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SUMMER 2012

GREEN ISSUE

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Five Ways Precast Helps Save the Earth

The Whole Package! Precast Insulated Wall Panels

Stand Up to Natural Disasters with Precast Concrete

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Photo courtesy of Boral Roofing (www.boralna.ca)

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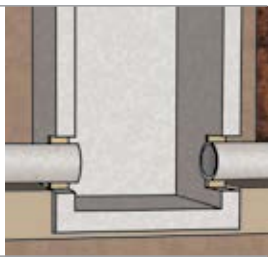

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LEED v4:
Upcoming Changes Affect Precast Concrete Credits

2013 changes to LEED credit ratings and requirements will include recycled content, regional materials zone definitions and environmental product declarations (EPDs).

By Claude Goguen, P.E., LEED AP

If you are a designer, specifier or regulator, chances are you have been involved in at least one LEED project. LEED stands for Leadership in Energy and Environmental Design and was developed by the U.S. Green Building Council (USGBC) in 2000. It provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. Since its inception, the LEED green building program has been used to promote sustainable building, design, construction and operations practices. The current version is known as LEED 2009.

Changes in the new LEED v4

LEED v4 is the next version of the LEED program and will include the step in the continuous improvement process and the ongoing development cycle of the LEED program, including the Building Design + Construction, Interior Design + Construction, Operations + Maintenance, Neighborhood Development, and LEED for Home Rating Systems. LEED v4 will be more globally aligned with international standards to make it more applicable for LEED projects outside of the United States.

LEED v4 offers increased technical rigor, expands the market sectors able to use LEED and strives for simplicity in terms of usability. The differences between LEED 2009 and LEED v4 are seen in three main areas:

1. *New market sectors.* New definitions affect data centers, warehouses and distribution centers, hospitality, existing schools, existing retail, and LEED for Homes Mid-Rise.
2. *Changes to technical content.* Stakeholder input will increase the technical rigor of the rating system. The proposed technical changes have been informed by market data, stakeholder generated ideas, expert engagement, and advances in technology and market acceptability of LEED and green building practices.
3. *Revised credit weightings.* Revised point distribution will more closely tie the rating system requirements to the priorities articulated by the USGBC community.

There are new prerequisites and credits across the LEED credit categories and rating systems. Point values have also changed. Each rating system has gone through

a weighting process and has LEED points associated with each credit and option of the rating system.

How does LEED v4 affect the use of precast concrete?

Some of the changes affecting the use of precast concrete include:

- *Site Development – Protect or Restore Habitat.* (Formerly SS 5.1) Precast will still contribute in this category, because it's made to order, reduces storage space on site and minimizes site disturbance.
- *Rainwater Management.* (Combined former 6.1, "Stormwater Design – Quality Control," and 6.2, "Stormwater Design – Quantity Control") Precast will still contribute through the use of stormwater products.
- *Heat Island Reduction – Combined Heat Island Effect – Non-roof with Heat Island Effect – Roof.* (Renamed "Heat Island Reduction") Architectural precast concrete with an SRI[1] of at least 29 will qualify.
- *Environmentally Preferable Products and Materials, Prescriptive Attributes.* (New credit for 2013) The former regional requirement will be replaced with the new "Support Local Economy" attribute. Recycled content (50% of total material cost), which currently applies to structure and enclosure, will apply only to non-structural elements.
- *Regional Materials.* "Regional" definition will no longer be 500 miles. It is currently based on "Regional Core Based Statistical Area" updated Dec. 1, 2009, by the U.S. Office of Management and Budget.
- *Thermal Comfort.* (Renamed from "Controllability of Systems – Thermal Comfort," combined with "Thermal Comfort – Design Requirements for Achievement") Design of heating, ventilation and air conditioning (HVAC) systems and the building envelope will need to meet the requirements of ASHRAE[2] Standard 55-2010, "Thermal Comfort Conditions for Human Occupancy."
- *Precast Concrete Shell.* Precast enclosure will contribute to LEED design due to thermal mass properties.

Current status of LEED v4

The LEED v4 fourth public comment period was open from May 11 to May 28. A number of key changes have been made to address the technical and market issues voiced throughout the course of previous comment periods.

Projects currently registered with LEED should follow the version under which they are currently registered. Project teams will not be able to register for LEED v4 until it has undergone a ballot vote by USGBC membership and is officially launched.

Due to overwhelming feedback from stakeholders, the USGBC recently announced that it will delay balloting on LEED v4 until June 1, 2013. As a result, changes may be made that will impact our industry. NPCA will continue to stay on top of any developments and will publish updates as they occur. ps

For questions about this article, please contact Claude Goguen, director of Technical Services, at (317) 571-9500 or cgoguen@precast.org.

[1] Solar Reflectance Index

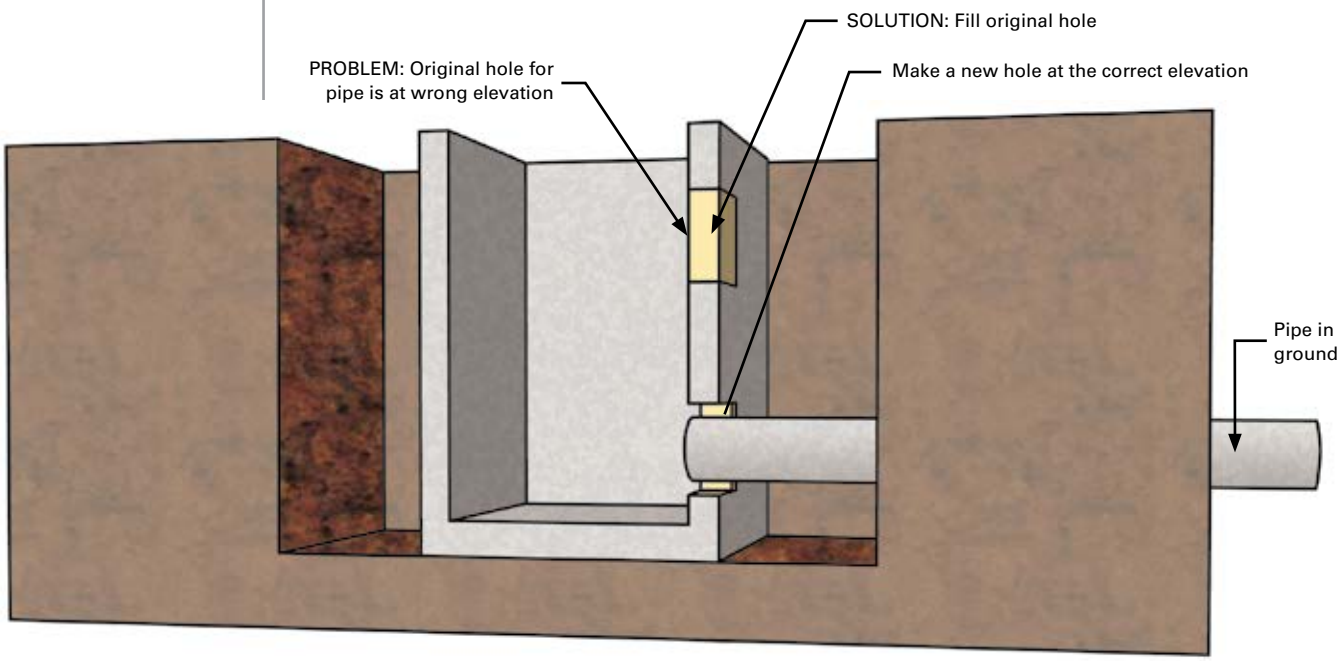
[2] American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc.

Precaster's Notebook:

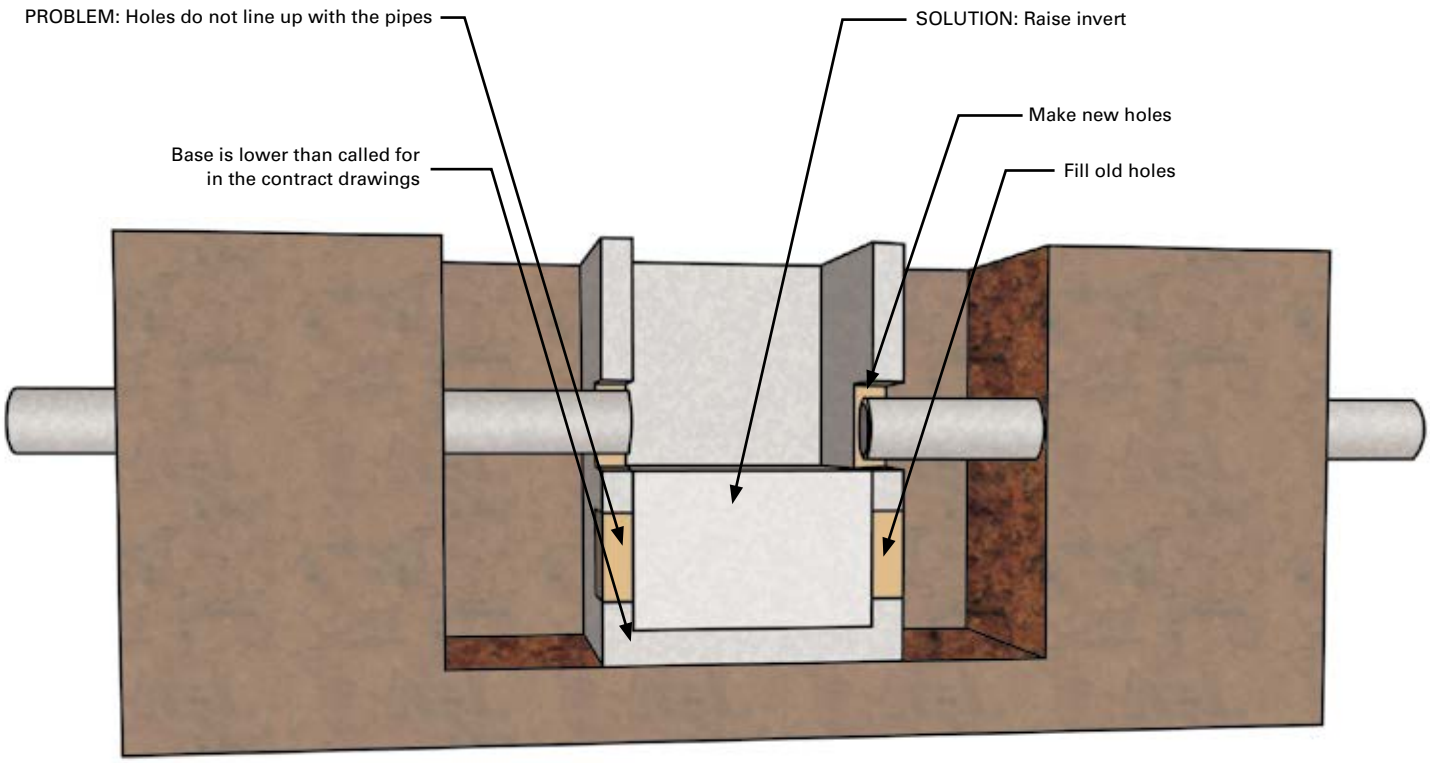
Fixing Manhole Installation Problems

By Gary K. Munkelt, P.E.

What problems become obvious during installations, and what can be done to correct the situation?

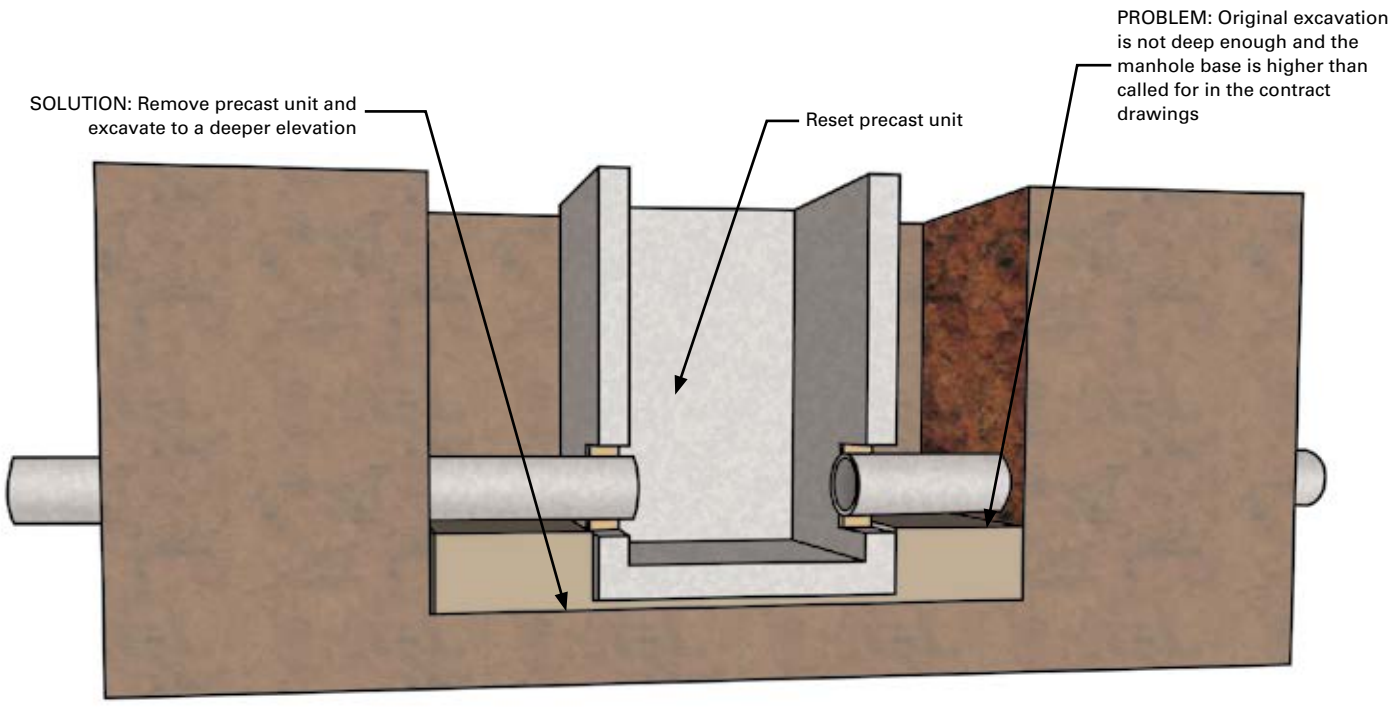


1. The holes for pipes entering or leaving the manhole are the wrong size or in the wrong place. This situation involves filling the original hole and cutting a new hole. Drilled anchors plus expansion-type, quick-setting grout make a watertight repair possible.



2. When a base unit is placed at the wrong elevation, the holes do not line up with the pipes in the ground.

A. If the base was placed at a lower elevation, holes can be relocated as described above and the invert must be rebuilt to match the holes.



B. If the base was placed at a higher elevation, the precast unit needs to be removed and the excavation must be made deeper before reinstalling the precast concrete base. ps

Gary K. Munkelt, P.E., is a consulting engineer with Gary K. Munkelt & Associates in North Wales, Pa. Contact him at gkm2001@verizon.net

PRECAST INSULATED WALL PANELS:

GET THE WHOLE PACKAGE!

Offering design flexibility with rapid installation, precast concrete sandwich wall panels deliver a complete energy-efficient building envelope, including exterior membrane, moisture barrier, insulation and interior finish.

By Chris Von Handorf, P.E.

Precast concrete insulated wall panels offer a quick, environmentally friendly alternative to building envelope construction, and with minimal site disturbance.

Standard building construction requires materials to be delivered to a job site, stored and then placed by skilled laborers from multiple trades. Tilt-up wall panels require significant on-site space as well as time for setup and casting, and then need to be rotated onto the building and finished properly to achieve an architecturally desirable exterior.

Conversely, precast concrete insulated wall panels are delivered 'just-in-time' and installed, typically by a crew of four to six skilled laborers, directly from the truck onto the building with final finishes already complete.

Insulated precast concrete wall panels have been successfully specified in a plethora of building construction applications. These applications include residential, educational, retail, commercial, governmental (including blast-loaded structures), industrial/warehouse, correctional facilities and more.

So, what is an insulated precast concrete wall panel?

An insulated precast concrete wall panel, or "sandwich" wall panel as it is sometimes called, is a precast concrete wall panel with two layers of concrete separated by a layer of rigid insulation (see Figure 1). The two layers of concrete, often referred to as concrete wythes, are connected by one of many wythe-connecting systems. The concrete wythes can vary in thickness depending on the structural and architectural requirements of a project. Typical concrete wythe thicknesses range from 2.5 in. to 6 in.

Wythe connections affect insulating properties

Several materials are used as wythe connectors. Some of the wythe-connecting systems in use today are plastic pin systems, carbon-fiber truss systems, solid concrete sections and various bent steel-shaped systems.

When selecting a wythe-connecting system, it is important to understand the conductivity of the material being selected. If a highly conductive material

is selected, the wythe-connecting system can act as a bridge allowing unwanted heat or cold to pass through the insulation. This will cause the overall R-value of the insulated precast concrete panel to decrease.

It is also important to note that some wythe-connecting systems have been engineered to work with a particular type of insulation. Therefore, verification of compatibility between the selected insulation and wythe connector is necessary.

R-values and insulation materials

The R-value achieved by precast concrete insulated wall panels can vary widely depending on the desired performance of the wall panel. Increased R-values are achieved by increasing the insulation thickness between the two concrete wythes. R-values for insulated wall panels range from R-5 to R-50. The vast majority of the insulating properties come directly from the insulation; however, concrete does possess some insulating properties as well.

Three types of insulation are commonly used in insulated precast concrete wall panel construction. The R-values are approximate and can vary depending on the insulation manufacturer. The common types of insulation in precast insulated wall panels are:

- Expanded polystyrene (EPS), R-value: 3.85/in. to 4.35/ in. (varies with material's density)
- Extruded polystyrene (XPS), R-value: 5.0/in.
- Polyisocyanurate, R-value: 6.0/in. to 8.0/in.

Based on the R-values above, the polyisocyanurate insulation provides a greater R-value per inch. However, it is important to note that a cost analysis of the three types of insulation may determine that one of the other two insulation types may be more desirable depending on insulation costs in a given area. Additionally, insulation performance in extreme climates should be considered when selecting the insulation type to be used on a given project.

Depending on the insulating material selected, the R-value of sandwich wall panels can be as high as 8/in. Photos courtesy of STABIL Concrete Products LLC (www.stabilconcrete.com)

Benefits of precast concrete insulated wall panels

Speed of construction. A precast concrete insulated wall panel system can be used as the complete building envelope, including exterior membrane, moisture barrier, insulation and interior finish. As all of these systems can be installed in one quick process instead of building separate wall elements with multiple trades, the time required to complete the building envelope can be significantly decreased by using insulated precast concrete wall panels.

Also, insulated precast concrete wall panels are fabricated in an off-site manufacturing facility. Wall

fabrication is typically nearly complete soon after the first precast panels arrive on site. It is even possible to install the window system in precast panels at the production facility, further decreasing time required to close in a structure. Panels can then be delivered to the job site as needed in order for construction to progress as quickly as possible.

Versatility. Not only can insulated precast concrete wall panels be used to replace multiple exterior insulating and cladding systems, in many structures they can also be used to replace structural elements. Many industrial, educational and correctional facilities have been designed as total-precast structures. In this scenario, insulated precast concrete wall panels can be designed to eliminate both cast-in-place columns and/or steel columns. In addition to eliminating columns, precast insulated concrete wall panels can also serve as the resisting system for the main seismic force and the main wind force. Eliminating the additional cost of columns and truss systems that are no longer required also makes insulated precast concrete wall panels very attractive from a cost standpoint.

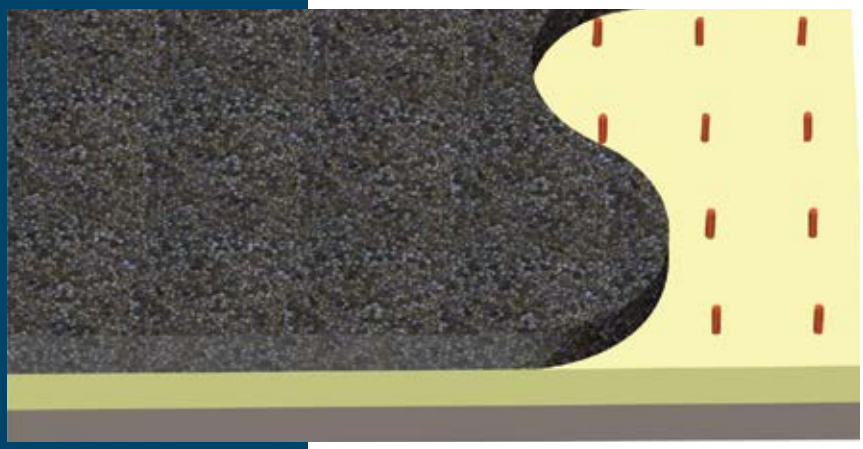


Figure 1. The light colored area in this diagram depicts the rigid insulating material placed between two panels of precast concrete. Illustration by Chris Von Handorf

Quality control. The skilled laborers at precast concrete manufacturing facilities perform the same or similar tasks day in and day out with the same tools, under the same controlled conditions. Over time, these workers become very proficient at producing quality concrete products for on-time delivery.

On the other hand, products that are manufactured on site typically have more limited quality control measures in place. These products are also more susceptible to delays and quality issues associated with adverse weather conditions and substandard concrete, as they are typically not produced in a controlled environment.

Energy efficiency. Precast concrete has a very high thermal mass when compared with other less-massive materials. Thermal mass is defined as a property that enables materials to absorb, store and later release significant amounts of heat. Concrete's inherent ability to absorb and store heat and cold can delay and reduce peak HVAC loads. This may allow for initial building cost decreases in the form of a smaller-capacity HVAC system.

Due to the slow release of heat and cold, the thermal mass of concrete can also shift the demand to off-peak time periods when utility rates are lower, thereby decreasing energy costs further (see Figure 2).

The use of wythe connectors with very low heat conductivity, along with the extremely tight building envelope that is created by the use of precast concrete insulated wall panels, creates a very energy-efficient building. Wythe connectors with low heat conductivity will minimize heat transfer from the exterior concrete wythe to the interior concrete wythe and vice versa. Consequently, heat stays inside in the winter and outside in the summer.

Maintenance. An insulated precast concrete wall panel building envelope will require very little maintenance over the life span of the structure. Standard maintenance on this type of construction includes only occasional cleaning as aesthetically desired, and maintenance of the caulking and waterproofing systems. The insulated concrete wall panel system will deliver a service life of more than 75 years.

Fire resistance. Inherently, concrete is extremely fire resistant compared with other materials. As such, insurance costs for a concrete structure are often lower than those incurred when insuring a typical stick-built structure.

The concrete wythes that sandwich the rigid insulation also act as fire protection for the insulation. A typical dry-walled interior finish is flammable and deteriorates quickly when compared with concrete. Once the drywall has deteriorated, the insulation contained within a conventional wall will begin to emit harmful chemicals. The use of insulated precast concrete wall panels will greatly delay the release of these harmful chemicals within the building envelope.

Environmental impact. A recent life cycle assessment (LCA) of exterior cladding products commissioned by the Natural Stone Council and performed by the University of Tennessee's Center for Clean Products found that "precast concrete and granite exhibit the greatest advantages, although it is unclear which is most environmentally preferable overall." This study was specifically

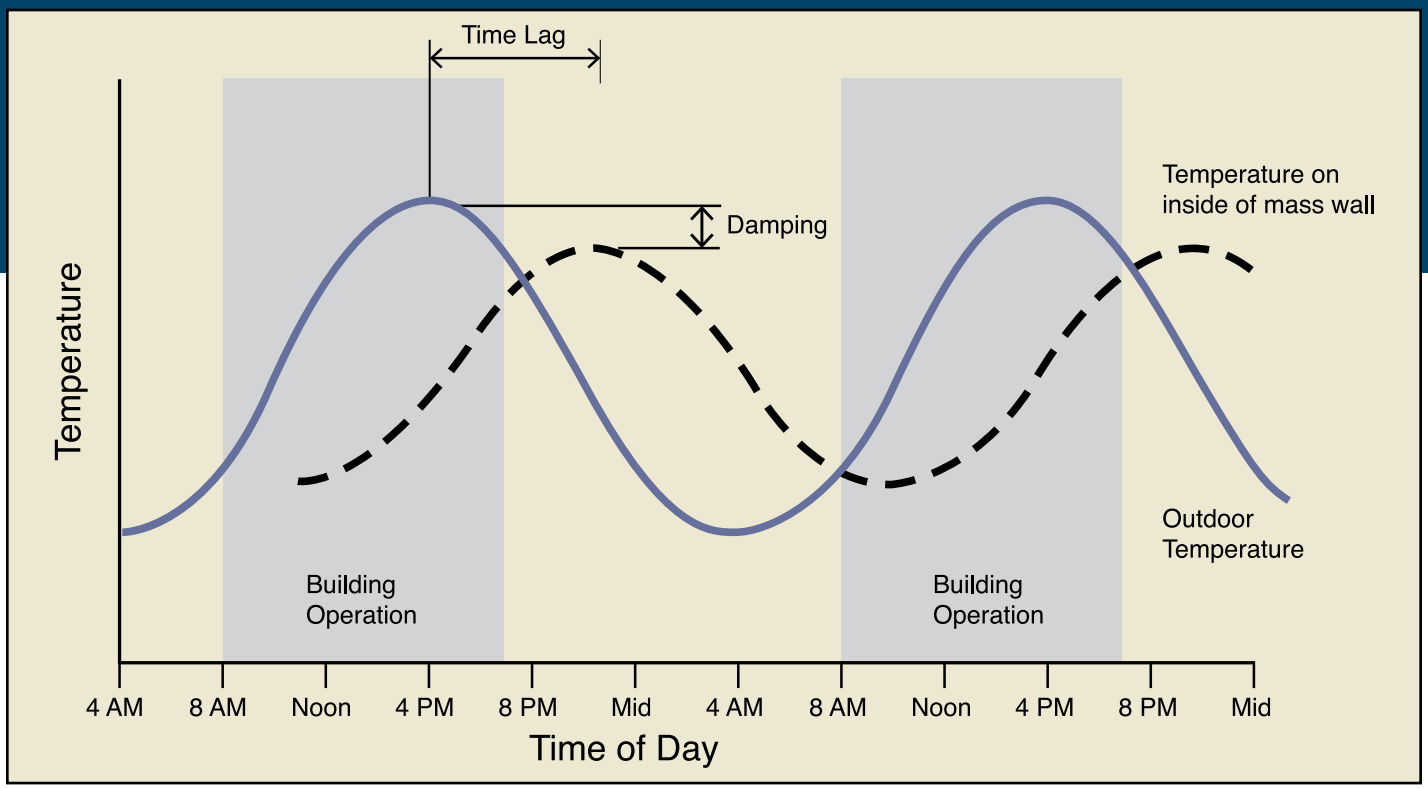


Figure 2. Concrete's high thermal mass effectively shifts a building's energy demand to off-peak periods, saving HVAC costs.
Courtesy of Portland Cement Association (www.cement.org)

investigating a two-story load-bearing structure. It is important to note that typical precast concrete cladding is significantly less expensive than granite cladding.

Precast concrete also has the ability to limit the environmental impact of a building project on the building site. As precast concrete insulated wall panels are manufactured off site, and crane-lifted from the delivery truck and installed directly onto the building, the adverse impact that the precast wall panels impose on a site is very minimal. With precast, there is no on-site space required for stored materials, and there is minimal construction debris and less overall site disturbance.

Three design options

Three basic design options can be chosen when specifying an insulated precast concrete wall panel. These options are non-composite panel design, composite panel design and partially composite panel design.

Non-composite panels. When designing a non-composite panel, the two concrete wythes work independently of one another to resist any applied loads. Each concrete wythe will take a portion of the load based on the proportionality of each wythe's section modulus compared to the other wythe. There is typically a structural or load-bearing concrete wythe and a non-structural or non load-bearing concrete wythe. Any dead loading (gravity loading), such as self-weight or window or louver loading is transferred through the wythe connector to the structural wythe. The non load-bearing wythe is essentially "hanging" from the load-bearing wythe.

Composite panels. In a compositely designed panel, the two concrete wythes work together to resist applied loads. A composite panel of the same thickness will be significantly stronger in flexural strength than a non-composite panel of the same thickness. The wythe connector must be designed to have sufficient shear strength to transfer the horizontal shear between the two concrete wythes. Composite insulated wall panels can typically provide a thinner panel section than a non-composite insulated wall panel. However, the savings in concrete material may be at least partially offset by the additional wythe connector costs associated with making a fully composite panel.

Partially composite panels. Some wythe connector manufacturers will offer a product that is not 100% composite and also a connector that is not completely non-composite; these are partially composite wythe connectors. This is essentially a hybrid between the two extreme design philosophies (composite and non-composite). The wythe connector manufacturers should be consulted for assistance as to which design philosophy applies to their products.

Conclusion

Insulated precast concrete wall panels lend themselves to fast and environmentally friendly construction while remaining virtually maintenance free for years to come. As a building owner, architect or engineer, do not settle for specifying an inferior building system just because it is what you have been doing for years. Set your next project up for success during all phases of the building's life cycle by choosing insulated precast concrete wall panels and take advantage of this system's many structural, architectural, environmental, construction and energy-saving benefits. PS

Chris Von Handorf, P.E., is a technical services engineer with NPCA.

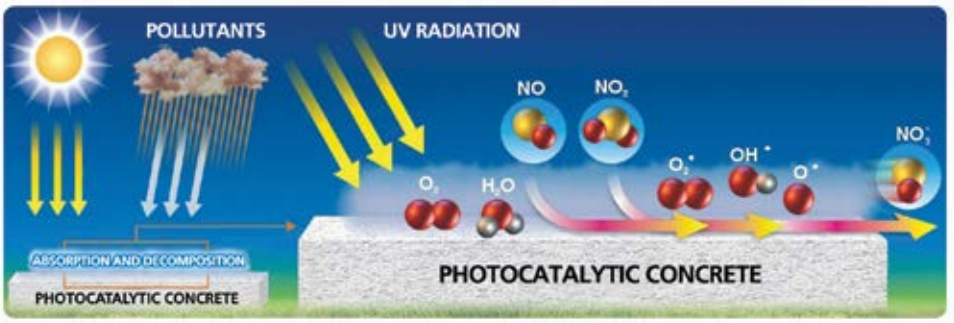
Five Ways Precast Helps Save the Earth

REDUCE SMOG

From roof tiles in California to highway sound walls in Canada, diverse and sustainable precast concrete applications are serving to measurably clean our air and water, and conserve energy.

By Sue McCraven

Titanium dioxide-coated precast concrete roof tiles made with photocatalytic cement can measurably reduce air pollution.
Photos courtesy of Boral Roofing (www.boralna.com)



Courtesy of ESSROC Italcementi Group (www.essroc.com)

1. Precast Concrete Versus Dairy Cows

Precast roof tiles can transform smog into clean air and add architectural refinement.

In the No.1 dairy-producing region in the United States, San Joaquin Valley, Calif., palm trees sway in warm breezes and the sun always shines, but there's something else distinctive in the air: smog.

San Joaquin Valley's perpetual smog has long confounded scientists, because this rural area produces more intense air pollution than Los Angeles. The reason? More than 1.5 million cows reside in this bucolic valley. Recent scientific studies have found that the valley's fermented cattle feed produces 25 tons of ozone per day compared to 14 tons from automobile emissions. When sunlight combines with fog and air pollution, smog is formed.

Technically, smog is a sunlight-induced photochemical reaction with hydrocarbons that produces nitrogen oxide and volatile organic compounds (VOCs). Innovative cement technology can help remove this polluting nitrogen oxide from the air. When nitrogen oxide is removed from the air, smog can't form.

How photocatalytic precast reduces smog

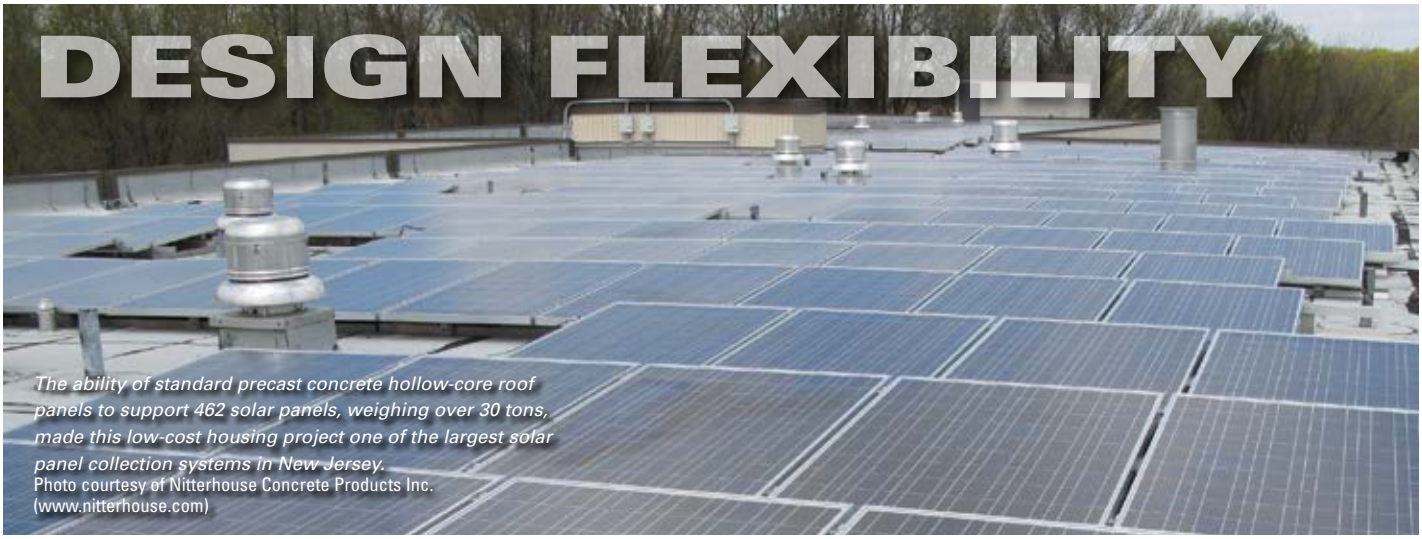
"Smog-eating" precast concrete roofing tiles made with photocatalytic cement, produced by Boral Roofing of Stockton, Calif., have been proven to measurably reduce air pollution. A home roof covered with 2,000 sq ft of smog-eating roof tiles can oxidize the amount of nitrogen oxide equivalent to that produced from a car driven 10,000 miles.[1] Precast concrete roofing tiles can add only about $900 to the cost of a 2,000-sq-ft home.

According to John Renowden, Boral's vice president of product development, "it's the tile's titanium-dioxide coating that works with the sun to take the nitrogen oxide out of the air." This chemical reaction continues year after year, because the titanium-dioxide coating doesn't wear away. "Smog-eating tile is the first product of its kind in the nation," said Renowden.

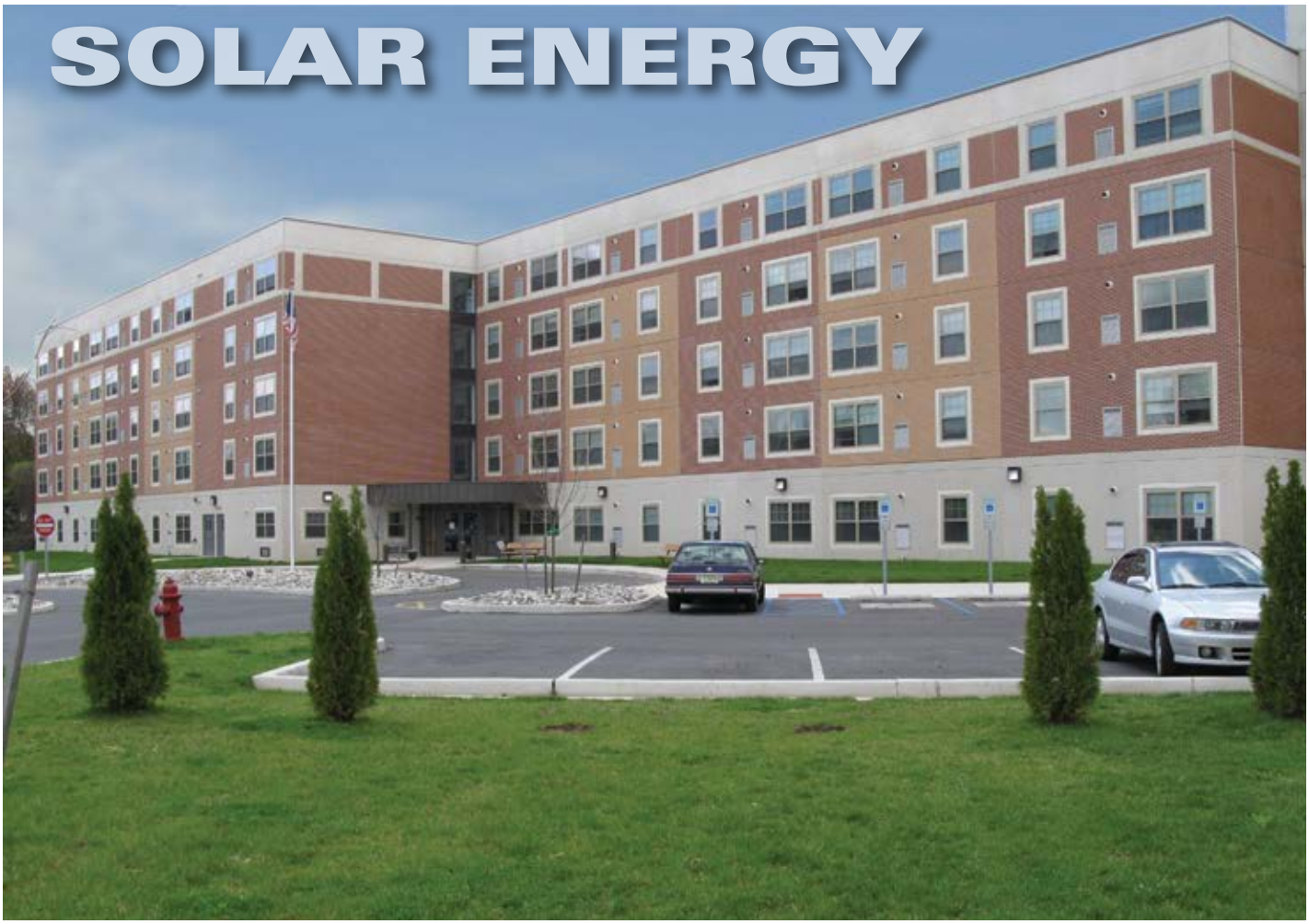
The sustainable attributes of photocatalytic precast concrete roofing tiles include:

- Locally sourced raw materials (sand and water)
- Long service life, little to no maintenance, fire resistance
- Energy-saving benefits of concrete's high thermal mass and the insulating air space between the roof tile and the deck that help homeowners achieve about 20% savings in energy costs[2]
- Full recyclability, as it can be crushed after its service life to be used in new concrete construction (roadways and buildings)
- Measurably less air pollution

While the air-pollution reduction achieved obviously depends on the number of homes installing smog-eating tiles, "Any little bit helps," said Brenda Turner of the San Joaquin Valley Air Pollution District.



The ability of standard precast concrete hollow-core roof panels to support 462 solar panels, weighing over 30 tons, made this low-cost housing project one of the largest solar panel collection systems in New Jersey.
Photo courtesy of Nitterhouse Concrete Products Inc. (www.nitterhouse.com)



2. Precast Design Flexibility Opens the Door for Solar Energy

Strength of typical precast concrete roof panels gave the contractor the design flexibility to add solar roof panels for a sustainable low-income housing project.

"The biggest challenge on this project was when the financing fell through," says Mark Taylor, president of Nitterhouse Concrete Products Inc. in Chambersburg, Pa. Mark is talking about the sustainability award-winning Kent Avenue Apartments, a low-income housing project for elderly and handicapped persons in Pennsville, N.J. "Nitterhouse was 49% complete with production at the time (2007)."

Fortunately, Tri-County Real Estate Maintenance Co. of Carneys Point, N.J., took over the project. Unfortunately, the new owners were "more familiar with wood and steel-stud construction, and they were concerned that the new financing would not allow for a totally precast structure," recalls Taylor.

Convincing project owners to opt for all-precast structure

Nitterhouse invited the new owners, Ron Rukenstein and John Bibeau of Tri-County, to its Chambersburg plant and explained the benefits of a totally precast design, including speed of construction, strength, low maintenance and energy efficiency. The words "energy efficiency" perked up the two partners' interest as Rukenstein said, "My concern, along with the financial incentives, made our decision to be environmentally responsible of paramount importance." Nitterhouse won the contract.

Precast construction of the five-story, 101-unit Kent Avenue Apartments was complete in 37 days. The $2.6-million precast portion of the project included: 39,237 sq ft of 12-in.-thick insulated exterior wall panels; 16,693 sq ft of 7-in.-thick interior wall panels; 85,652 sq ft of 8-in. precast hollow-core planks; and 34 precast stairs with landings.

Originally, roof-mounted solar panels were not part of the design and "were not actually considered until after the building had been designed and constructed," said Taylor. The typical precast hollow-core roof slabs, made with 6,000 psi concrete, had the structural strength

▲ *This sustainability award-winning Kent Avenue Apartments complex disproves the assumption that standard-looking, low-cost materials need to be used when building affordable housing.* Photo courtesy of Nitterhouse Concrete Products Inc. (www.nitterhouse.com)

LEFT PHOTO
Jarrett Carlson, tunneling engineer with McNally/Kiewit ECT JV, stands in front of the five primary pieces of the cutter head, the business end of the huge 27-ft, $20-million tunnel-boring machine (TBM). The TBM was manufactured by Herrenknecht of Germany and assembled and tested in China. Disassembled TBM pieces began arriving at the Euclid Creek Tunnel project job site in April 2012, and tunneling is expected to take three years.
Photo courtesy of Kellie Rotunno, NEORSD director of engineering and construction (www.neorsd.org)

RIGHT PHOTO
Precision precast concrete tunnel segments in the CSI/Hanson JV segment production yard in Macedonia, Ohio.
Photo courtesy of Leonard A. Worden, CEO, CSI Group of Companies (www.csigroup.com)

to afford design flexibility for the owners to consider a roof-mounted solar energy system for the project. The roof's reserve structural capacity meant that the precaster could "accommodate their (the owners') change in plans without needing to otherwise reinforce or add supplemental structural members to support the solar panels," says Daryl Wenger, sales manager at Nitterhouse. "Not all structural systems are as accommodating as precast."

Precast panels handle added weight of solar panels

The addition of 462 solar panels to the roof of the precast structure added 61,000 lbs of loading, making the housing project one of the largest solar panel collection systems in New Jersey. This additional weight of 30-plus tons was no problem for the 8-in.-thick, 4-ft-wide, 32.5-ft-long hollow-core roof planks. The precast panels themselves each weigh in at almost 8,000 lbs.

"Building design is increasingly incorporating alternate energy sources such as solar panels," said Wegner. "Designers view the building rooftop as the preferred location for mounting the panels, adding substantial loading to the roof structure. Precast hollow-core plank provides the capacity necessary while maintaining excellent free-span characteristics. Today's designer is looking to incorporate every sustainable ingredient possible in the design. Total precast design also offers benefits in local, natural material selection and in thermal mass quality."

According to Goff Sun Power, N.J., the company that built the system, within the solar panels' life span, the system will produce 2.7 million kilowatt-hours of electricity and reduce 1,450 tons of CO_2 emissions, the equivalent of planting 19,725 trees or 2.2 million miles not driven in a car. Because of the combined energy efficiencies achieved, the owner was able to eliminate 101 gas meters, making these units much more affordable than comparable housing. The average monthly heating cost for residents is about $40.

The upscale-looking Kent Avenue Apartments complex won the 2008 Governor's Housing Conference Award for the most sustainably built building in New Jersey.

3. Beneath Lake Erie: Precast Tunnel Will Prevent Water Pollution

A massive 24-ft-diameter precast concrete tunnel will greatly improve regional water quality.

More than 750 of the oldest U.S. cities still have 19th-century sewer systems that result in CSOs (combined sewer overflows) wherein human and industrial waste and dirty stormwater are discharged together into a single collection system. This means problems often come with the pouring rain. In some cities, even moderate rainfall flowing into these outmoded underground pipes exceeds the sewer system's capacity. As a result, these CSOs dump environmentally toxic wastes into streams, rivers and lakes, causing serious water pollution and risks to human and aquatic health.

Meeting Clean Water Act requirements

In Cleveland, a 24-ft-diameter tunnel constructed with precast segmental tunnel liners manufactured by CSI/Hanson-JV of Hudson, N.H., will be built 200 ft below the bed of Lake Erie, part of the 18,200-ft-long, $198-million Euclid Creek Tunnel project. "Construction of the Euclid Creek Tunnel is part of the consent agreement with the EPA and other state and federal agencies to reduce CSOs into rivers that flow into Lake Erie," said Doug Gabriel, district construction program manager at the Northeast Ohio Regional Sewer District (NEORSD). "The consent agreement by NEORSD is intended to meet the requirements of the federal Clean Water Act." Euclid Creek Tunnel is one of seven underground tunnels, totaling 20 miles in length that will be constructed under NEORSD's Project Clean Lake program (http://neorsd.org/cleanlake) at a cost of $3 billion over 25 years.

Production of 24-ft-diameter precast ring segments

Production of the precast concrete segmental liners, reinforced with steel fibers, started in early 2012. Six segments make up each 24-ft-diameter ring, and there are more than 21,000 precast concrete segments to be produced for the project by CSI/Hanson-JV at its segment plant in Macedonia, Ohio. About 100 segments are produced each day, and delivery of the product to the construction site began in April 2012. The precision precast concrete segments are manufactured with mold tolerances of 0.018 in. to 0.040 in. Tunnel boring for the Euclid Creek portion is expected to begin in late 2012. McNally/Kiewit ECT JV is the prime contractor for the tunnel.

The purpose of the project is to catch and temporarily retain sewer overflows during rainstorms. Sewage collected from a 31-square-mile area, a portion of the Cleveland metropolitan area, will be pumped to a treatment plant and then returned as purified water to Lake Erie. The underground precast concrete pipe will be part of a sewerage containment system that, when completed, is expected to reduce the total volume of raw sewage and other pollutant discharges into Lake Erie by more than 90% annually.

[1] PICADA: Photocatalytic Innovative Coverings Applications for De-pollution Assessment, Europe, 2004.

[2] Steep-slope Assembly Testing of Clay and Concrete Tile, Oak Ridge National Laboratory. The results vary based on the profiles of the tiles installed.

Air-quality testing equipment adjacent to precast concrete sound walls will amass operational data for analysis by the University of Toronto for Canada's Ministry of Transportation. Photo courtesy of Shawn Smith, project engineer, MTO Provincial Highways Management Division (www.mto.gov.on.ca/English)

4. Canadian Precast Sound Walls for Cleanest Roads in North America

University will measure a material innovation in creating cleaner air along urban highways.

Along Highway 401 in metropolitan Toronto, a high-volume traffic route, precast concrete sound walls are being monitored by air-quality recording equipment. The University of Toronto, beginning in summer 2012, will be testing the effectiveness of precast concrete sound walls made with photocatalytic cement to remove pollutants from the air. Today, as transportation officials across North America consider sustainability in project cost/benefit analyses, it becomes necessary to obtain a scientifically proven measure of positive environmental impacts. So, precast concrete sound walls in Toronto, Ontario's provincial capital and Canada's largest city, are the new "specimens" for scientific analysis.

When precast concrete products incorporate photocatalytic cement, their surfaces can improve air quality. Because of its cost, photocatalytic cement is often used just on the surface of structures. Production considerations, however, led precast producer Armtec/Durisol of Mitchell, Ontario, to use this special cement "uniformly throughout the mix used for the 54 sound wall units," according to Ron Galloway, Armtec technical sales representative. Individual precast wall panels are 10 ft long and 20 in. high and may be stacked one upon the other. At the Highway 401 test site, the area under surveillance is 14.5 ft high and extends 60 ft.

Precast sound walls improve air quality for urban highways

When activated by ultraviolet rays from sunlight, titanium dioxide acts as a catalyst to accelerate the oxidation process that converts nitrogen oxides (and other smog components such as fine particulate material, carbon monoxide and sulfur dioxide) to less harmful compounds (see the illustration of this process in the story "Precast Concrete Versus Dairy Cows").

The project's initial intent was to conduct a 12-month-long sound wall test to verify other studies done throughout the world. This project scope, however, was not feasible due to time restraints and logistical complications. The Ontario Ministry of

Transportation (MTO) is conducting a scaled-back test to confirm previously published results. For the field test, MTO partnered with Armtec, the University of Toronto and photocatalytic cement producer Essroc Italcementi Group. Published data from European and Asian demonstration studies have shown that photocatalytic cement applications can improve air quality by 20 to 70% and that about 10 sq ft of treated concrete can remove 2.1 x 10^{-3} ounces of nitrous oxide per day. Effectiveness depends on wind (strong winds perpendicular to the precast sound wall are optimal), intensity of sunlight, concentration and location of air pollution (more is better) relative to the treated concrete and other factors. "European research shows that photocatalytic concrete placed in an area the size of a soccer field can remove emissions equal to approximately 190,000 km (118,000 miles) per year," says Shawn Smith, project engineer at MTO Provincial Highways Management Division.

Precast concrete with photocatalytic cement is also used to keep its surfaces clean. "The surface-cleaning capabilities of the material are a bonus," says Smith. "The concrete is self-cleaning, depending on conditions. It doesn't do big stuff like graffiti or gum, but it will remove many of the compounds that form on it, relying to some degree on the rain to wash them away. Many structures in Europe use the product to keep buildings looking white."

What is MTO's long-range goal? To have the greenest roads in North America.

5. Company Brews Up Geothermal Energy Savings

Custom precast concrete vault feeds geothermal energy field.

Bell's Brewery of Galesburg, Mich., a regional craft beer brewery, employs more than 100 people and distributes 24 brands in 18 states. In 2011, the brewery opted for an 85-ton geothermal heat-exchange system[3] of high-density polyethylene tubing as a sustainable energy source for the facility. About 100,000 ft of tubing was installed 8 ft underground (at an 8-ft depth, the earth stays at a steady temperature of about 52 F), and spread in a close-looped coils design covering two acres. The tubing holds a solution of 20% propylene glycol and 80% water that transfers geothermal energy from the earth to the facility. The brewery's geothermal system will provide heating, cooling and power for a 42,000-sq-ft office extension.

"Geothermal is one of the most proven renewable energy sources," said Evan Meffert, sustainability manager at Bell's Brewery, "and there are decent business cases to be made for this technology in Michigan, where sun and wind (solar and wind power) may not be as abundant as in other states."

A precast concrete valve vault houses the business end of 48 pipes and the inflow and outflow piping. Advance Concrete Products Inc.[4] of Highland, Mich., fabricated and installed the 9- by 13- by 7-ft custom valve vault for this geothermal project. "We needed a custom design for the vault that involved moving the reinforcing steel to make room for the tube openings," said Marcus Delong, president and owner of Geothermal Loop Pros

[3] 1 ton is equivalent to 12,000 BTU

[4] See July-August 2012 issue of NPCA's *Precast Inc.* magazine for a company profile on Advance Concrete Products

[5] Visit www.geothermallooppros.com

[6] 2009 American Recovery and Reinvestment Act

LLC, Jenison, Mich.[5] "The precaster was easy to work with, and there was no problem coring the 1.25-in. openings for the tubing."

Geothermal system: 50% energy savings

A geothermal installation can provide more than energy savings for a company – it can also be a smart capital investment. By installing the $150,000 geothermal project, the brewery was able to take advantage of the 2009 federal stimulus package,[6] which meant a tax credit of 10% up front on the total investment and 100% depreciation against company profits in the first year. In 2012, companies can claim a bonus 50% depreciation the first year, on top of an accelerated five-year 100% depreciation. Many states offer additional incentives.

"Michigan utilities offer incentives for energy-efficient projects," said Meffert. "The funds we were able to secure helped in the effort to present a solid business case for the system."

A geothermal system has a lot to say about a company's commitment to sustainability, the environment and the community. With a geothermal system, Bell's Brewery foresees a 50% reduction in energy costs over the long term. ps

Sue McCraven, NPCA technical consultant and Precast Solutions editor, is a civil and environmental engineer.

FAR LEFT PHOTO
A custom precast concrete vault houses valves and tubing connections for a geothermal energy system installed at Bell's Brewery in Galesburg, Mich.
Photo courtesy of Advance Concrete Products Inc. (www.advanceconcreteproducts.com)

CENTER PHOTO
Interior of a new brewhouse shows five stainless steel brewing vessels and architectural wood beams. The owners expect a 50% reduction in energy costs for its new office addition over the long term.
Photo courtesy of Evan Meffert, sustainability manager, Bell's Brewery (www.bellsbeer.com)

ABOVE PHOTO
Bell's Brewery built a two-acre geothermal energy system to supply heating, cooling and power for its new office addition.
Photo courtesy of Scott J. Anderson, Geothermal Loop Pros LLC (www.geothermallooppros.com)

Built Army

A U.S. Army Corps of Engineers project in Texas uses an all-precast system to meet the combined goals of environmental design and security standards.

By Deborah R. Huso

Photos courtesy of ATKINS (www.atkinsglobal.com)

TOUGH!

PROJECT PROFILE

Project: San Marcos Armed Forces Reserve Center, San Marcos, Texas

Project Owner: U.S. Army Corps of Engineers, Louisville District, Louisville, Ky.

Project Architect: Atkins, Orlando, Fla.

Project Builder: Satterfield & Pontikes Construction Inc., San Antonio

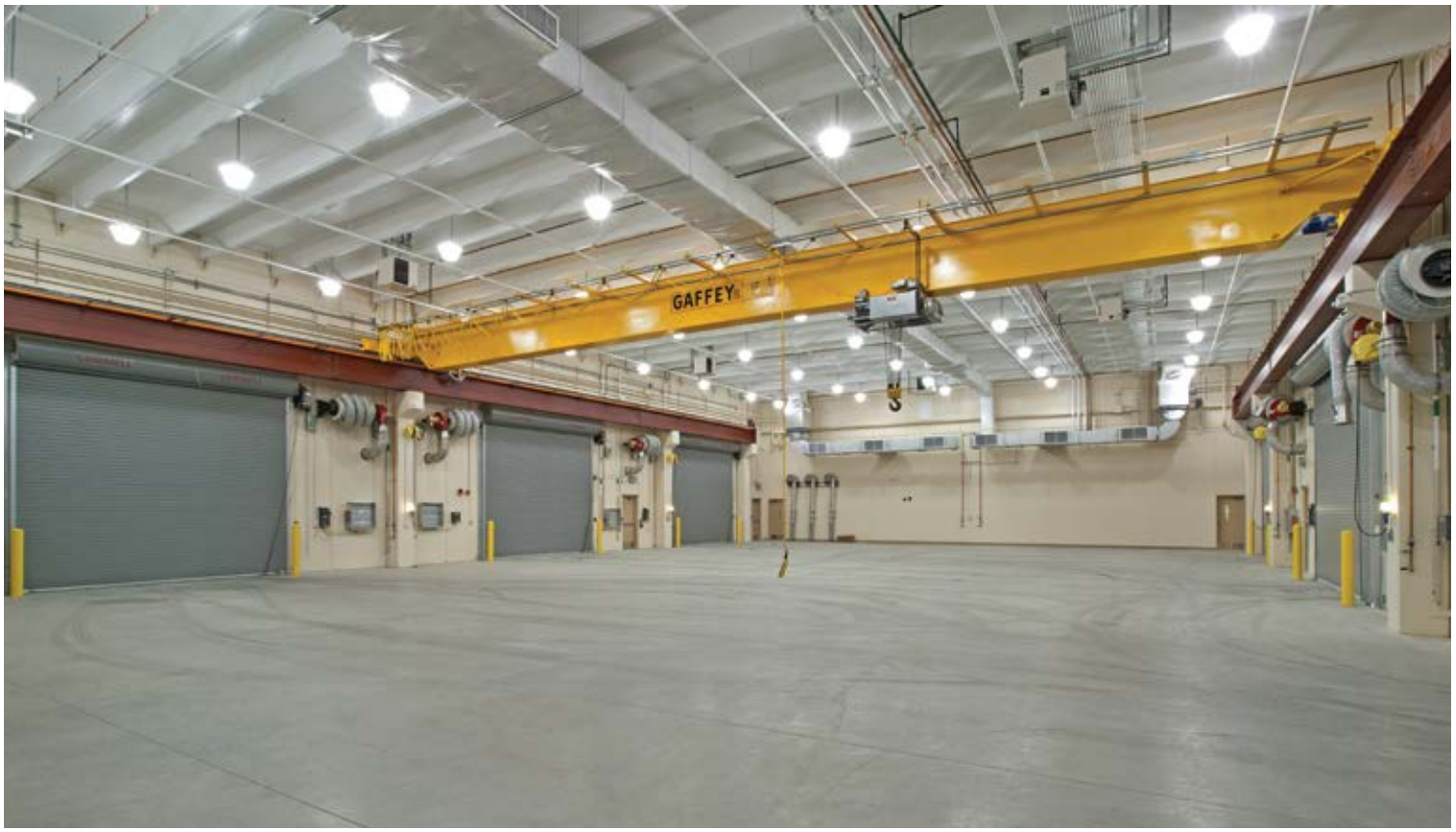
Project Engineer: Schwab Structural Engineering Inc., New Braunfels, Texas

Precast Manufacturer: Heldenfels Enterprises Inc., San Marcos, Texas

When the design-build team began the design of a new $25-million Army Reserve center in south-central Texas, they had to meet goals of sustainability and blast resistance. Designers turned to a natural solution for the project – an all-precast concrete structure from the ground up.

Designed as three freestanding buildings totaling some 112,000 sq ft, the project provides space for the joint operations of the U.S. Army Reserve, the Texas National Guard and the San Marcos Armed Forces Reserve Center (AFRC) in San Marcos, Texas. The complex had to meet the U.S. Army Corps of Engineers' sustainable building standards, based on the U.S. Green Building Council's LEED Gold certification standards, as well as Anti-Terrorism Force Protection (ATFP) requirements. And while the requirements might seem stringent, the use of an all-precast system to build the operations center resulted in an inherent melding of both ATFP and LEED goals.

Situated on 15 acres, the AFRC includes a central



training and administrative building, plus a storage building and organizational maintenance shop. "One of the reasons we selected precast was because of how quickly we could put the structure up," says Alejandro Gonzalez with Satterfield & Pontikes Construction Inc., the general contractor for the project. "Precast allows you to work on other phases of construction while the precast components are being fabricated."

Precast for fast-track schedule and blast-resistant design

Given the Corps of Engineers' goals for structures that reflect the strength, security and traditions of the U.S. Armed Forces, precast concrete was a natural and efficient design fit. Precast panels are a perfect option for projects like this one, which requires rectilinear massing and symmetry. Designers enhanced the exterior facade by adding a brick veneer to the first floor by using locally manufactured brick.

Steve Moller, senior architect and project manager with Atkins, says there was really nothing architecturally complex about the structures. "The buildings are rectilinear with cubed massing and punched openings," he notes, but the very simplicity and straightforwardness of the design made the project ideal for an all-precast system. "The design supported precast," Moller adds.

The use of an all-precast system was a goal from the project's start in large part to meet the Corps of Engineers' fast-track construction goals while still achieving ATFP and LEED benefits. "Their schedule was pretty aggressive," says Gil Heldenfels, vice president and general manager of the building systems division of Heldenfels Enterprises Inc., the precast manufacturer. Work on the project began in June 2009 and was completed in the spring of 2011.

Precast concrete offered both renewability and recyclability, and the precast plant was only four miles away from the job site. Furthermore, precast offered natural thermal mass, fire protection and insulation, thus contributing to the structures' 34.3% energy consumption savings.

Precast concrete panels easily meet the requirements of Force I and II blast resistance from just about any distance without any unique design or manufacturing processes. "We had to ensure our design met the stand-off distance," Heldenfels explains. "It was a minimal blast resistance requirement, and our product inherently met it."

Moller adds that precast was a natural choice for meeting the combined needs of fast-track construction and blast resistance, since it combined easy assembly of components with reinforced concrete's known explosion resistance. And while he notes that it was not necessarily cheaper material-wise to go with precast concrete over other possible building systems, the erection process was cheaper.

BIM allows construction simultaneously with design

All three buildings included wall panels serving as both structural support and exterior facade. Heldenfels said the three buildings make use of a mix of hollow-core and double-tee flooring, double-tee roof panels, columns and beams, and somewhat repetitive wall panels. The three-building project consisted of a total of 1,424 precast pieces. The wall panels that serve as both structure and facade are exposed, painted, elastomeric precast.

Heldenfels says the design-build team used Building Information Modeling (BIM) to design and track the project, thus providing not only a 3-D representation of the AFRC but allowing all parties involved in construction to be on the same page and contribute to the BIM as the project progressed. BIM allowed the AFRC design-build team to basically follow the life cycle of the construction project, including tracking time and costs.

The modeling meant that the precast manufacturing and construction began before the buildings' design was even complete. "As architects," Moller explained, "we had a kit of parts and we knew what they were, so construction was actually able to start before we finished our work as designers." The simultaneous design and construction, however, revealed that the structures' crawl spaces had to be re-excavated as the structural design developed.

Heldenfels says what made the AFRC especially unique despite its rather conventional facade design was that it made use of precast structural suspended slabs. The columns and beams bore directly on the piers. "We do suspended slabs, but the thing that was novel was that it was precast from the piers up," he says. "It was the first time in my experience we were out of the hole coming up precast."

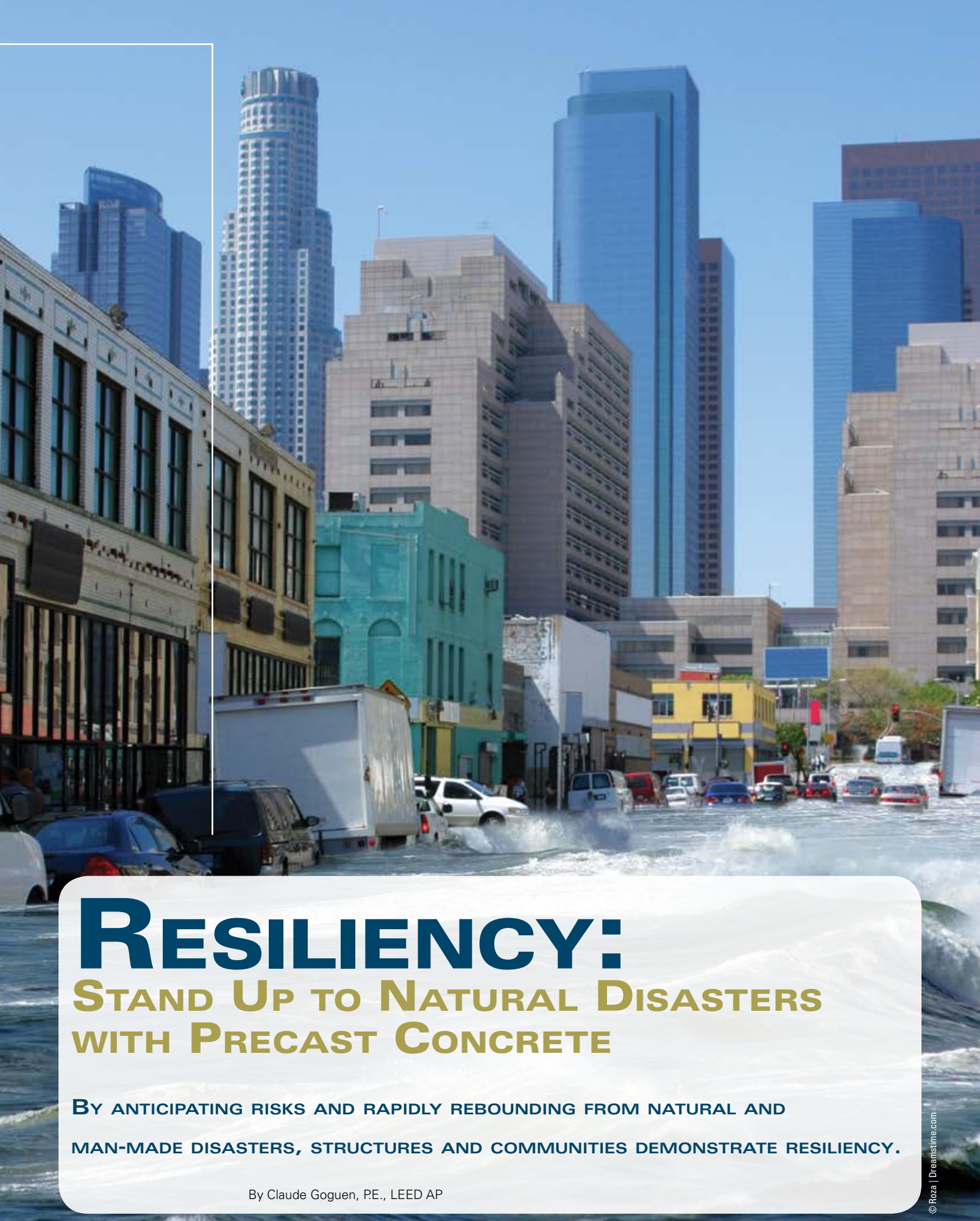
Gonzalez agrees. "Sometimes you have elements of precast, but it was the entire structure here, which is rather unique," he says.

Coping with challenges

Total erection of the all-precast structures took only about four months, and given the extremely wet year south-central Texas experienced in 2010, precast ended up being a distinct advantage. "Access to the job site was sometimes a challenge because of the wet weather," Heldenfels notes, "but, in the end, precast allowed us to get going really fast." Weather was not the only challenge. Heldenfels says if he could do the project over again, he thinks the design-build team would re-evaluate the connections systems. "We had planned to use grout-filled mechanical splices for panels and beams, but it didn't work," Heldenfels says. "We didn't hit (align) the tubes in the beams with the rebar in the panels, so we had to adjust a lot." Heldenfels says, in retrospect, they should have used JVI Mini-V connectors for their double-tee shear connections.

Prior to his work on the AFRC, Moller says he'd never designed for a total precast project, but he says he felt precast offered the ideal option for the U.S. Army Corps of Engineers. "For a project that has this kind of client where the schedule is tight and the particular qualities of concrete are needed, it's a perfect marriage," he notes. "Precast concrete is a renewable, recyclable material with great thermal mass, too." PS

Deborah R. Huso is a freelance writer who covers home design and restoration, sustainable building and design, and home construction.



Resiliency:
Stand Up to Natural Disasters with Precast Concrete

By anticipating risks and rapidly rebounding from natural and man-made disasters, structures and communities demonstrate resiliency.

By Claude Goguen, P.E., LEED AP

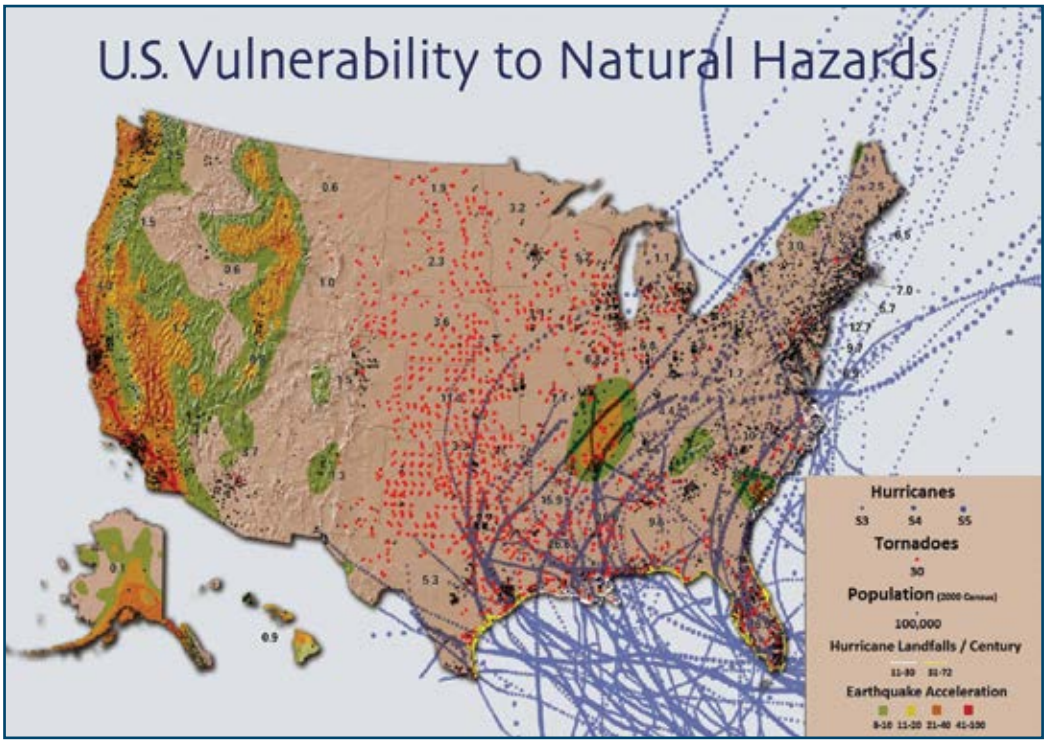


Figure 1. Hurricanes, tornadoes, flooding and earthquakes affect nearly every region of the United States. Courtesy of Community and Regional Resilience Institute (CARRI) (www.resilientus.org)

We've been hearing a lot about sustainable construction over the past few years. Now "resiliency" is the new buzzword. Sustainability and resiliency are actually complementary concepts, where resiliency relates to a more short-term recovery from a recent crisis while sustainability describes a long-term balance between consumption and resources. Resilient construction and development may seem like a new trend, but the concept has been around for many years.

But what exactly is resiliency?

To those unfamiliar with this terminology, a familiar sports example might help. In the recent Kentucky Derby, "I'll Have Another" was a 15-to-1-shot colt ridden by a rookie jockey, who resisted the turbulence and dangers of the mid-pack to emerge as the winner in the final stretch. This unheralded colt and jockey had the resiliency to bounce back in extreme adversity because of excellent anticipation, strategy and training for this singular event. Likewise, resiliency can be defined as the adaptability of a system (communities or buildings) to maintain its functions and structure in the face of turbulent internal and external change.

The key attributes of enhanced structural resiliency are improvements in:

1. Longevity (service life)
2. Robustness (minimized potential for structural progressive collapse)
3. Sustainability
4. Life safety
5. Durability
6. Adaptability for reuse
7. Resistance to disasters

Community resiliency has been defined as the "capability of a community to anticipate risk, limit impact, and recover rapidly through survival, adaptation, evolution and growth in the face of turbulent change."[1] According to the Department of Homeland Security (DHS), resiliency is the ability of any system (infrastructure, government, business and citizenry) to resist, absorb and recover from or successfully adapt to an adversity.

"Turbulent change" and "adversity" can refer to a range of various natural and man-made calamities including the following:

- Extreme weather (tornadoes, hurricanes or flooding)
- Geological (earthquakes, tsunamis and volcanic eruptions)
- Man-made crises (terrorism, war, forest fires, pandemics or large-scale industrial accidents)
- Economic (company closing, recession or depression)

A community's ability to recover from these events depends on many factors. The effects of the first three categories can be minimized with conscientious construction methods using durable, strong materials. Precast concrete is an example of such a material that is designed to absorb large static and dynamic loads, and resist damage due to flooding and fires.

Local reaction preferable to government response

Historically, the United States has drawn on the strength of its citizens in times of crisis. However, as the threats have expanded and grown more complex, Americans have been moving to the sidelines, allowing

[1] From the Community and Regional Resilience Institute (CARRI)

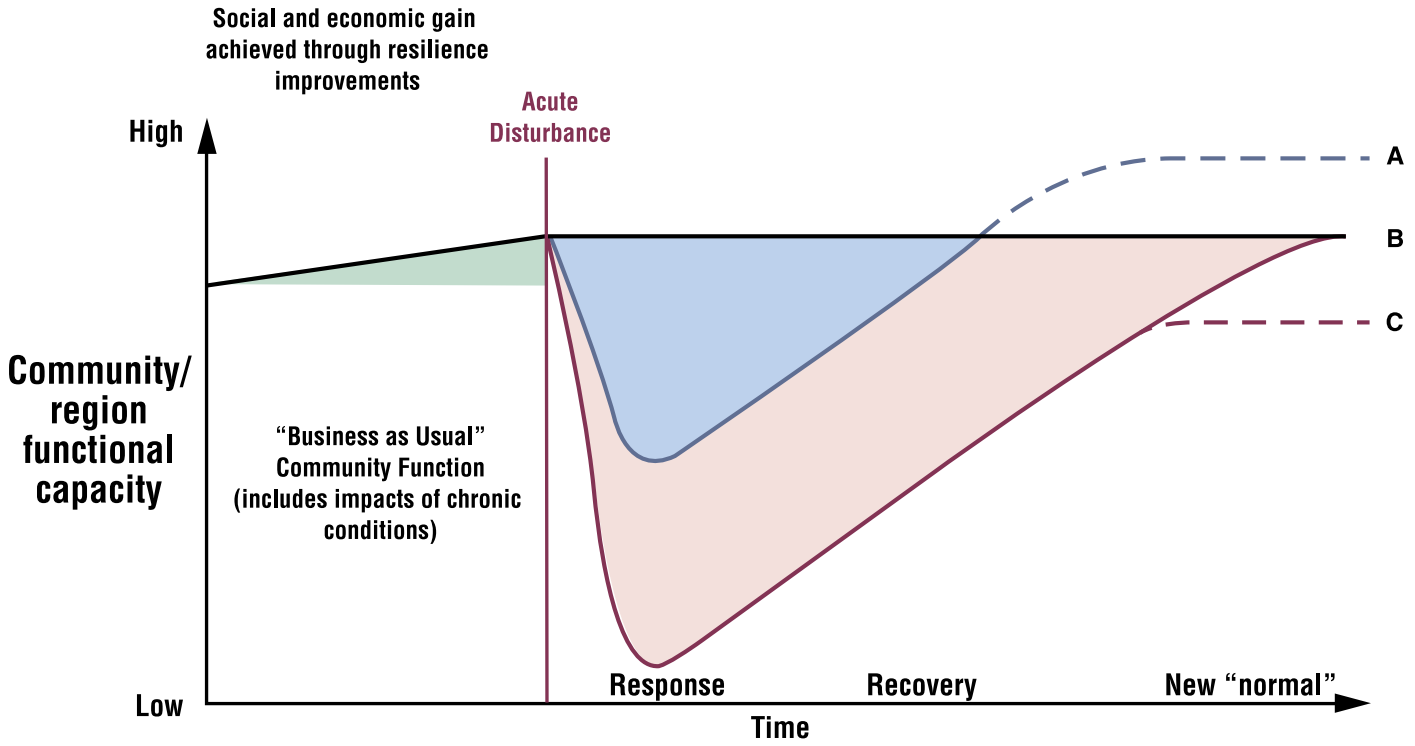


Figure 2. Resilience Loss Recovery Curve
Courtesy of Community and Regional Resilience Institute (CARRI) (www.resilientus.org)

government agencies to issue warnings, monitor threats and deploy resources. Many agree that this is a trend that must be reversed. Too much reliance on federal agencies such as the DHS, the Federal Emergency Management Agency (FEMA) and the military can be detrimental to a quick and thorough recovery. The reaction of local communities after a disaster can play a critical role and avoid overdependence on limited government resources. Further, local building codes can ensure resiliency by mandating resilient structural designs for new construction.

Who is at risk?

Nearly every part of the United States has been affected by severe weather conditions. In fact, for most of the country, there are a number of natural hazards to be concerned with from hurricanes to earthquakes (see Figure 1).

The Institute for Business and Home highlights how natural disasters affect Americans:

- In 2006, 34.9 million people were seriously threatened by Atlantic hurricanes, compared with 10.2 million in 1950.
- Approximately 40% of the population resides in counties that face medium to high seismic risk.
- One-quarter of residents live in a county that has been ravaged by wildfire during the past 25 years.
- In 2008 alone, there were 16 major tropical storms (eight of which were hurricanes), 1,700 tornadoes, and widespread flooding (due to winter and tropical storms, spring melts and other severe weather).

Some scientists believe that the frequency and intensity of extreme weather are likely to worsen with continued climate change (global warming).

How resilient communities differ from the status quo[2]

The Resilience Loss Recovery Curve (see Figure 2) helps explain how community function is affected by an acute disturbance (earthquake, chemical spill or hurricane) and depicts response and recovery curves. Community functions decline precipitously (blue and pink areas) as citizens respond to a disaster.

A more resilient community can more quickly restart local services (utilities, businesses, schools) and chart a path to a "new normal." The more resilient community incurs some losses (blue area) but avoids additional losses (pink area), because it has taken informed measures (anticipating threats, disaster response plans and recovery strategies) to minimize the impact of the disturbance. Mitigation efforts of resilient communities include: improved land-use decisions and building code implementation; construction of resilient infrastructure; improved business and household planning to minimize loss; and a better orchestrated response of both citizens and local agencies.

[2] From the Community Resilience System Initiative (CRSI) Steering Committee Final Report by Community and Regional Resilience Institute (CARRI)

Figure 3. Recommended times for return to functionality after a disaster.[3]
Courtesy of the San Francisco Planning and Urban Research Association (www.spur.org)

Resilient communities may find opportunities to transform themselves and grow. Thus, a resilient community's "new normal" may be a higher level of function (Line A) or it may be able to return to a level of function existing before the disturbance (Line B). The key to disaster recovery is not only to get essential services back up and running, but also to get people back to work. That means buildings not only must resist the damages caused by an adverse event, but must be in a condition suitable to occupancy as soon as possible.

Recommended Post-Disaster Recovery Times

The San Francisco Planning and Urban Research Association evaluated buildings in various categories from police and fire departments to hospitals to schools (see Figure 3). This evaluation shows recommended time lines (arrows) for reoccupation and functionality/service for a minimum level of community resilience after a disaster. Notice, for example, that hospitals and police and fire departments must be functional immediately after an adverse event in a resilient community.

Building Codes: First Line of Defense Against Disaster

Floods: One of the ways to achieve enhanced resiliency is with a few modifications to existing model building code requirements. For example, current international building codes set the base flood elevation as determined by FEMA or local jurisdiction. The requirement for enhanced resiliency would set the minimum elevation at no less than 3 ft above the base flood elevation as determined by FEMA Flood Insurance Rate Maps.

High winds: Damage from wind hazards is not only important for the performance of a building, but when failures occur, debris also can damage nearby structures and pose an increased threat to human life. The requirement for enhanced resiliency would require that basic wind speeds be increased by 20 mph for design purposes.

Fire sprinklers: Fire sprinklers, while not always capable of extinguishing or controlling fires, have clearly proven to increase evacuation time. In fact, the ICC[4] codes now require automatic sprinkler systems in most occupancies and even in one- and two-family dwellings. The criteria for enhanced resiliency simply extend the requirement for sprinklers to all buildings except low-hazard factories and storage facilities.

Storm shelters: Storm shelters have clearly demonstrated their ability to provide life safety during high-wind events. FEMA advises that even for most tornadoes, there is usually at least five minutes notice to seek shelter. The international building codes reference design and construction criteria for storm shelters where present, but

[3] For more information, see "The Resilient City" at www.spur.org/files/u7/RC-overarching.pdf

[4] International Code Council (ICC)

unfortunately do not provide guidance as to where storm shelters should be placed. Enhanced resiliency simply requires storm shelters for all buildings unless there is adequate, accessible shelter within ¼ mile.

Shelter from tornadoes: federal standards for safe rooms

The horrific devastation in Tuscaloosa, Ala., and Joplin, Mo., with a loss of more than 400 people, made 2011 the deadliest year for tornadoes in the United States since 1936. More than 1,500 confirmed tornadoes took some 550 lives and caused billions of dollars in damages. There has to be a better way to protect people from these storms. Certified and approved precast concrete safe rooms and storm shelters provide a secure area and peace of mind for families and communities when severe weather threatens.

To ensure that safe rooms are structurally sound units that provide near-absolute protection from adverse elements, FEMA has developed design, construction and operation criteria for architects, engineers, building officials, local officials, emergency managers and prospective safe room owners/operators. Two design guidelines are FEMA 320 and FEMA 361. FEMA 320 outlines the design criteria for residential safe rooms (up to 16 occupants), while FEMA 361 covers the development of public and community safe rooms.

Using FEMA guidelines as a standard, design and construction professionals led by the ICC and the National Storm Shelter Association (NSSA) have joined forces to produce the first ICC/NSSA Standard for the Design and Construction of Storm Shelters (ICC-500). Manufacturers of products meeting this standard assure prospective owners that their safe rooms will be able to provide life-safety protection. While fully supporting this effort, FEMA has continued to promote FEMA 320 and FEMA 361 guidelines to communities and individuals seeking further guidance.

Precast concrete safe room design meets federal standards[5]

Precast concrete safe rooms and shelters are classified according to location: aboveground (stand-alone) or in-ground (internal safe room). Each has several inherent advantages.

When designing a precast concrete safe room, structural integrity is the primary design consideration. Although human safety and health are fundamental to design, the first consideration should be a structurally sound unit that can withstand the direct and secondary forces of wind and windblown debris.

FEMA 320, FEMA 361 and ICC-500 outline the design requirements for the main wind-resisting structural system and components as well as cladding of these precast units. Standards also cover safety and health considerations such as lighting, ventilation, sanitation, fire safety, means of egress and minimum floor space.

Since tornadoes are typically short-term events, comfort is not a major factor in design, although precast concrete safe rooms provide additional comfort over other safe room designs in terms of ventilation, insulation and ease of installation. FEMA and ICC state that safe rooms designed to withstand tornadoes must provide a minimum of 5 sq ft of floor area per person. For long-term events, a minimum of 7 sq ft to 20 sq ft of floor area per person is required.

Resilient rebound of Greensburg, Kansas

For a real-world example of how a community came together to bounce back from a disaster and adopt resilience in their rebuilding, one only has to look to Greensburg, Kansas.

At 9:50 p.m. on May 4, 2007, an EF5[6] tornado leveled the city of Greensburg, totally destroying its infrastructure and more than 90% of its homes and buildings. While the average tornado is less than 50 yds across, this monster storm produced a twister that was 1.7 miles wide as it barreled through town with gusts exceeding 250 mph. Fortunately, Greensburg's citizens were given 20 minutes of warning that a big storm was coming, thanks to the National Weather Service, which upgraded the storm from a tornado warning to an "emergency," emphasizing the magnitude of its power. Eleven people lost their lives in the Greensburg tornado. It was estimated that if the storm had occurred later that night, hundreds of casualties might have occurred.

[5] Visit http://precast.org/2011/09/shelter-from-the-storm for Evan Gurley's article on precast concrete safe rooms in the September-October issue of *Precast Inc.* magazine.

[6] Enhanced Fujita Scale (EF5)

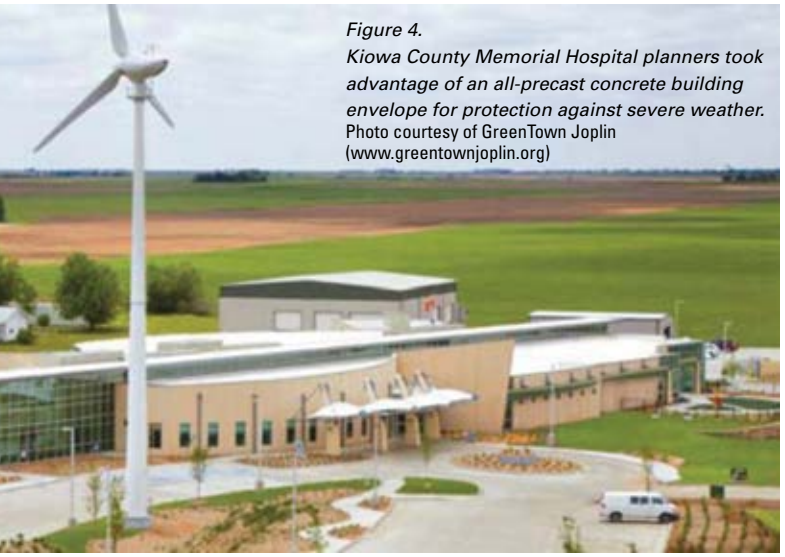


Figure 4.
Kiowa County Memorial Hospital planners took advantage of an all-precast concrete building envelope for protection against severe weather.
Photo courtesy of GreenTown Joplin (www.greentownjoplin.org)

Rebuilding with precast concrete resiliency

In the days immediately following the storm, several entities simultaneously had the notion to rebuild the community in a sustainable and resilient manner. Local leaders started meeting in a tent and residents came up with the idea to rebuild as "America's model green community" and "Greensburg Greentown" was born.

Many buildings were rebuilt using precast concrete. The Kiowa County Memorial Hospital is one such building, earning LEED Platinum certification, the highest certification level (see Figure 4).

The city's public works building was rebuilt on the site of the old power plant after the tornado, earning LEED Gold certification. The building envelope is precast concrete.

The Twilight Theatre, originally built in 1917, will be rebuilt as the all-new "Twilight Theatre & Community Auditorium" and will make use of modern construction methods and materials including precast concrete that support long-term sustainability, exemplifying standards for energy efficiency and resource conservation.

Resiliency and the role of precast concrete

While the challenges facing communities wishing to improve their resilience to natural and man-made disasters are significant, the benefits, in terms of saving lives and property, can be immeasurable. As the new construction in Greensburg's rebound illustrate, precast concrete systems are the preferred choice for resilient communities and structures.

Precast concrete has a solid track record for ensuring the fore-mentioned attributes of resiliency: long service life, robustness, sustainability, life safety, durability, recyclability and resistance to disasters. These are the many reasons communities across the United States are choosing precast concrete to protect their infrastructure, businesses, and homes and loved ones. PS

NPCA is a member of the Concrete Joint Sustainability Initiative (CJSI) and is partnering with other concrete industry members to encourage enhanced resiliency. For questions about this article, please contact Claude Goguen, NPCA's director of Technical Services, at (317) 571-9500 or cgoguen@precast.org.

Metrics: Hard to Swallow

Why metrics proved impractical for U.S. construction.

By Sue McCraven

You can lead a horse to water, but you can't make him drink." This adage is apropos of the unsuccessful adoption of metrics in U.S. construction. Our federal government has vacillated on mandating metrics as the primary system of measurement for decades. After almost 50 years of failed efforts, this article explains why the building industry has abandoned metrication.[1]

Metrics make sense

Metric units make more sense, right? In the first place, metric units are based on a rational, interrelated base unit system with prefixes in powers of 10. Secondly, the whole world has already converted to metrics. Even the U.S. pharmaceutical, electronics, education, beverage and auto industries use metrics. So why hasn't the building industry gone metric? To help clarify the answer, some historical background is in order.

Metric trivia for conversation starters

- **1866:** U.S. Congress legalizes the use of the metric system. While American scientists and engineers embrace and advance metrics, the general public clings to the familiar inch-pound or Imperial System of measurement.
- **1975:** The Metric Conversion Act of 1975 establishes the U.S. Metric Board to coordinate and plan increased use and voluntary conversion to the metric system; no target dates are set.
- **1982:** President Ronald Reagan disbands the U.S. Metric Board because of its ineffectiveness at bringing about national conversion.
- **1988:** Congress encourages metrification in the Omnibus Trade and Competitiveness Act by designating metrics as the preferred system of weights and measures for U.S. industry, trade and commerce. Most federal agencies are required to use metrics. There is no mandate for the private sector or for highway and construction industries to convert.
- **1991:** President George H. W. Bush signs Executive Order 12770, "Metric Usage in Federal Government Programs," directing all executive departments and federal agencies to implement the use of the metric system. Consequently, the Federal Highway Administration (FHWA) mandates metrification and state DOTs administer the policy. The Concrete Reinforcing Steel Institute (CRSI)[2] encourages reinforcing steel manufacturers to use soft metric markings for rebar size and grade (a No. 8 bar still retains its 1.00-in.-diameter measure, but includes the 25 mm [25 M] "soft" metric conversion marking).
- **1991 to 2011:** Use of metric markings on reinforcing bars continues to generate confusion on job sites with respect to specifications. Non-governmental firms and private organizations do not adopt metric units.
- **2008:** Because all FHWA partners have effectively abandoned metrics, the mandate is deemed to no longer make sense, and state DOTs abandon metrics.
- **2011:** ACI's Technical Activities Committee[3] encourages CRSI members to mark steel bars with traditional designations. CRSI passes a resolution for members to revert to inch-pound markings on steel reinforcing bars.

Why metric mandates don't work for construction

Bob Risser, P.E.

NPCA asked Bob Risser, P.E., president and CEO of CRSI, for his perspective on why the U.S. construction industry has abandoned metric conversion:

Do any U.S. construction projects use metric units?

Risser: No. There are no plans or specifications for construction produced anywhere in the U.S. that currently use metric units. By the late 2000s, the

remaining DOTs using metric specifications had converted to inch-pound units. The U.S. GSA (General Services Administration) and the U.S. Army Corps of Engineers no longer use metrics. In fact, no one in the engineering community, federal government, state government or private business anywhere in the country uses metrics for construction projects.

Why is CRSI reverting back to the traditional inch-pound system?

Risser: It makes logical sense for the industry to begin the process to move away from soft metric markings, because none of our private or government customers are using metric plans or specifications any longer. CRSI's recent resolution phase-in period (until January 2014) will allow industry members (who produce more than 90% of domestic steel) to make the changeover at minimal additional expense. CRSI is now in the process of making the appropriate changes to our manuals and literature.

With the rest of the world using the metric system, why doesn't construction make this seemingly logical conversion?

Risser: Because there is no incentive, no motivation, no market force pushing U.S. construction to use the metric system. It is important to understand that construction is not an "exportable" product. The U.S. liquor and pharmaceutical industries, for example, use dual units (both inch-pound and metric), because these businesses trade in the international marketplace where buyers use metrics as the primary system of measurement. There is a necessary mandate for metrics for industries that sell products globally. There is no market incentive or profit motive for the domestic building industry to use metrics.

If metrics never made sense for the building industry, why was there ever an effort to transition to metric units?

Risser: Money. In the '90s, the federal government mandate forced state DOTs to go metric if they wanted to be eligible for federal infrastructure dollars. The private construction sector (about 80% of all domestic construction) was never affected by the federal mandate and remained with inch-pounds, so private architects and engineers designing structures stayed with inch-pounds. This meant that contractors were forced to go from project to project, switching from metric to inch-pound units on the job site depending on the funding source. DOTs spent millions of dollars converting from inch-pound units to metric units. Money, not international pressure, was the only reason for federal-money agencies to convert to metric.

Even though there was a federal agenda for metrics, there was general public backlash to the metric system. Our speed limit signs remain in miles/hour, not kilometers/hour. We purchase gas in dollars/gallon, not dollars/liter, and so on. Does the typical person think of housing cost by sq ft or m^2? How does a construction worker visualize concrete compressive strength – in psi or MPa?

Why did many consider converting to metric a fiasco?

Risser: Millions of dollars were wasted because the FHWA, representing less than 20% of the total construction market, wanted to go metric. But because private industry and designers never budged,

CRSI has passed a resolution for steel reinforcing bar producer members to revert to inch-pound markings on reinforcing bars. NPCA file photo

the entire metric conversion agenda was dead in the water. We haven't calculated the cost to the steel reinforcing industry to retool the stamps to show soft metric conversions.

One of the reasons it was unworkable can be explained with a practical example. We have 12-ft traffic lanes in the U.S., and Europe has 3.8-m lanes (or 11 ft 10 in.). Well, when we started talking hard metric (actual narrower lanes: 11 ft 10 in. instead of 12-ft widths for vehicular traffic), the lawyers got involved. There was the possibility of lawsuits involving safety if lane widths were decreased in a metric conversion. Also, all the American paving equipment manufacturers were producing 12-ft or 24-ft equipment according to the inch-pound system of measurement. These paving equipment manufacturers would have to completely retool, at a cost of millions of dollars, to go to hard metric machinery. Eventually, by the early 2000s, about 40 state DOTs had abandoned metric units entirely.

U.S. CONSTRUCTION INDUSTRY STANDS ALONE

Outside the United States, this discussion of reverting to inch-pound units might take a different turn. From a more international vantage point, the U.S. construction industry's failure to convert to the metric system of measurement is apt to be viewed as a step backward. In the late 1960s, for example, England mandated the use of SI units of measurement for all construction, and private designers and engineers followed suit. The U.S. construction industry stands alone in the world in retaining inch-pound units.

One thing is clear after more than 40 years of pushing metrics on the U.S. construction industry: International market forces, not the government, are more effective at mandating wholesale conversion in measurement systems. Apparently you can give Americans the metric system, but you can't make them swallow it. **ps**

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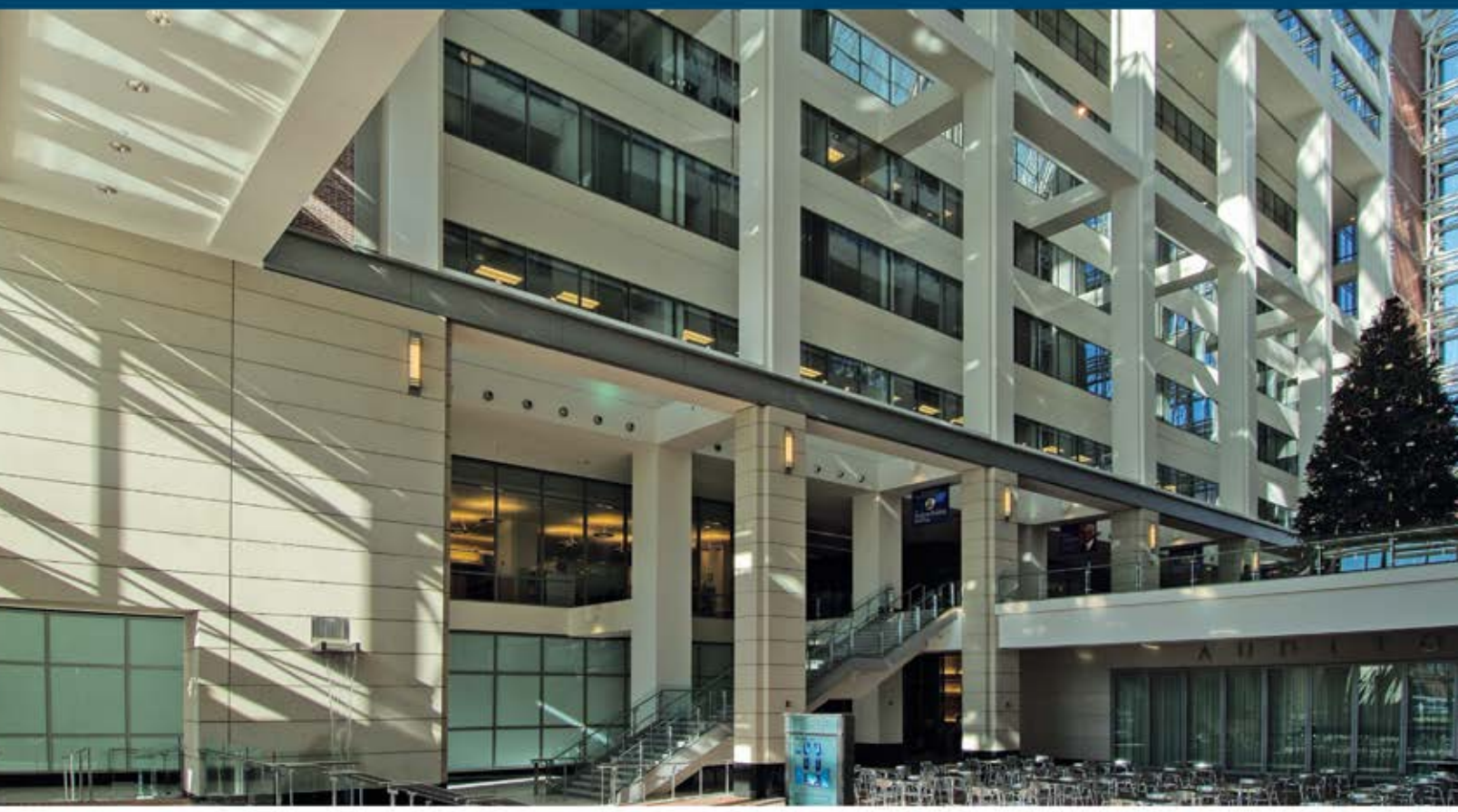
[1] Metrication is the conversion to the International System of Units (SI), a metric system of measurement, from a region's customary units of measurement, such as inch-pound.

[2] See "Steel & Concrete: Love at First Sight," Nov-Dec 2011 issue of *Precast Inc.* magazine, for an overview of CRSI.

[3] ACI is The American Concrete Institute. In 2003, ACI's Technical Activities Committee decided to maintain the inch-pound system of measurement in all its documents. For more information on the American Concrete Institute (ACI), see the May-June 2011 issue of *Precast Inc.* magazine for "ACI Strength through Consensus."



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