Inc., Des Moines (800) 826-0464	C4
IPC Inc., Iowa Falls (641) 648-2579	B4, C4A
IPC Inc., West Burlington (319) 754-0477	A1, B4, C3A
MPC Enterprises Inc., Mount Pleasant (319) 986-2226	C3A

KANSAS

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

KENTUCKY

de AM - RON Building Systems LLC, Owensboro (270) 684-6226	A1, C4
Gate Precast Company, Winchester (859) 744-9481	A1
Prestress Services Industries LLC, Decatur (260) 724-7117	B4, C4
Prestress Services Industries LLC, Grove City (614) 871-2900	B4
Prestress Services Industries LLC, Henderson (270) 826-6244	B4, C3
Prestress Services Industries LLC, Lexington (859) 299-0461	A1, B4, C4
Prestress Services Industries LLC, Melbourne (859) 441-0068	B4, C3

LOUISIANA

Boykin Brothers Inc./Louisiana Concrete Products, Baton Rouge (225) 753-8722	A1, B4, C3A
Fibrebond Corporation, Minden (318) 377-1030	A1, C1
F-S Prestress LLC, Princeton (318) 949-2444	B4, C3
Rotondo Weirich, Pollock (215) 256-7940	C1

MARYLAND

Larry E. Knight Inc., Glyndon (410) 833-7800	C2
Oldcastle Precast Building Systems, Edgewood (410) 612-1213	C3A

MASSACHUSETTS

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

MICHIGAN

Dura-Crete Products, Warren (586) 759-4286	B2
Gerace Construction Company Inc., Midland (989) 496-2440	A1, B3, C3
Grand River Infrastructure Inc., Grand Rapids (616) 534-9645	B4, C1

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

Kerkstra Precast Inc., Jenison (800) 434-5830 — **C3A**
National Precast Structural Inc., Shelby Township (586) 247-1201 — **C3**
National Precast Inc., Roseville (586) 294-6430 — **A1, C3**
Nucon Schokbeton / Stress-Con Industries Inc., Kalamazoo (269) 381-1550 — **A1, B4, C3A**
Stress-Con Industries Inc., Detroit (313) 873-4711 — **B2, C3**
Stress-Con Industries Inc., Saginaw (989) 239-2447 — **B4, C3**

MINNESOTA

Cretex Concrete Products North Inc., Maple Grove (763) 545-7473 — **B4, C2**
Hanson Structural Precast Midwest Inc., Maple Grove (763) 425-5555 — **A1, C4A**
Molin Concrete Products Co., Lino Lakes (651) 786-7722 — **C3A**
Wells Concrete Products Co., Wells (507) 553-3138 — **A1, C4A**

MISSISSIPPI

F-S Prestress LLC, Hattiesburg (601) 268-2006 — **B4, C4**
Gulf Coast Pre-Stress Inc., Pass Christian (228) 452-9486 — **B4, C4**
J.J. Ferguson Prestress-Precast Company Inc., Greenwood (662) 453-5451 — **B4**
Jackson Precast Inc., Jackson (601) 321-8787 — **A1, C2A**
Prestress Services Industries of MS LLC, Ridgeland (601) 856-4135 — **B4, C1**
Rotondo Weirich Enterprises Inc., Natchez (215) 256-7940 — **C1**
Tindall Corporation, Biloxi (228) 435-0160 — **C4A**

MISSOURI

Coreslab Structures (MISSOURI) Inc., Marshall (660) 886-3306 — **A1, B4, C4A**
Egyptian Concrete Company, Bonne Terre (573) 358-2773 — **B4**
Mid America Precast Inc., Fulton (573) 642-6400 — **A1, B1, C1**
Mid West Prestress LLC, Wright City (636) 745-7480 — **C3**
Prestressed Casting Company, Ozark (417) 581-7009 — **C4**
Prestressed Casting Company, Springfield (417) 869-1263 — **A1, C3A**

MONTANA

Missoula Concrete Construction, Missoula (406) 549-9682 — **A1, B3, C3**
Montana Prestressed Concrete, Billings (406) 656-4310 — **B4, C3**

NEBRASKA

Concrete Industries Inc., Lincoln (402) 434-1800 — **B4, C4A**
Coreslab Structures (OMAHA) Inc., LaPlatte (402) 291-0733 — **A1, B4, C4A**
CXT Inc., Grand Island (308) 382-5400 — **C2**
Enterprise Concrete Products LLC, Omaha (214) 631-7006 — **B3, C3**
Enterprise Precast Concrete Inc., Omaha (402) 895-3848 — **A1**
GFRC Inc., Lincoln (402) 466-3200 — **G**
Stonco Inc., Omaha (402) 556-5544 — **A1**

NEW HAMPSHIRE

Architectural Cladding Systems Inc., Hollis (603) 889-6310 — **G**
Newstress Inc., Epsom (603) 736-9348 — **B3, C3**

NEW JERSEY

High Concrete Group LLC, Buena (856) 697-3600 — **C3**
Jersey Precast Corp., Hamilton Township (609) 689-3700 — **B4, C3**
Precast Systems Inc., Allentown (609) 208-1987 — **B4, C4**
Universal Concrete Products of NJ Inc., Folsom (609) 704-9400 — **A1, C1**

NEW MEXICO

Castillo Prestress, Belen (505) 864-0238 — **C1**
Coreslab Structures (ALBUQUERQUE) Inc., Albuquerque (505) 247-3725 — **A1, B4, C4**
Ferreri Concrete Structures Inc., Albuquerque (505) 344-8823 — **A1, C4**

NEW YORK

David Kucera Inc., Gardiner (845) 255-1044 — **A1, G**
Lakelands Concrete Products Inc., Lima (585) 624-1990 — **A1, B3A, C3A**
Oldcastle Precast Building Systems, Manchester (585) 289-3530 — **C3**
Oldcastle Precast Building Systems, South Bethlehem (518) 767-2116 — **B3, C3**
Rotondo Weirich Enterprises Inc., Yaphank (404) 414-4649 — **C1**
The Fort Miller Co. Inc., Schuylerville (518) 695-5000 — **B1, C1**
The L. C. Whitford Materials Co. Inc., Wellsville (585) 593-2741 — **B3, C3**

NORTH CAROLINA

Gate Precast Company, Oxford (919) 603-1633 — **A1, C2**
Metromont Corporation, Charlotte (704) 372-1080 — **A1, C3**
Oldcastle Precast, Inc / dba NC Products, Raleigh (919) 772-6301 — **C1**
Prestress of the Carolinas LLC, Charlotte (704) 587-4273 — **B4, C4**
S & G Prestress Company, Leland (910) 397-6255 — **B4**
S & G Prestress Company, Wilmington (910) 763-7702 — **B4, C3**
Utility Precast Inc., Charlotte (704) 596-6283 — **B3A**

NORTH DAKOTA

Concrete Inc., Grand Forks (701) 772-6687 — **C4A**

OHIO

DBS Prestress of Ohio, Huber Heights (937) 878-8232 — **C2**
High Concrete Group LLC, Springboro (937) 748-2412 — **A1, C3**
Hollowcore Midwest LLC, Fairfield (513) 829-1555 — **B1, C2**
KSA, Sciotoville (740) 776-3238 — **C2**
Mack Hollowcore Systems, Valley City (330) 483-3111 — **C2**
Sidley Precast, Youngwood (440) 298-3232 — **A1, C4A**
Sidley Precast, Thompson (724) 755-0205 — **C3**
United Precast Inc. Box-Beam Production Area, Mt.Vernon (740) 393-1121 — **B3, C1**
United Precast Inc. I-Beam Production Area, Mt.Vernon (800) 366-8740 — **B4, C3**

OKLAHOMA

Coreslab Structures (OKLA) Inc. (Plant No. 1), Oklahoma City (405) 632-4944 — **A1, C4A**
Coreslab Structures (OKLA) Inc. (Plant No. 2), Oklahoma City (405) 672-2325 — **B4, C1**
Coreslab Structures (TULSA) Inc., Oklahoma City (918) 438-0230 — **B4, C4**
Rotondo Weirich Enterprises Inc., Sayre (215) 239-7589 — **C1**
Tulsa Dynaspan Inc., Broken Arrow (918) 258-1549 — **C3**

OREGON

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

PENNSYLVANIA

Architectural Precast LLC, Middleburg (570) 837-1774 — **A1, C2A**
Castcon Stone Inc., Saxonburg (724) 352-2200 — **C1**
Concrete Safety Systems LLC, Bethel (717) 933-4107 — **B1, C1**
Conewago Precast Building Systems, Hanover (717) 632-7722 — **C2A**
Hanson Pipe & Precast, Pottstown (610) 970-2216 — **B1A, C1A**
High Concrete Group LLC, Denver (717) 336-9300 — **A1, C3**
High Concrete Group LLC, Williamsport (570) 329-4228 — **C3**
J & R Slaw Inc., Bowmanstown (610) 852-2020 — **A1, B3, C3**
Newcrete Products, Roaring Spring (814) 224-2121 — **B4, C4**
Nitterhouse Concrete Products Inc., Chambersburg (717) 267-4505 — **A1, C4A**
Oldcastle Precast Building Systems, Morrisville (215) 736-9576 — **C3**
Pittsburgh Flexicore Company Inc., Monongahela (724) 258-4450 — **C2**
Say-Core Inc., Portage (814) 736-8018 — **C2**
Schuylkill Products Inc., Cressona (570) 385-2352 — **B4, C3**
Top Roc Newcrete Products Company, Erie (814) 838-2011 — **B4**
Universal Concrete Products Corporation, Stowe (610) 323-0700 — **A1, C3A**

SOUTH CAROLINA

Coreslab Structures (COLUMBIA) Inc., Columbia (803) 783-5460 — **A1**
Florence Concrete Products Inc., Sumter (803) 775-4372 — **B4, C3A**
Metromont Corporation, Greenville (864) 295-0295 — **A1, C4A**
Tekna Corporation, Charleston (843) 853-9118 — **B4, C2**
Tindall Corporation, Spartanburg (864) 576-3230 — **A1, C4A**

SOUTH DAKOTA

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

TENNESSEE

Construction Products Inc. of Tennessee, Jackson (731) 668-7305 — **B4, C4**
Gate Precast Company, Ashland City (615) 792-4871 — **A1**
Metromont Corporation, LaVergne (615) 793-3393 — **C4A**
Mid South Prestress LLC, Pleasant View (615) 746-6606 — **C3**
Prestress Services Industries of TN LLC, Memphis (901) 775-9880 — **B4, C3**
Ross Prestressed Concrete Inc., Bristol (423) 323-1777 — **B4, C3**
Ross Prestressed Concrete Inc., Knoxville (865) 524-1485 — **B4, C4**
Sequatchie Concrete Service Inc., Knoxville (423) 867-4510 — **C2**
Southeast Precast Corporation, Knoxville (865) 524-3615 — **A1**

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

TEXAS

Coreslab Structures (TEXAS) Inc., Cedar Park (512) 250-0755 **A1, C4A**
CXT Inc., Hillsboro (254) 580-9100 **B1, C1**
Gate Concrete Products Company, Pearland (281) 485-3273 **C2**
GFRC Cladding Systems Inc., Garland (972) 494-9000 **G**
Heldenfels Enterprises Inc., Corpus Christi (361) 883-9334 **B4, C4**
Heldenfels Enterprises Inc., San Marcos (512) 396-2376 **B4, C4**
Lowe Precast Inc., Waco (254) 776-9690 **A1, C3A**
Manco Structures Ltd., Schertz (210) 690-1705 **B4, C4A**
North American Precast Company, San Antonio (210) 509-9100 **A1, C4A**
Rocla Concrete Tie Inc., Amarillo (806) 383-7071 **C2**
Rotondo Weirich Enterprises Inc., Lubbock (215) 256-7940 **C1**

UTAH

EnCon Utah LLC, Tooele (435) 843-4230 **A1, B4, C3A**
Hanson Structural Precast Eagle, Salt Lake City (801) 966-1060 **A1, B4, C4A, G**
Owell Precast LLC, Sandy (801) 571-5041 **C3**

VERMONT

J. P. Carrara & Sons Inc., Middlebury (802) 388-6363 **A1, B4A, C3A**
William E. Dailey Precast LLC, Shaftsbury (802) 442-4418 **A1, B2A, C3A**

VIRGINIA

Bayshore Concrete Products Corporation, Cape Charles (757) 331-2300 **B4, C4**
Bayshore Concrete Products/Chesapeake Inc., Cape Charles (757) 549-1630 **B4, C2**
Coastal Precast Systems LLC, Chesapeake (757) 545-5215 **B4, C3**
Metromont Corporation, Richmond (804) 222-8111 **C4A**
Rockingham Precast Inc., Harrisonburg (540) 433-8282 **B4, C3**
Rotondo Weirich Enterprises Inc., Salem (215) 631-4264 **C1**
The Shockey Precast Group, Winchester (540) 667-7700 **A1, C4A**
The Shockey Precast Group, Fredericksburg (540) 898-1221 **A1, C3A**
Smith-Midland Corporation, Midland (540) 439-3266 **A1, B1, C3**
Tindall Corporation, Petersburg (804) 861-8447 **C4A**

WASHINGTON

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

WEST VIRGINIA

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

WISCONSIN

Architectural Precast Inc., Browntown (608) 966-4370 **C3A**
County Materials Corporation, Eau Claire (800) 729-7701 **B4**
County Materials Corporation, Roberts (800) 426-1126 **B4, C3**
International Concrete Products Inc., Germantown (262) 242-7840 **A1, C1**
J. W. Peters Inc., Burlington (800) 877-9040 **C3A**
MidCon Products Inc., Hortonville (920) 779-4032 **A1, C1**
Mid-States Concrete Industries Co., Beloit (608) 364-1072 **C3**
Precast Concrete Specialties Inc., Omro (920) 685-2727 **A1**
Spancrete Industries Inc., Waukesha (414) 290-9000 **A1, B2A, C3A**
Spancrete Inc., Valders (920) 775-4121 **A1, C3A**
Spancrete Inc., Green Bay (920) 494-0274 **B4, C4**

CANADA

ALBERTA

Con-Force Structures Limited, Calgary (403) 248-3171 **A1, B4, C4**
Lafarge Canada Inc., Edmonton (780) 468-5910 **A1, C1**
P. Kruger Concrete Products Ltd., Edmonton (780) 438-2072 **A1, C1**

BRITISH COLUMBIA

Con-Force Structures Limited, Richmond (604) 278-9766 **A1, B4, C3**

MANITOBA

Con-Force Structures Limited, Winnipeg (204) 338-9311 **B4, C3A**
Lafarge Canada Inc., Winnipeg (204) 958-6381 **C2**

NEW BRUNSWICK

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

NOVA SCOTIA

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

ONTARIO

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

QUEBEC

Betons Prefabriques du Lac Inc. Papeterie Plant, Alma(418) 668-6161 **A1, C1**
Betons Prefabriques du Lac Inc. Bombardier Plant, Alma (418) 668-6161 **A1, C3, G**
Betons Prefabriques Trans. Canada Inc., St. Eugene (819) 396-2624 **A1, B4, C3A**
Prefab De Beauce, Sainte-Marie (418) 387-7152 **A1, C3**
Saramac Inc., Lachenaie (450) 966-1000 **A1**
Schokbeton Quebec Inc., St. Eustache (450) 473-6831 **A1, B4A, C3**

MEXICO

PRETECSA, S.A. DE C.V., Atizapan De Zaragoza **A1, G**

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

PCI-Qualified & Certified Erectors

(as of February 2008)

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

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

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

Guide Specification

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

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

Erector Classifications

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

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

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

GROUPS

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

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

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

Certified erectors are listed in red.

ARIZONA

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

ARKANSAS

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

CALIFORNIA

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

COLORADO

Colorado Fabricators & Constructors Inc., Highlands Ranch (303) 471-9902	S2
Gibbons Erectors Inc., Parker (303) 841-0457	S2
Hardrock Structures Inc., Penrose (719) 372-6269	S2
Mehring Welding & Erection, Penrose (719) 372-6607	S2
Rocky Mountain Prestress, Denver (303) 480-1111	S2
S. F. Erectors Inc., Elizabeth (303) 646-6411	S2

CONNECTICUT

Blakeslee Prestress Inc., Branford (203) 481-5306	S2
Echelon Erectors LLC, New Haven (203) 389-4300	S2, A
Marikina Construction Corp., West Haven (203) 799-1013	S1

FLORIDA

All Florida Erectors and Welding Inc., Apopka (407) 880-3717	S2, A
Concrete Erectors Inc., Altamonte Springs (407) 862-7100	S2
Coreslab Structures (ORLANDO) Inc., Orlando (407) 855-3191	S1
Finfrock Industries Inc., Orlando (407) 293-4000	S2
Gate Precast Erection Co., Jacksonville (904) 757-0860	S2, A
James Toffoli Construction Company Inc., Fort Myers (239) 479-5100	S2
Pre-Con Construction of Tampa Inc., Tampa (813) 626-2545	S2, A
Randy J. Mellor Construction Inc., Nokomis (941) 321-1826	S1
River City Concrete Systems Ltd., Jacksonville (904) 786-3181	S1
Solar Erectors U. S. Inc., Medley (305) 825-2514	S2, A
Southeast Tilt-Wall Erectors Inc., Deltona (407) 402-9664	S1
Specialty Concrete Services Inc., Altoona (352) 669-8888	S2, A
Summit Erectors Inc., Jacksonville (904) 783-6002	S2, A

GEORGIA

ConArt Inc., Cobb (229) 853-5000	S2, A
Precision Stone Setting Co. Inc., Hiram (770) 439-1068	S2, A
Rutledge & Sons, Woodstock (770) 592-0380	S2

ILLINOIS

Creative Erectors LLC, Rockford (815) 229-8303	S1
Mid-States Concrete Products Company, South Beloit (800) 236-1072	S2
Spancrete of Illinois Inc., Crystal Lake (815) 459-5580	S2

INDIANA

Sofco Erectors Inc., Indianapolis (317) 352-9680	S2, A
Stres Core Inc., South Bend (574) 233-1117	S1

IOWA

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

KANSAS

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

MAINE

Reed & Reed Inc., Woolwich (207) 443-9747	S2, A

MARYLAND

E & B Erectors Inc., Pasadena (410) 360-7800	S2, A
E. E. Marr Erectors Inc., Baltimore (410) 837-1641	S2, A
EDI Inc., Upper Marlboro (301) 568-4585	S1, A

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

L. R. Willson & Sons Inc., Gambrills (410) 987-5414 S2, A
Mid Atlantic Precast Erectors Inc., Baltimore (410) 837-1641 A
Oldcastle Building Systems Div. / Project Services, Baltimore (518) 767-2116 S2, A

MASSACHUSETTS

Concrete Structures Inc., Marshfield (781) 837-1931 S1, A
Prime Steel Erecting Inc., North Billerica (978) 671-0111 S2

MICHIGAN

Alpha Omega Development, Saginaw (989) 399-9436 S2
American Erectors Inc., Waterford (248) 674-0060 S2, A
Assemblers Precast & Steel Services Inc., Saline (734) 429-1358 S2, A
Devon Contracting Inc., Detroit (313) 965-3455 S2
G2 Inc., Cedar Springs (616) 696-9581 S2, A
Kerkstra Precast Inc., Grandville (616) 224-6176 S2
Moyle Construction, Houghton (906) 482-3000 S1
Pioneer Construction Inc., Grand Rapids (616) 247-6966 S2

MINNESOTA

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

MISSOURI

Acme Erectors Inc., St Louis (314) 647-1923 S2
J. E. Dunn Construction Company, Kansas City (816) 474-8600 S2, A
Prestressed Casting Co., Springfield (417) 869-7350 S2, A
Starns Steel LLC, Garden City (816) 773-8897 A

NEBRASKA

Concrete Industries Inc., Lincoln (402) 434-1800 S2
Remcon General Contractors Inc., Omaha (402) 333-1652 A

NEW HAMPSHIRE

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

NEW JERSEY

Car-Win Construction, Eastampton (800) 352-1523 S2, A
J. L. Erectors Inc., Blackwood (856) 232-9400 S2, A
JEM-Erectors Inc., Shamong (609) 268-0332 S2, A
Jonasz Precast Inc., Westville (856) 456-7788 S2, A

NEW MEXICO

Ferreri Concrete Structures Inc., Albuquerque (505) 344-8823 S2

NEW YORK

All Systems Precast Inc., Farmingdale (631) 694-4720 S2
Arben Group LLC, Pleasantville (914) 741-5459 S1
Oldcastle Building Systems Div. / Project Services, Manchester (585) 289-3530 S2, A
Oldcastle Building Systems Div. / Project Services, South Bethlehem (518) 767-2116 S2, A

NORTH CAROLINA

Buckner Steel Erection Inc., Graham (336) 376-8888 S2
Carolina Precast Erectors Inc., Taylorsville (828) 635-1721 S2
Rabon Erectors Inc., Archdale (336) 434-3308 S2, A
T & M Concrete Inc., Waxhaw (704) 843-3292 S2
Tri State Erectors Inc., Oxford (919) 603-0922 S1, A

NORTH DAKOTA

Concrete Inc., Grand Forks (701) 772-6687 S2

OHIO

Capital City Group Inc., Columbus (614) 278-2120 S2, A
Precast Services Inc., Twinsburg (330) 425-2880 S2, A
Sidley Precast Group, Thompson (440) 298-3232 S2
Sofco Erectors Inc., Cincinnati (513) 771-1600 S2, A

OKLAHOMA

Coreslab Structures (OKLA) Inc., Oklahoma City (405) 632-4944 S2, A

PENNSYLVANIA

Century Steel Erectors, Kittanning (724) 545-3444 S2, A
Conewago Enterprises Inc., Hanover (717) 632-7722 S2
High Concrete Group, Denver (717) 336-9300 S2, A
Maccabee Industrial Inc., Belle Vernon (724) 930-7557 A
Nitterhouse Concrete Products Inc., Chambersburg (717) 267-4505 S2
Patterson Construction Company Inc., Monongahela (724) 258-4450 S1
Say-Core Inc., Portage (814) 736-8018 S1
Structural Services Inc., Bethlehem (610) 282-5810 S1

SOUTH CAROLINA

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

TENNESSEE

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

TEXAS

Gate Concrete Products Company, Pearland (281) 485-3273 S1
Precast Erectors Inc., Hurst (817) 684-9080 S2, A

UTAH

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

VERMONT

CCS Constructors LLC, Morrisville (802) 888-7701 S1

VIRGINIA

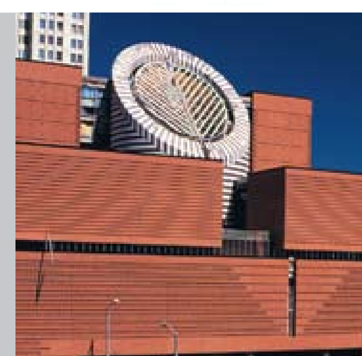
The Shockey Precast Group, Winchester (540) 665-3253 S2, A
W. O. Grubb Steel Erection Inc., Richmond (804) 271-9471 A

WISCONSIN

The Boldt Company, Appleton (920) 225-6127 S2, A
County Materials Corporation, Roberts (715) 749-3927 S2
Modern Crane Service Inc., Onalaska (608) 781-2252 S1
Spancrete Industries Inc., Waukesha (414) 290-9000 S2, A
Spancrete Inc., Valders (920) 775-4121 S2, A

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


2008 PCI
DESIGN AWARDS
The Search for Excellence
PCI



Architects Receive a 25% Discount!

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

This fully revised edition of *Architectural Precast Concrete* includes new sections on sustainability, condensation control, and blast resistance. You'll get extensive updates in the areas of color, texture, finishes, weathering, tolerances, connections, and windows, along with detailed specifications to meet today's construction needs. With more than 500 beautiful, full-color photographs and a bonus DVD, no architecture or design-build firm should be without a copy.

Architectural Precast Concrete, 3rd edition
MNL-122-07. ISBN: 978-0-937040-78-3
$180 / Architects $135 / PCI Members $90

To order, go to www.pci.org/publications and select "bookstore"

PCI™ Precast/Prestressed Concrete Institute
209 West Jackson Boulevard | Suite 500 | Chicago, IL 60606
Phone: 312-786-0300 | Fax: 312-786-0353 | www.pci.org