A Magazine for Specifiers and Engineers

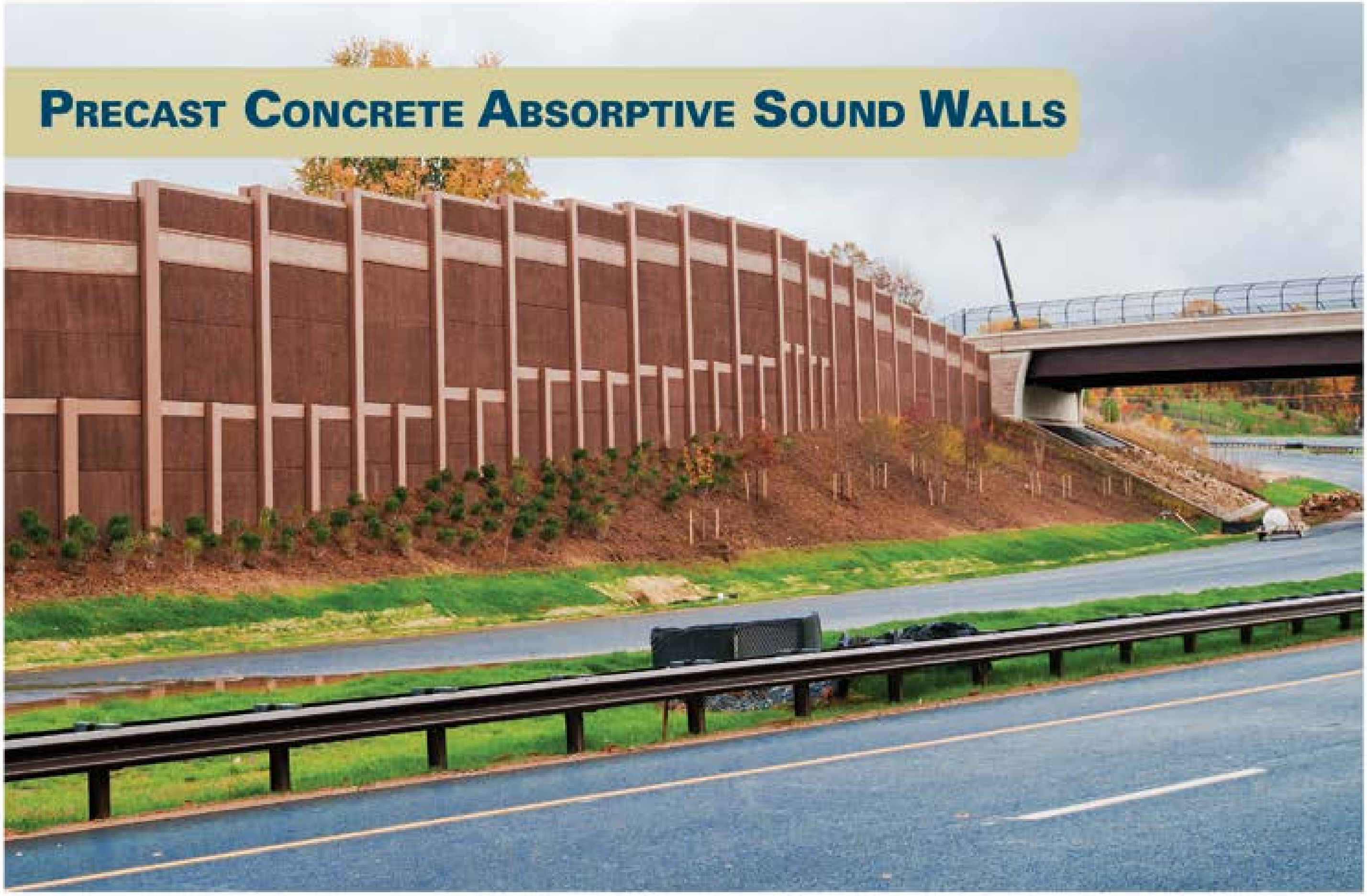
precast solutions

FALL 2012

NEW TECHNOLOGIES/MARKETS

In this issue:

Precast Concrete Absorptive Sound Walls



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FALL 2012
VOLUME 10 | NUMBER 4

ON THE COVER:
After arriving from the Oldcastle Precast - San Diego plant in California, an erection crew positions a BubbleDeck panel during construction of the new Harvey Mudd College teaching and learning center.

Photo Courtesy: Boora Architects (www.boora.com)

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NPCA
Precast ... The Concrete Solution

Custom Precast: Where Creativity and Concrete Meet

By Kirk Stelsel

When precast concrete began gaining popularity in the years following World War II, septic tanks and a few other mainstay products dominated the industry. Mix designs and forms were rudimentary compared with those used today, so early experimentation with new products was limited by the available technology.

Since then, major advances such as self-consolidating concrete (SCC), a wide range of admixtures, and batching equipment that can control mix designs with incredible precision have revolutionized the industry. In addition, cranes and trucks have gotten larger, enabling plants to manufacture larger and heavier products, and custom forms have evolved to the point where an endless array of shapes, textures and aesthetics are possible.

All of these developments have led to a precast

[1] Previous issues of *Precast Solutions* can be viewed online at http://precast.org/magazines

concrete industry that can manufacture virtually any structure an architect or engineer can design. Products that would have been unimaginable or simply unprofitable in the past – such as one-off pieces, custom changes to a standard product, elaborate and precise shapes, or architectural colors and textures – are now everyday realities.

For above-ground precast, this means products that belie the public perception of concrete as a gray, mundane building material. In the Winter 2011 issue of *Precast Solutions*,[1] the "Precast by Design" article showcases custom veneers, finishes, colors, shapes and textures. Versatile form liners enable precast plants to mimic virtually any look from natural stone to wood grain. Add to that today's advanced surface options and coloring systems, and almost any artistic aim is achievable.

Even underground products that spend their service life out of the public eye have changed dramatically. In the Fall 2011 issue of *Precast Solutions*, the three underground projects that won NPCA's Creative Use of Precast (CUP) Awards perfectly illustrate this point.

Oldcastle Precast – San Diego manufactured massive caissons for a sensitive military project. Each base weighed in at a whopping 279,600 lbs, and all pieces were cast to exacting specifications. In New York, Garden State Precast's Bronx River Combined Sewer Overflow project included three specially designed chambers that remove solids from the sewer's outfall. And in Ohio, Norwalk Concrete Industries worked with Delta Engineers, located in Endwell, N.Y., to design a space- and time-saving precast concrete sluiceway that was originally slated to be cast-in-place concrete. This precast solution won over the project engineers. The sluiceway was part of Indianapolis' reinvention of a three-block stretch of road into a pedestrian promenade, which became the hub of all street-level activity during Super Bowl XLVI.

While standard precast concrete is still the go-to solution for many construction projects, unique and innovative products have become more customary than custom for today's advanced precast concrete industry. **ps**

Kirk Stelsel is NPCA's director of Communication and associate editor for Precast Solutions *magazine.*

Precaster's Notebook:

Fixing Manhole Installation Problems

How to assess and repair manholes with misaligned rungs, leaks and section damage from improper backfill operations.

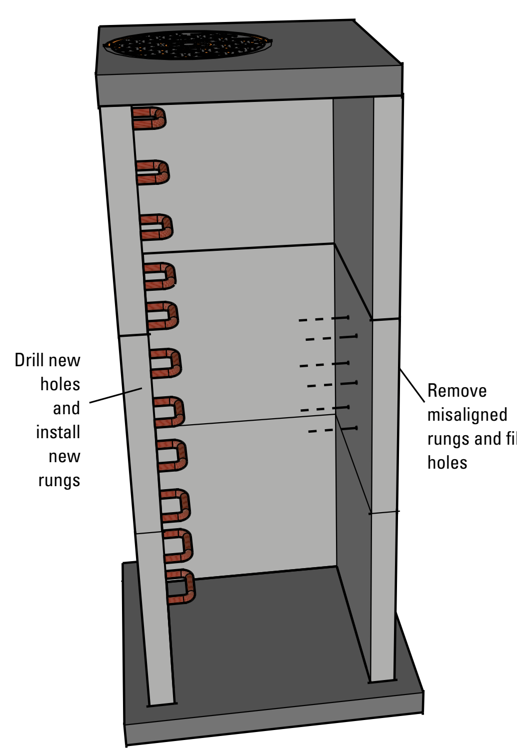
By Gary K. Munkelt, P.E.

Rungs are installed directly below the manhole cover or hatch to provide access to the inside, and so it is essential to ensure that they line up from section to section during manhole installation. When the rungs are not in line, new holes must be drilled, new rungs installed and old rungs removed.

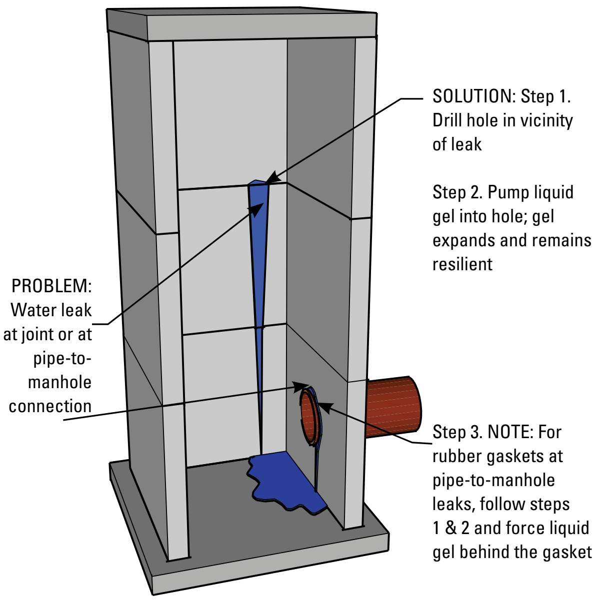
PROBLEM A: During installation, rungs are not properly aligned from section to section.

Most precast concrete structures on sanitary sewer projects must be watertight. Occasionally, leaks occur at the section joint or at the pipe-to-manhole connection. These leaks are easily repaired with chemical gel that expands when exposed to water. To repair, drill a small hole in the area of the leak and pump the chemical into the hole. When the chemical is in contact with water, it expands and provides a permanent, resilient seal. Use chemical gel in accordance with the manufacturer's instructions.

SOLUTION A



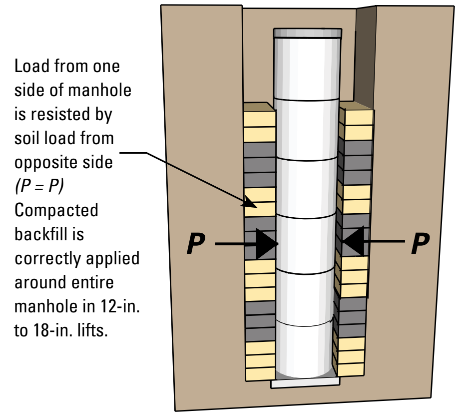
SOLUTION B



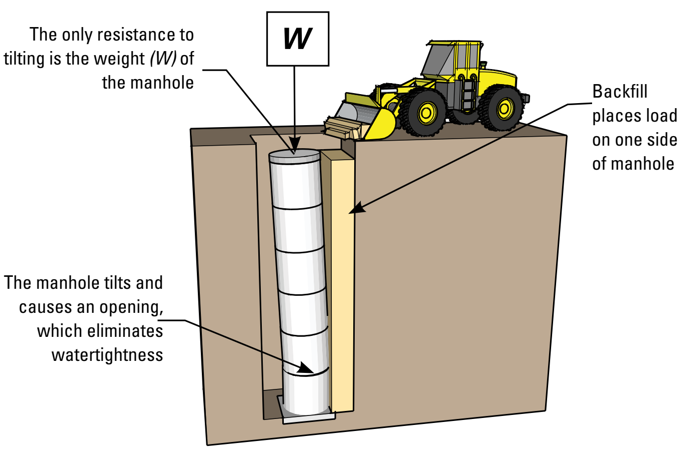
PROBLEM B: Water leaks can occur at joints or at pipe-to-manhole connections.

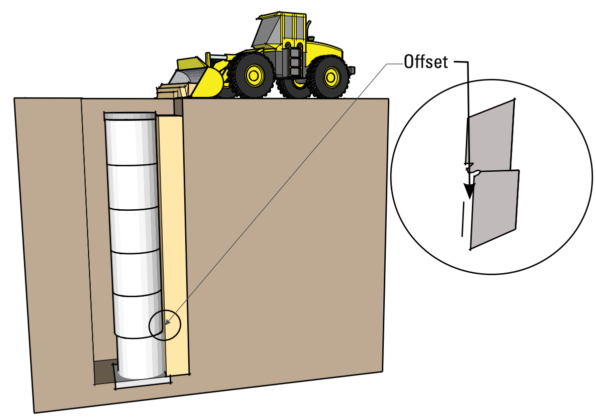
The correct way to place backfill is to alternate compacted 12-in. to 18-in. lifts on both sides of the manhole. This allows the soil load from one side of the manhole to be resisted by the soil load from the opposite side (See graphic at right).

There are situations, however, when contractors will place backfill material on one side of the structure, all the way up to grade. This places loads on the concrete that are different from the design.



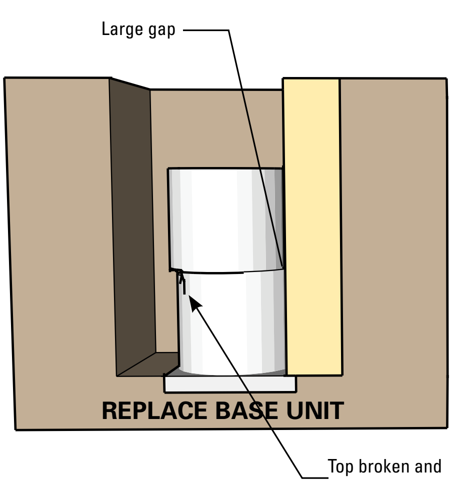
PROBLEM C: First, a tall thin structure such as a 48-in. diameter manhole could be tilted, leaving the chamber exposed to leaks from groundwater (See graphic at lower left).

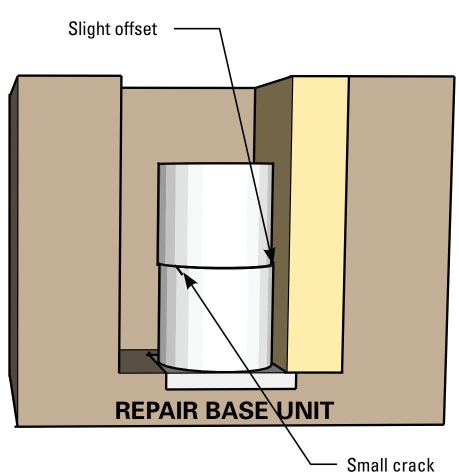




Second, larger-diameter manholes may not tilt but the uneven load places a large force on the shiplap or tongue-and-groove joint. This could cause the upper section to move laterally so that the walls do not form a straight line (See graphic above right).

Third, sometimes the movement is so large that the base unit needs to be replaced. When the movement is small, however, repairs can be made in the field (See graphic below). 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 Concrete Can Be Habitat-Forming

A NetZero Habitat for Humanity home in Canada could become the prototype for the future of sustainable housing.

By Sue McCraven

Canadian engineers and architects have created a structure unlike any other in North America. Using the latest energy-efficient designs, materials and technologies, this experimental, one-of-a-kind building will house two families in cooperation with Habitat for Humanity Edmonton, Alberta. But this prototype's purpose is more than humanitarian. The energy use of the occupied home will be monitored for three years, with the test results serving as both a learning experience in NetZero[1] design and construction and as a model for the future of economical, sustainable housing. Given Alberta's harsh winters – where peak low temperatures reach -30 F – this project will serve as a severe test of energy efficiency.

Habitat for Humanity Edmonton teamed up with Lafarge and Stantec, an Edmonton-based consulting firm, to build this first-of-its-kind, NetZero home. Klaas Rodenburg, sustainable design coordinator for Stantec, said, "This NetZero prototype can be mass produced and shipped to other locations at significant cost and time savings." The project collaborators hope to attain

[1] NetZero means that the energy produced = the energy used.

LEED® Canada for Homes Platinum certification from the Canada Green Building Council.

How to design a zero-energy home

The design of the Edmonton home is so efficient that, over time, the resident families should receive no heating or electrical bills at all. Instead, they will rely completely on the home's renewable solar and geothermal systems for all their energy needs.

The home generates its own solar power on sunny days during the summer and returns the collected solar and geothermal energy to the power grid for storage. During the winter season, the residents obtain their heat and electricity by drawing on the accumulated energy in the power grid. Energy transfer from the fluid in the underground geothermal pipes delivers heat for warmth while the photovoltaic rooftop panels provide hot water and electricity. The duplex's interior finishes use sustainable materials throughout as well.

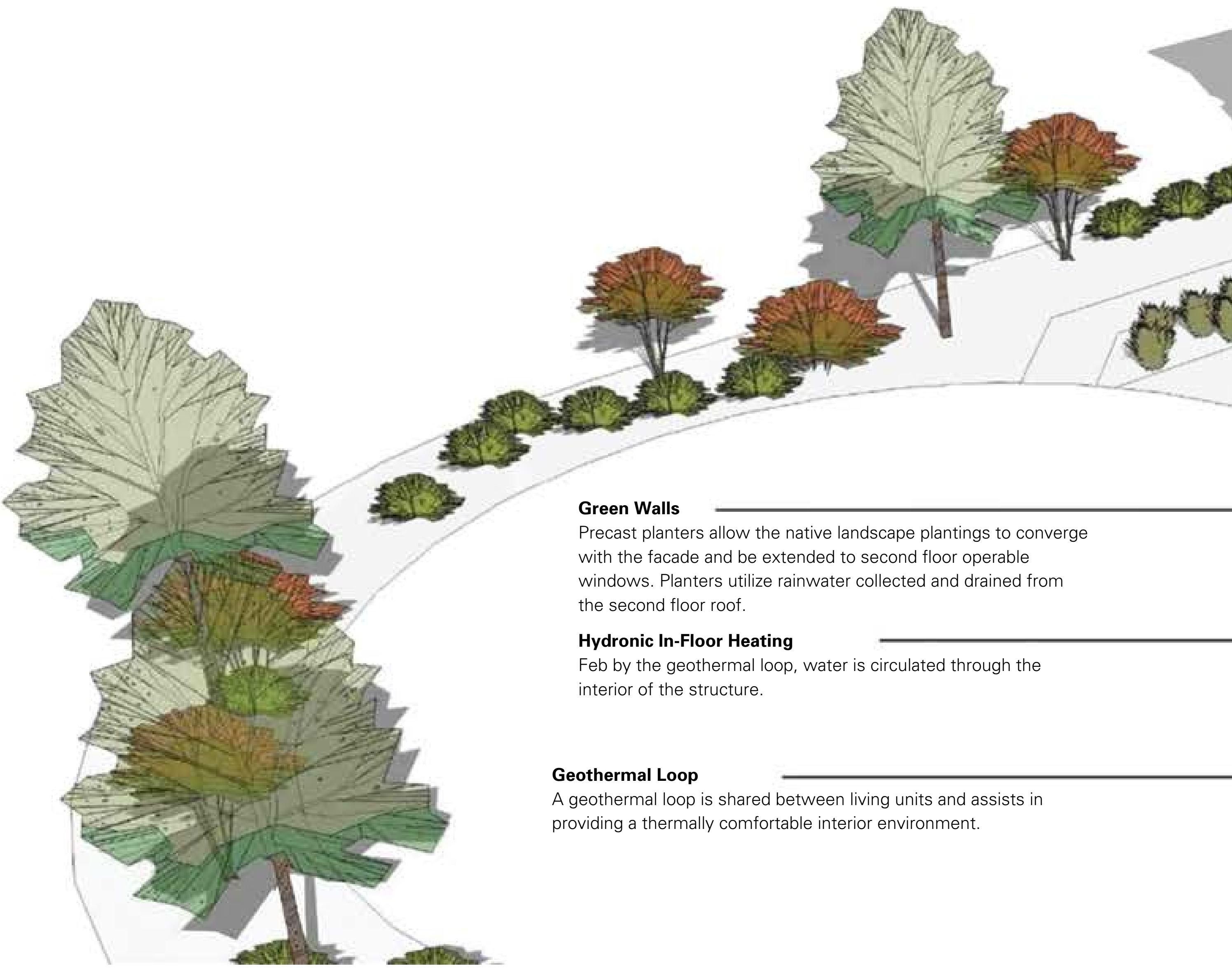
Rodenburg explains that, in terms of energy savings, the precast building envelope is the most important element of the NetZero home design. "Up to this point, a zero-energy house has been only engineering theory. But

The two Edmonton families (on the left in the photo) who will live in the NetZero precast concrete duplex will pay an interest-free mortgage to Habitat for Humanity and will invest 500 hours of "sweat equity" into their new home. The three gentleman on the right are: Dennis Lattimore, Lafarge; David Dorward, MLA for Edmonton – Gold Bar; and Edmonton Mayor Stephen Mandel.

Photo courtesy of Stantec (www.stantec.com)

Net Zero Systems

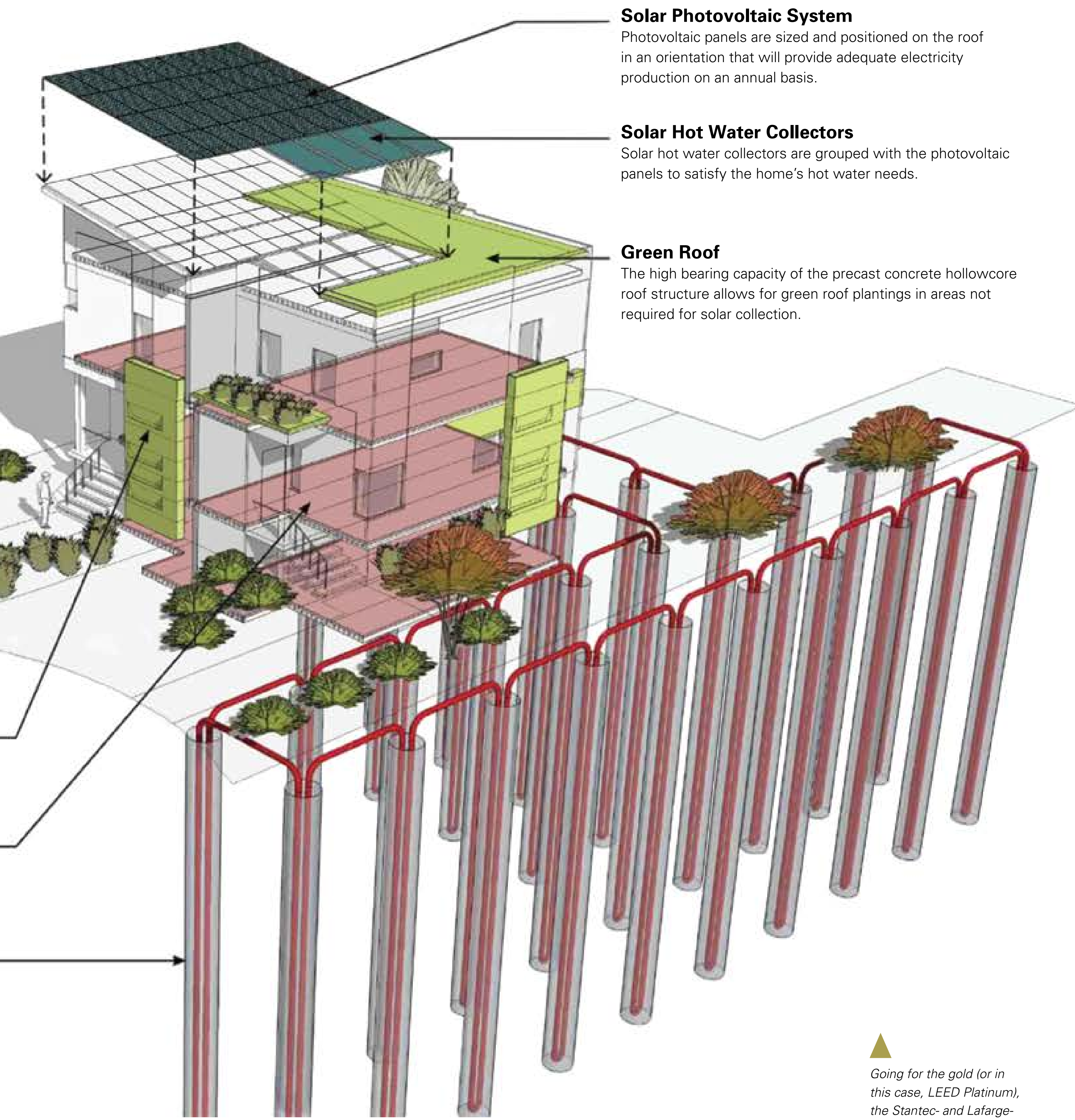
Throughout the development of the Habitat Net Zero Prototype, sustainable systems were designed to be incorporated to allow the duplex units to achieve zero net energy on an annual basis.



we hope to prove the energy efficiency of the Edmonton home's performance through monitoring and testing."

MIT versus "greenwashing"

Until now, most claims of energy efficiency and sustainability have been just that: claims. "Too often we hear of buildings that are pronounced LEED certified or targeted NetZero at ribbon cutting," said Don Zakariasen, Lafarge director of precast marketing, "but no one sees the operating results." To remedy this situation, Lafarge and Stantec

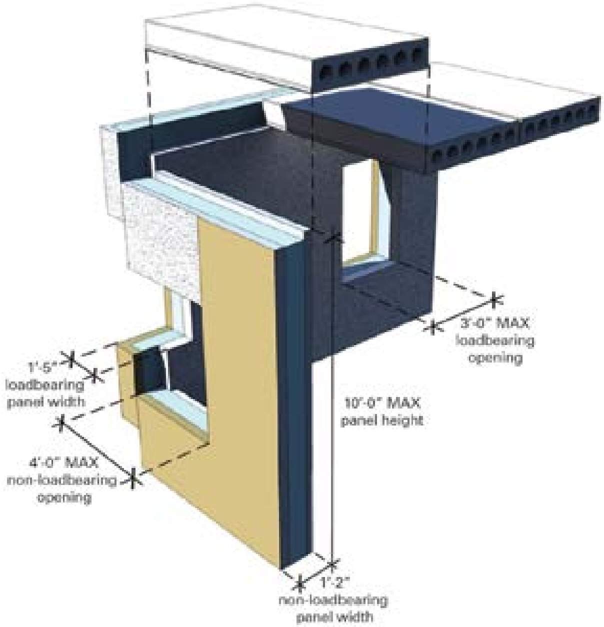


Going for the gold (or in this case, LEED Platinum), the Stantec- and Lafarge-designed Edmonton NetZero Habitat for Humanity home uses the latest heating and energy technologies in solar, geothermal, hydronic and green sustainable solutions.

Graphic Courtesy of Stantec Architecture LTD (www.stantec.com)

engaged the Massachusetts Institute of Technology (MIT)[2] to perform a third-party, objective, 24/7 monitoring study on the Habitat for Humanity home while it is occupied and in normal use by the resident families. The hope is that MIT's test results will provide proof of the prototype's energy-efficient performance and matchless design. An example of one test, said Rodenburg, will be "an air-blower door test to generate data on heat loss" through entranceways.

[2] Lafarge has been involved with the MIT Concrete Sustainability Hub on initiatives looking at concrete from the nanoscale to the urban building scale. The NetZero Edmonton home will serve as benchmarks to this research.



Using insulated precast concrete panels, the exterior of the Habitat for Humanity home was assembled in one day. Precast concrete fabricated by Lafarge's Edmonton facility makes up the home's airtight, energy-efficient envelope.

Photo courtesy of Stantec
(www.stantec.com)

The precast concrete envelope of the NetZero home will be severely tested in Edmonton's harsh winters, where daily temperatures average around 11 F and can reach peak low temperatures of -30 F.

Graphic courtesy of Stantec
(www.stantec.com)

How different families use energy

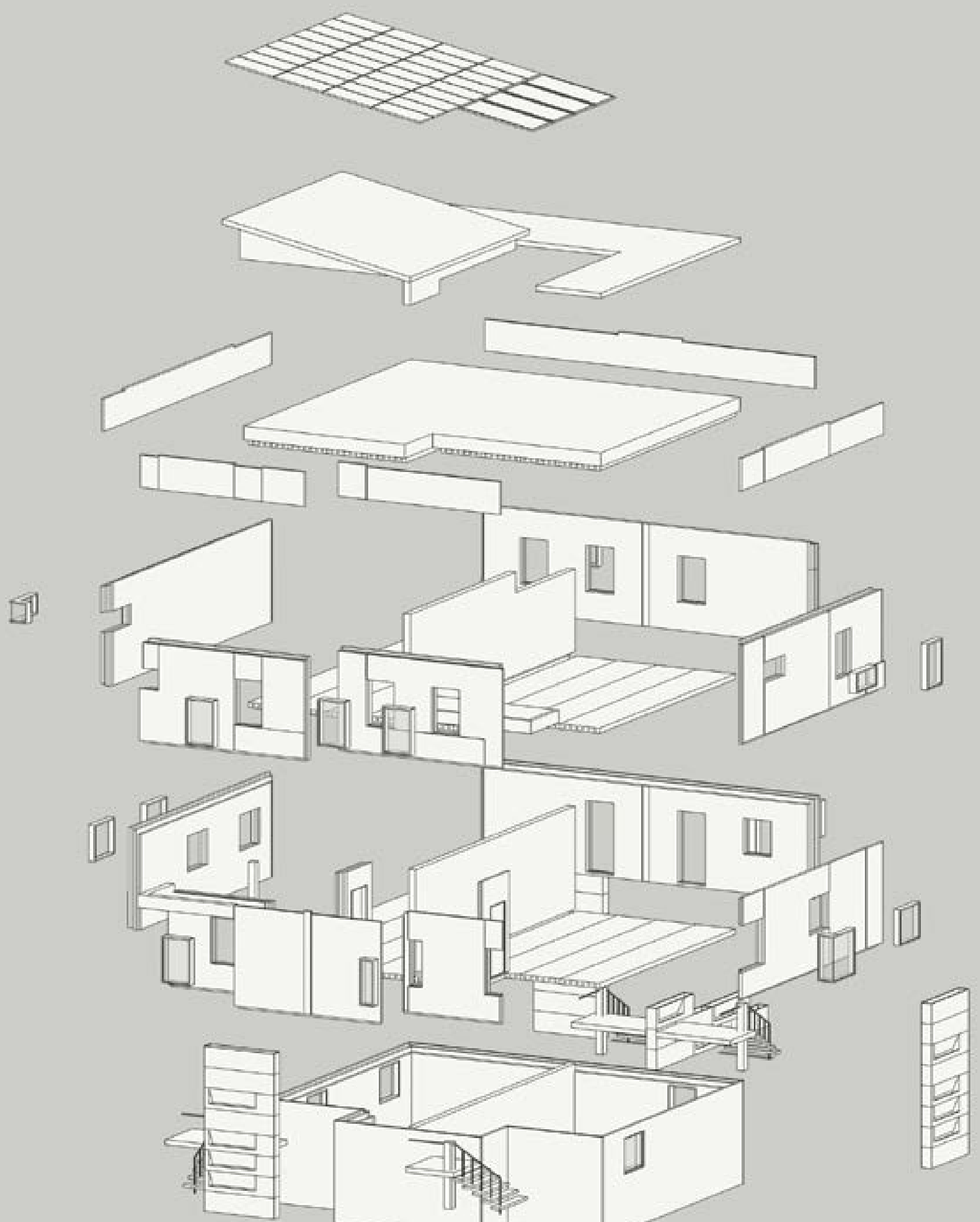
Monitoring the energy performance of the NetZero duplex home during a three-year occupancy will provide important information for designers. Performance data will compare each family's energy use and will also see how results compare with Edmonton's typical wood-frame housing. Results will reveal how many Joules of energy are transferred for every square inch of precast concrete used in construction. And because Edmonton's winter temperatures average a bone-chilling 11 F, the energy performance of the prototype's design and construction will reflect challenging conditions.

By recording the energy use of two different families, results can show how personal preferences for thermostat settings and electric lighting affect home energy efficiencies. For example, explained Rodenburg, the length of time family members leave doors and windows open can significantly affect total energy use. In addition to energy use, monitoring will measure temperatures and humidity inside and outside the home.

The human face of ultimate engineering design

"Habitat for Humanity Edmonton is a nonprofit organization working toward a world in which everyone has a safe and decent place to live," said Alfred Nikolai, president and CEO of Habitat for Humanity Edmonton. "Innovative projects such as this NetZero home are imperative as we seek to provide sustainable and

HABITAT NET-ZERO PROTOTYPE



affordable home ownership to families in need."

A most telling measure of the human value of the NetZero precast concrete home comes from one of people who will live in the modernistic duplex. "My family is so grateful to everyone involved in making home ownership a reality for us," said Tracy, Habitat partner and mother of four. "My husband and I will soon be building equity in this NetZero home and be able to save for our children's future." PS

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

This rendering shows the precast concrete elements that comprise the envelope, inner walls, floors and roof of the prototype home.

Graphic courtesy of Stantec Architecture LTD (www.stantec.com)

Assistant professor in the College of Engineering, Tristan Al-Haddad (left), and students Patrick Di Rito (center) and Sam Kim (right) evaluate highly customized precast concrete wall panels that were manufactured using a new process.

Photo courtesy Georgia Institute of Technology (rick.robinson@innovate.gatech.edu)
Photograph by Gary Meek (gm@garymeek.com)

Liquid Walls

Computer to Construction: Technique enables mass production of custom concrete building components from digital designs.

Story by Rick Robinson, photos by Gary Meek

Like other professionals, architects have used computer-aided design (CAD) software in their work for decades. Typically, the resulting digital files are converted to hard-copy plans, which are then used to support traditional construction practices.

Researchers in the College of Architecture at the Georgia Institute of Technology are now automating some of the processes by which computer-based designs are turned into real-world entities. They're developing techniques that fabricate building elements directly from digital designs, allowing custom concrete components to be manufactured rapidly and at low cost.

"We're developing the research and the protocols to manufacture high-end customized architectural products economically, safely and with environmental responsibility," said Tristan Al-Haddad, an assistant professor in the College of Architecture who is a leader in this effort. "We think this work offers opportunities for architectural creativity at a new level and with tremendously increased efficiency."

In one recent project, Al-Haddad and a College of Architecture team collaborated with Lafarge North America to fabricate an award-winning building-element concept called a "Liquid Wall." The Georgia Tech team employed digital techniques to help construct a prototype wall, using ultra high-performance concrete; the result was displayed by the New York Chapter of the American Institute of Architects (AIANY) in the "Innovate:Integrate" exhibition.

In another Lafarge-sponsored project, Al-Haddad and a College of Architecture team are developing a complete free-standing structure using ultra high-performance concrete (UHPC) elements fabricated directly from digital designs.

The Liquid Wall, originated by Peter Arbour of Paris-based RFR Consulting Engineers, won the 2010 Open Call for Innovative Curtain-Wall Design competition conducted by the AIA. The concept advanced a novel approach to curtain walls, which are building coverings that keep out weather but are non-structural and lightweight.

RFR's plans called for the Liquid Wall to be constructed of stainless steel and Ductal, a light and strong UHPC produced by Lafarge. Moreover, the new building enclosure was conceived as an entire system, including integrated louver systems, solar shading, integrated

Assistant professor at Georgia Tech's College of Architecture, Tristan Al-Haddad, on the left, examines architectural prototypes in the college's Digital Building Laboratories with research scientist Karl Brohammer. Digitally created and using UHPC, lightweight precast concrete prototypes were successfully fabricated by Coreslab Structures Inc. in its Atlanta facility.
Photo courtesy Georgia Institute of Technology (rick.robinson@innovate.gatech.edu)
Photograph by Gary Meek (gm@garymeek.com)

passive solar collectors and other advanced features.

Georgia Tech became involved in the Liquid Wall project when RFR decided to build a full-scale prototype of the complex concept. RFR asked Al-Haddad to help turn Arbour's original parametric sketches into a manufacturable design.

Supported by the College of Architecture's Digital Building and Digital Fabrication Laboratories, the researchers refined the geometry of the original sketches for manufacturability and developed the techniques required for fabricating a full-size curtain wall. Then, working from their digital models and using a five-axis CNC router – a device capable of machining material directly from a digital design – the Georgia Tech team milled a full-scale model of the wall. The model was made from a lightweight polymer material, expanded polystyrene (EPS) closed-cell foam, which was then given a polyurea coating.

The digitally milled foam model created an exact replica – a positive -- of the final wall. The lightweight positive could then be used to produce a negative capable of forming the actual prototype. In this case, the collaborators used the positive to produce a rubber mold – the negative – from which the final wall was cast.

The foam positive was shipped to Coreslab Structures Inc., a large corporation that specializes in industrial-scale casting. The Georgia Tech team then worked with Coreslab to identify the best techniques for creating the rubber mold and for pouring in Ductal to form the concrete wall.

"It was a very collaborative process – the four major players were Peter Arbour and RFR, Georgia Tech, Coreslab and Lafarge," Al-Haddad said. "And we had all of three weeks to finish the work before the exhibition deadline – so it was pretty intense."

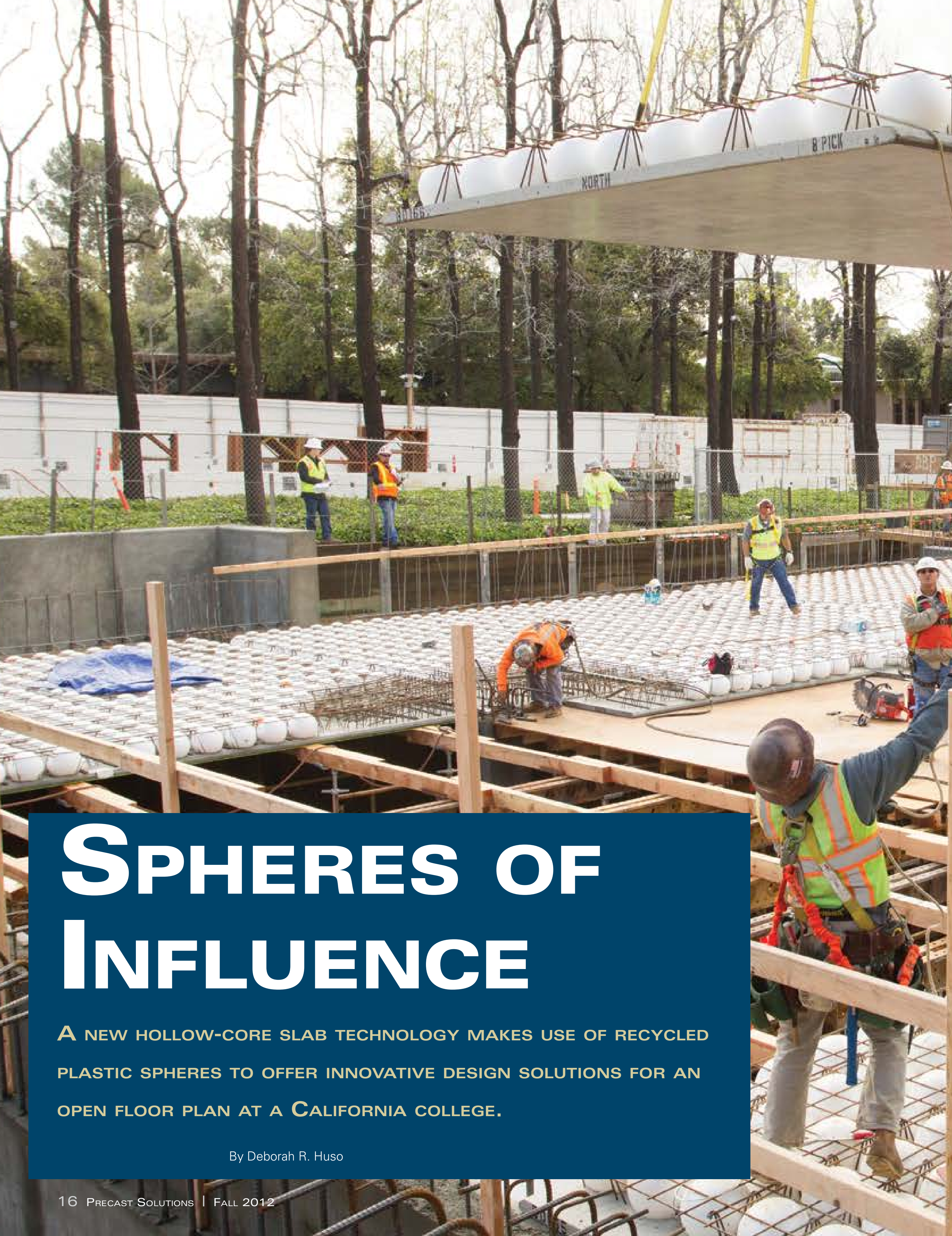
"The Liquid Wall project was challenging," said Charles Eastman, director of the Digital Building Laboratory, who holds joint appointments in the College of Architecture and the College of Computing at Georgia Institute of Technology. The process not only involved producing rubber negatives using wall-form designs created with CAD and parametric-modeling software, but also required identifying the right production procedures and finding effective ways of installing a completed full-size wall on a building.

"When you're creating a completely new process like the Liquid Wall, you're faced with developing a whole new manufacturing process for this kind of material," Eastman said.

A future project, expected to be about 20 by 20 ft square and 15 ft high, will be built using Ductal UHPC, principally or entirely. A central technical challenge will involve molding the many custom elements so that all edges fit together and form a structure that is stable, practical and aesthetically pleasing.

"We understand the structural side of a project like this quite well – the difficulty comes in the actual manufacturing of the elements," Al-Haddad said. "We want to advance the use of digital parametric models with custom molding systems, and create a free-form manufacturing system that can produce many variations quickly and accurately." **PS**

This article was provided courtesy of the Research News & Publications Office, Georgia Institute of Technology, Atlanta, Ga. For more information, contact Media Relations representative John Toon at (404) 894-6986 or jtoon@gatech.edu.



Spheres of Influence

A new hollow-core slab technology makes use of recycled plastic spheres to offer innovative design solutions for an open floor plan at a California college.

By Deborah R. Huso

When officials at Harvey Mudd College decided to build a new teaching and learning center, they wanted to update its 1950s look. The college leaders envisioned a sustainable structure with naturally lit open spaces that would preserve the predominant concrete architecture of the campus. The challenge was to create large open spaces in classrooms and lecture halls without the interruption of columns and beams. The project's design-build team found the solution in BubbleDeck, a new hollow-core slab technology that allows for extensive spans of floor and ceiling without typical column supports.

Although it was the first in California and one of the first in the United States to make use of

BubbleDeck panels are produced by setting the steel-mesh-encased plastic spheres into 2.5 in-to 3-in. of fresh concrete.

Photo Courtesy: Spancrete (www.spancrete.com)

Aerial photo shows the inner courtyard and erection crane during construction of the new Harvey Mudd College teaching and learning center. "We're obviously a bit of guinea pig here," said the general contractor of this first experience with new BubbleDeck technology.

Photo Courtesy of Matt Construction (www.mattconstruction.com)

BubbleDeck technology, the product has been used successfully in Europe, Canada and Australia. The college selected the BubbleDeck technology mainly because it helped meet the school's goals for open floor plans and sustainability with a reduced construction timeline. In addition, the BubbleDeck system offered easier construction within the tight parameters of the job site. (For a description of the technology, see the sidebar "What Is Bubbledeck?")

Building up to a new design

Founded in 1955, Harvey Mudd College (HMC) has maintained a very uniform, mid-century aesthetic and has done little building since its founding. The teaching and learning center is the college's first major construction project in decades, and, as Josh Brandt says, "They knew they needed to step forward design-wise."

Brandt, project architect with Boora Architects and designer of the new structure, points out that many of the school's existing buildings are dark with low ceilings. He says one of his firm's major goals was to "provide a building that reflected the quality of the work going on inside"– that is, HMC's status as an engineering school. The objective was to provide as much height and daylighting as possible within the building's classrooms.

Brandt says Boora Architects anticipated using concrete from the start. "All the other buildings on campus are concrete, so there were aesthetic reasons for using concrete," he explains. More importantly, concrete offered the benefit of fireproofing without additional finishes. However, Brandt says typical designs that use a flat-slab concrete system would have been really limiting. The building presented a significant design challenge with its large classrooms for up to 50 people and the desire to maintain open space without columns. It was the structural engineering firm, KPFF of Los Angeles, that introduced the design-build team to BubbleDeck technology.

"A First" for precaster and contractor

Oldcastle Precast – San Diego took on production of the BubbleDeck slabs after learning about the technology from BubbleDeck North America. "We're known for taking on unconventional projects," explains Todd Ebbert, Oldcastle Precast – San Diego's general manager.

"BubbleDeck has to find a precaster locally for every project in a new market," Elan Hertzberg, general manager at Matt Construction, explains, noting that the Oldcastle plant is about three hours away from the HMC building site. For Matt Construction, the general contractor, this is its first BubbleDeck project. "The precast work we've done in the past has been vertical systems," says Hertzberg. "This is the first horizontal structural deck we've done."

Ebbert says the HMC project has been ideal for BubbleDeck, because it calls for an open floor plan with high ceilings. HMC is an engineering school, so

the BubbleDeck slabs will be exposed, revealing "raw concrete as ceilings," Ebbert notes, "and in most cases, plumbing and electrical will be exposed as well." Seeing the configuration of building utility systems provides a valuable experience for budding designers.

Scheduled for completion in fall 2013, the HMC project will have an interior courtyard and feature 360 BubbleDeck panels, about 100 floor panels and 58 panels on the roof. The building's four floors, including one subgrade level, will contain 90,000 recycled plastic bubbles, totaling 70,000 sq ft of surface area. Brandt says that unlike most projects involving precast concrete components, this one has not benefited from production repetition. In fact, he says, there is pretty much "zero repetition" in the size and shape of the slabs, which are basically a series of C and V shapes.

How the system comes together

The project team admits this first experience with a new technology comes with a steep learning curve. The diverse panel configurations "can be tricky" and consequently required careful production planning. "The underside of the deck is smooth, and it looks gorgeous," but to achieve that smooth surface for the building's ceilings, J boxes for light panels had to be precast into the panels, so there is significant pre-planning involved to make it work. "Everything had to be set according to a fabrication schedule."

Hertzberg says he'd be willing to take on another BubbleDeck project but offers advice for other

What is BubbleDeck?

BubbleDeck is the invention of Jorgen Bruenig, who devised the first biaxial hollow slab (now known as BubbleDeck) in Denmark. Since then, BubbleDeck has been taking off "in a big way" in Europe, according to Jerry Clark-Ames, manager of BubbleDeck North America. The technology moved overseas in 2005 with the first projects going up in Canada. There have also been numerous successful BubbleDeck projects in Australia, Malaysia and Brazil.

"Most projects in North America have been for floor plates," Clark-Ames says. His company does not manufacture the slabs themselves but delivers materials for making them to an approved precaster. "BubbleDeck doesn't usually conflict with a precaster's existing market," he adds. "Most precasters' stuff tends to be single-direction plate as opposed to BubbleDeck, which is a two-way plate."

The production process for BubbleDeck begins with the assembly of cages to hold the plastic spheres that serve as the slab's hollow core. Clark-Ames says there are two slats of steel mesh per panel. Basically, the mesh is a welded-wire fabric with an offset spring. Precast producers install a lattice girder in the longitudinal plane of the panel formwork and then add the hollow spheres. A top mesh locks everything together. The cages are then set in forms containing 2.5 to 3 in. of fresh concrete. A typical panel is about 8 ft wide by 30 ft long, about 250 sq ft.

The system uses a third less concrete than a traditional slab and does not require special concrete. "You can use standard products like 5,000 psi self-consolidating concrete," Clark-Ames says. He says BubbleDeck can represent a substantial cost savings for large decks with a 12-in. or greater slab thickness because of the reduction in concrete and construction time. "You can put all the panels together in as little as two days," he notes. "You're taking labor from the job site and putting it in the factory."

Spancrete first to use BubbleDeck in U.S.

BubbleDeck made its U.S. debut in 2011 with the construction of an underground walkway at the University of Wisconsin-Madison's La Bahn Arena. The open-space walkway had to be able to support a road overhead that would safely carry an 80,000-lb. emergency vehicle.

Clark-Ames explains that the walkway called for large, self-supporting spans able to carry significant dead and live loads. "It was an immense amount of weight over a large area," he says. The design-build team for the project, led by Wisconsin-based general contractor Findorff, looked to BubbleDeck to provide the needed span structural strength without traditional columns and beams.

Spancrete, the project's precaster, made two dozen 21-in.-thick panels for the walkway's 12,000-sq-ft ceiling, each holding the 16-in.-diameter recycled plastic spheres. "There was quite a learning curve associated with this project," says Clint Krell, director of sales for Spancrete. "But this product is already engineered when we get it. The bulk of our cost is labor."

For more information, visit www.bubbledeck.com.

A BubbleDeck panel arrives from the Oldcastle Precast - San Diego precast plant in Calif.

Photo Courtesy: Boora Architects (www.boora.com)

contractors. "The best thing to do is to actually view a project to see how simple it is, how beautiful the underside is, and how wide the column spacing is." He emphasizes the need to be part of the planning process early on, to work with engineers before panel fabrication begins to determine the size of panels and locations of floor boxes. "BubbleDeck is a state-of-the-art technology from an aesthetic standpoint," Hertzberg adds. "It's amazing."

Brandt agrees with Hertzberg in defining the major challenge as coordinating mechanical, electrical and plumbing into the slabs. "You have to make decisions a lot earlier in the process," he says.

The BubbleDeck slabs arrive on the job site partially assembled and have a 2- to 5-in.-thick precast concrete base embedded with a reinforcing steel cage securing the hollow plastic balls with each plastic sphere precisely spaced and locked in position. The honeycomb shape of the cage adds strength to the slabs. On site, the slabs are connected with steel bats and topped with a second wire mesh (for additional strength) before concrete is poured over the balls to create the smooth finish of the building floors.

In the HMC project, five sphere sizes are used in slabs ranging in thickness from 9 in. to 20 in. All the spheres, or bubbles, are made from recycled plastic. Brandt says 13.5 in. is the typical slab thickness. BubbleDeck's precast architectural base serves as the finished ceiling for classrooms, offices and lecture halls.

Panel sizes are based on what can fit on a truck, so most are 10 to 12 ft wide and 40 ft long, with four panels transported per truck. Each precast concrete panel with its steel-caged bubbles weighs between 9,000 and 15,000 lbs. Slabs are trucked to the job site and installed using a 161-ft crane. Hertzberg says his construction team can install 50 panels in eight hours, adding rebar between panels. Installation of the reinforcing steel takes about two weeks plus an additional two days to pour and cure concrete around the spheres.

According to Hertzberg, the crews use a 2-in.-wide construction joint every 40 to 50 ft of panel to "allow room for error." Crews also install floor boxes for electrical outlets in the classrooms and lecture halls, a process that often requires the removal and replacement of some of the spheres.

Three advantages of BubbleDeck systems

1. Open floor plan and finish control: The reason BubbleDeck is attractive to designers is because the slab carries its self-weight (without reliance on load-carrying columns and beams), allowing for more extensive and open floor plans. In the case of the HMC project, a traditional precast concrete (or cast in place) structure with support beams would have increased the building's height and required closer spacing between columns, thus disrupting the available open interior space envisioned by the client. "Aesthetically, we were excited about the level of control over finishes by having it done in the factory," said Brandt.
2. 35% less concrete, same strength: The system is designed to take the dead weight out of the center of a slab by filling it with plastic bubbles instead of concrete. One of the major advantages of BubbleDeck is that it uses 35% less concrete than traditional floor systems, yet has the same strength and more flexibility in terms of design.
3. More sustainable construction option: BubbleDeck uses less concrete than traditional concrete floor systems, offers a more sustainable construction option, contributes less CO_2 to the atmosphere in the manufacturing process and also meets

sustainability goals through the use of recycled plastic spheres. The spheres could be recycled yet again should the building be demolished or renovated in the future. The dead air space in the hollow spheres provides insulating value and can be injected with foam for additional energy efficiency. **PS**

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Pipe Inspections:

Robotic Laser Profiling Demystified

Engineers and stakeholders responsible for pipelines need to understand how the emerging technology of robotic laser profiling will impact system maintenance and specification decisions by documenting the in-service structural integrity of different pipeline materials.

By John Salik, Eng., and Oliver Conow | Images courtesy of C-Tec (www.ctecworld.com)

Pipelines are a costly investment. If installed and maintained properly, pipelines provide many decades of trouble-free service. Accurate knowledge of the condition of a pipeline is integral to avoiding unforeseen repair and replacement expenditures. Modern sewer and aqueduct inspection is increasingly done using pipe profiling robots that move within pipes and acquire inner geometry data. Any deviations from the installed inner diameter (I.D.) are of vital importance to infrastructure engineers who determine the extent of repairs. Laser-profiling robotic technology provides engineers with an accurate picture of the required maintenance, structural integrity and life-cycle costs of installed pipelines. In turn, this knowledge informs the specifying engineer of the most reliable and cost-effective pipe material for future projects.

Advances in laser testing technologies

Currently, mandrel testing comprises the bulk of pipeline testing in North America. While mandrel testing is an acceptable method, the newer robotic laser inspection systems provide a more thorough and accurate picture of the pipe's structural integrity.[1] A growing number of non-contact, robotic pipe-inspection systems are available and use a variety of measurement methods, including:

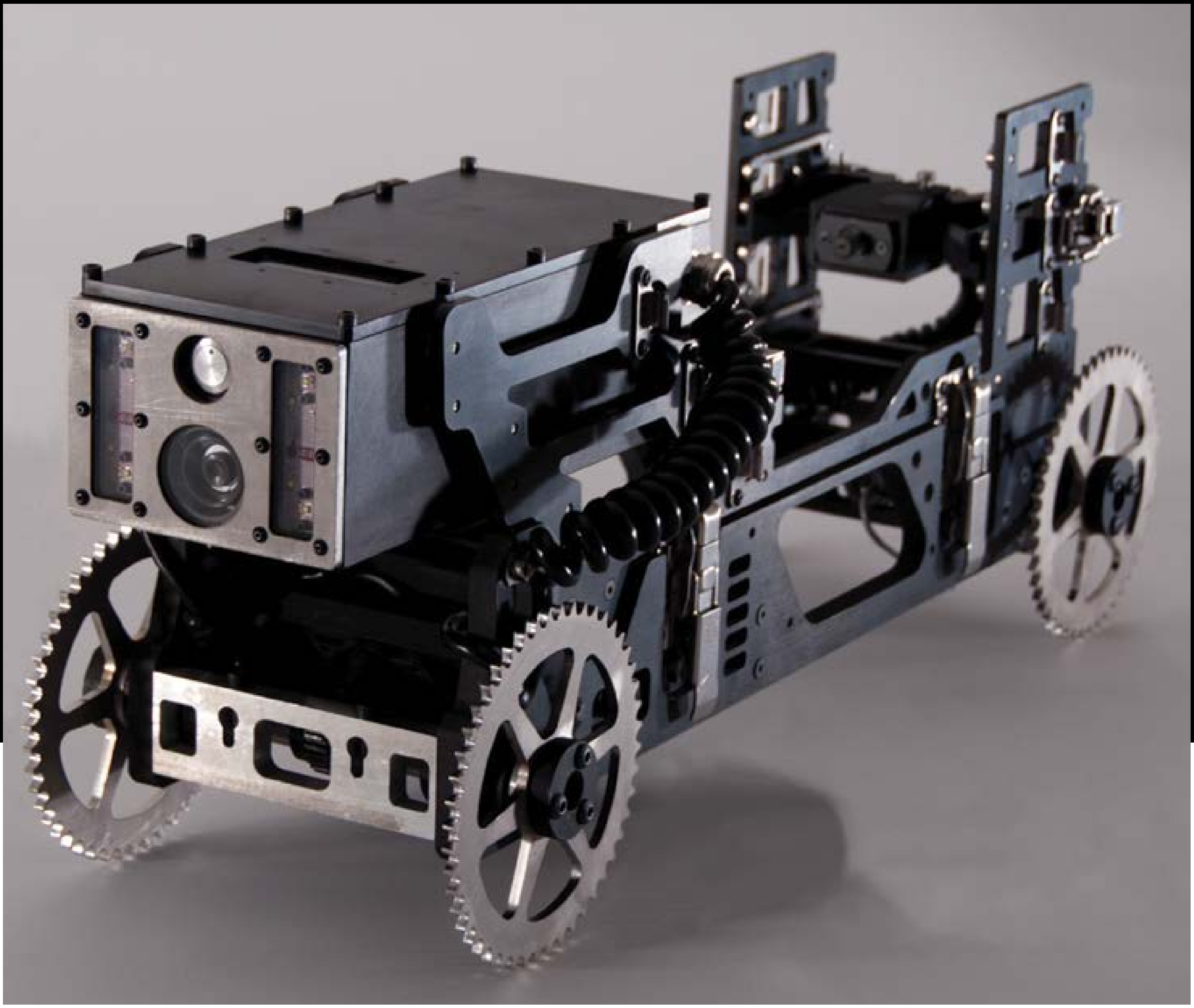
- Image processing methods such as pixel counting
- Laser-point distance triangulation
- Laser time-of-flight measurement

How three laser profiler models work

Understanding how each laser profiler works, its advantages and disadvantages, is imperative for engineers responsible for pipe specification, installation, maintenance or testing.[2] Robotic inspection systems that use lasers for distance measurements (from the pipe's center) are explained in this article. Each method assembles

[1] Laser profilers cannot be used to detect cracks or measure crack width inside RCP; video micrometers measure dimensions of a pipe feature, like cracks.

[2] Output from laser profiling systems can vary greatly. For example, the results from a full-ring laser profiler and a spinning laser system can be significant. DOTs and engineers must carefully assess the repeatability, accuracy and calibration of testing systems.



measurement data into a 2-D cross-section of the pipe's interior wall. Stacking these images sequentially renders a 3-D profile. Profilers may be stationary or mobile-data collectors and vary in how distance data are collected.

1. *Rotational profilers* use two lasers in rotation to determine distances using triangulation. The laser's dot projections originate from the center of the pipe with a small but known angle. Using a camera, the laser points are imaged with a calibrated digital camera. Because the distance between the points increases as the distance to the pipe wall varies, digital images are used to find the distance between laser projections by pixel counting and triangulation. While this method yields one measurement (pipe center to wall), the camera-laser system is robot-mounted so that it can rotate along the pipe axis while being held stationary. Because it measures one point at a time, forward motion results in radial distance measures that form a spiral (See Figure A). While no true cross-sectional profile can be obtained from such a system in motion, 3-D profiles may be generated by either significantly increasing the rotational speed relative to forward motion (so that its sampling spiral has a finer pitch), or by mathematical estimation of the best-fitting local cylinder that represents the pipe.
2. *LIDAR[3] systems* use a scanning laser that moves back and forth in a single plane. Distance measurements are acquired by measuring the time it takes for the laser to bounce off a target and return to its origin. Because the light propagation speed is constant, distance can be determined from the so-called "time of flight." The scanning motion results in a plane that projects along the interior pipe wall (See Figure B). Because the laser's angular step remains constant, the orthogonal measurements from the pipe's center to the wall are taken only two at a time (per sweep), but at many non-uniform distances from the robot. When placed in rotation, many pairs of distances are acquired so that a ring of measurements is formed. This measurement ring forms a 2-D cross section, and with many sections obtained

[3] LIDAR = Light Detection and Ranging or "laser radar"

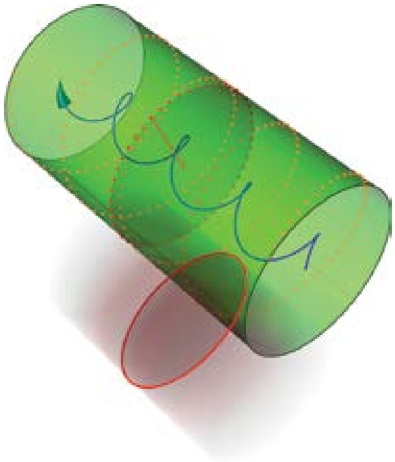


Figure A.
Depending on robotic and rotating speeds, rotational profilers generate spiral data points with varying pitch. "As the laser profiler moves down a pipeline, the scan acquisitions can be said to resemble rotini pasta." (Figure 1)

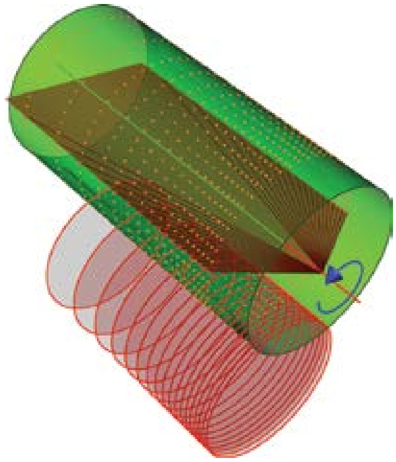


Figure B.
LIDAR technology, which uses time-of-flight from laser beams, performs multiple scans of the pipeline with a rotating head. The profiler must stop as the head scans from one side to the other down the length of the pipe. The head then rotates to scan multiple wedge-like planes. (As the profiler moves down the pipe, the scans can be said to resemble ruote pasta. [Figure 2])

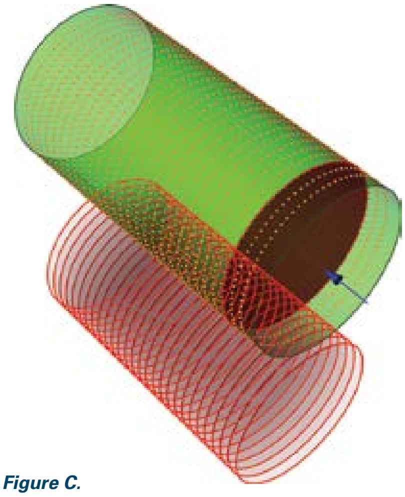


Figure C.
Laser ring technology uses laser-illuminated pixels in an image, making a continuous pipe wall scan. Even at the maximum standard inspection speed, many radial measurements are made at regular, evenly spaced distances. (As the laser profiler moves down a pipeline, the scan acquisitions together resemble rigatoni pasta. [Figure 3])

simultaneously, a 3-D pipe profile can be created. Here, we note three things. First, the cross-sectional profiles are not uniformly acquired, but with a sufficiently small scanning angle, this may not be an issue. Second, the robot is held statically within the pipe in order to acquire the pipe profile. Finally, measurements are made with respect to line-of-sight to the laser origin, so that any sufficiently large deformations or obstacles will block the laser from acquiring data downpipe. Typically, obstructions (laser shadows) are not a problem as sufficient data are available for estimates of deformation. Because spacing between profiles increases downpipe, certain features could be missed.

3. *Continuous-ring profilers* use a planar laser whose light rays emanate radially outward in a continuous fashion from a fixed focal point. The laser plane is perpendicularly aligned to the pipe axis. Incident rays on the interior wall readily illuminate its orthogonal cross section. Using a calibrated high-definition digital camera, the illuminated ring is imaged along the pipe's axis and then analyzed. Because of the camera calibration, the digitized image contains usable spatial information (known relation between pixels and actual distance). By counting the number of pixels from the center of the pipe to the incident laser, many radial distance measurements are obtained simultaneously along the pipe wall. When the camera-laser is in motion, the camera frame rate assures that the illuminated ring is imaged at fixed intervals along the pipe (See Figure A.) The result is many cross-sectional samples that generate a uniform 3-D profile.

What should engineers look for in laser profilers?

With a growing variety of pipe inspection robots available, many methods have emerged that provide an objective measure of a pipe's structural integrity. Engineering analysts are naturally concerned with pipe integrity from their client's perspective, and these preferences have resulted in three primary profiling modes, all based on a pipe's cylindrical geometry:

A. Deformation Measurement: This profiling mode focuses on local deviations from the pipe's specified I.D.
B. Corrosion Measurement: This profiling mode records deviations in average local I.D. that are caused by sectional surface changes resulting primarily from degeneration due to age or chemical reaction.
C. Liner Thickness Measurement: This profiling mode addresses deviations in local I.D. before and after a pipe liner has been placed, thus requiring a comparison of the two profiles.

Agencies, owners and stakeholders responsible for pipeline systems are interested in

- Reduction of life-cycle costs
- Efficient planning and pipeline condition assessment
- Mitigation of risk

Three major stakeholders who share responsibility for modern pipelines and who can benefit from robotic pipe inspection are:

1. Contractors – At the point of installation, as a method of quality control, contractors can determine pipeline conditions

Software Analysis: It's All in the Sauce

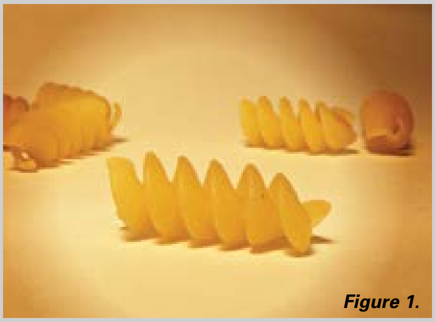


Figure 1.

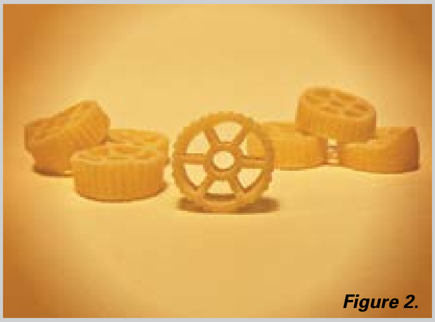


Figure 2.

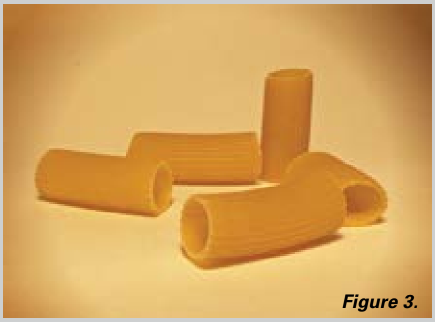


Figure 3.

Pipe measurements require data processing software. If we compare the measurements to pasta shapes (See Figures A, B and C) and compare measurement analysis to pasta sauce, an excellent meal could be an apropos metaphor for the client's satisfaction in a valid test report. Though data processing software is fairly "intelligent," correct data interpretation requires human validation of the results. As long as the data are professionally validated, final reports assure full confidence by the end user. *Bon Appétit!*

quickly and accurately so that they can perform necessary corrections before the project is completed and handed over to its owner.

2. Engineers – With reliable and repeatable pipe profiles in hand, engineers can perform a comprehensive structural integrity assessment anytime to manage maintenance budgets.
3. Proprietors – Pipe condition reports are project quality assessments to assure the owners of the new installation's value for the costs incurred.

Why are repeatability and accuracy important?

It is of vital concern to clients to obtain pipe inspection reports that contain valid measurements that are reliable enough to generate the same data in repeat testing. While it is the role of a regulatory body to define inspection standards,[4] it is the role of an independent testing facility to provide assurance that the testing system can generate accurate and repeatable data.

When measuring pipe deformations, for example, it is important to know to what extent and where deformations occur, so the better the system's repeatability simply translates to increased reliability. Statistical analysis tells us that the more the measurements, the better the estimate. When measurements are too far from what is expected in the ellipse model (which happens regularly), trained profilers know that this is likely due to dirt, debris, obstacles and water in the pipe. Consequently, not all measurements can be used for deformation measurement. If a profiler has very few measurements to make in the first place, the data collected may not be of sufficient once the unusable measurements are thrown out.

Accuracy is of great importance. The cost of early detection is much lower than of the cost of pipe failure. Measurement accuracy is a cost-mitigating factor that may be the pivotal point in deciding if pipe replacement is the only option. In cases where structural integrity is not of grave concern, deformation accuracy can be used as a quality control measure to assure that the pipe installation was done properly. Pipe testing accuracy is a leveraging tool in a project's cost/benefit analysis and also provides important data to ensure that installation was performed to specifications and your maintenance plan is on track.

Conclusion

Despite its relative infancy, laser profiling promotes fiscal confidence through reliable reports. This technology minimizes the possibility of missing serious pipe defects (unlike older measurement systems) and avoids cost overruns that result from scheduling work crews for ongoing test-and-fix cycles. Laser profiling provides an objective means of controlling the costs of installation, maintenance and repair over the system's service life. **PS**

John Salik, Eng.

John Salik, Eng., previously worked as chief scientific advisor for C-Tec in Laval, Quebec, and has twelve years of experience in satellite communication, inspection robotics and computer vision. He currently works as a lead research engineer at the Centre de Recherche Enviro, Laval, and serves as taskforce leader on ASTM Committee F36.20, working to establish standardized laser profiler performance metrics.

Oliver Conow is currently the client support manager at C-Tec, Laval, Quebec, for the past six years and specializes in electromechanical designs. He also serves in business strategy development and does presentations on laser profiling technology.

Oliver Conow

[4] AASHTO 27.6.1, "New Inspection Requirements for RCP"

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It's a Wash

How precast concrete buildings can clean themselves and our air.

By Claude Goguen, P.E., LEED AP

No kidding. Self-cleaning buildings are a reality. Better yet, architectural precast concrete with new material technology can remove pollutants from the air while actually rinsing itself clean in the rain. Self-cleaning buildings may sound like a futuristic concept, but they do exist today, providing aesthetic, environmental and no-cost maintenance service.

Case in point: Jubilee Church in Rome, Italy

Like white sails in the wind, three large, curved walls of precast concrete adorn the south side of the Jubilee Church in Rome. One of the primary purposes of these walls is to minimize thermal peak loads inside. The large thermal mass of the concrete walls controls internal heat gain; the result is less inside temperature variation and a more efficient use of energy.

As an added benefit to the owners, these "billowing" precast concrete walls contain titanium dioxide (TiO_2) to keep the appearance of the church clean, white and beautiful. The TiO_2 incorporated in the concrete absorbs ultraviolet light from the sun and becomes powerfully reactive, breaking down pollutants that come in contact with the concrete surface. There you have it: a self-cleaning building!

New formulations of cement, introduced in Europe in the '90s, can neutralize pollution. These altered cements are used in the same way as portland cement, and therefore any precast concrete structure can potentially function as a pollution fighter. But how does it work?

How photocatalytic materials work

Strong sunlight or ultraviolet light decomposes many organic materials in a slow, natural process. You may have witnessed this in the way the plastic dashboard of a car fades and becomes brittle over time. Photocatalysts are used to accelerate this process and, like other types of catalysts, stimulate a chemical transformation without being consumed or worn out by the reaction.

Photocatalysis is a reaction that uses light to activate a substance (the catalyst) that modifies the rate of a chemical reaction without the catalyst itself being affected. An analogy for a catalyst would be an instigator who starts an argument between two people and then walks away unscathed while a fight breaks out. When used on (as a topping) or in a concrete structure (incorporated into the concrete mixture), photocatalysts decompose some rather nasty organic materials.

Some of the targets of photocatalysts on structures are dirt, soot, oil, mold, algae, bacteria and allergens, and airborne pollutants. Organic pollutants in the air are formaldehyde, benzene, tobacco smoke, nitrous oxides (N_2O), and sulfuric oxides (sulfuric oxides are found in smog). Photocatalysts break down these airborne pollutants into oxygen, carbon dioxide, water and other environmentally healthy substances. A remarkable aspect of this material technology is that dirt, mold and other polluting substances actually wash off the surfaces of photocatalytic concrete when it rains. TiO_2 is the linchpin in self-cleaning concrete.

Titanium dioxide: white-hot cleanup agent

Proprietary material technology, based on particles of TiO_2, is what creates self-cleaning concrete. This technology can be applied to white or gray cement. TiO_2 is widely used as a white pigment in paint, plastics, cosmetics and a host of other products. Making it capable of photocatalysis requires manipulating the material to create extremely fine, nano-sized particles with a different atomic structure than that of the ordinary pigments.

At the nano scale, TiO_2 undergoes a quantum transformation and becomes a semiconductor. Activated by the energy in sunlight, TiO_2 creates what is technically termed an "electron-hole charge separation." This means that electrons disperse on the surface of the photocatalyst and react with external substances (airborne pollutants), causing chemical reductions and oxidations, and forming hydroxyl radicals that act as powerful oxidants to decompose organic compounds. Simply put, TiO_2 breaks down unwanted and unhealthy organic compounds in the air and transforms pollutants into oxygen, water, carbon dioxide, nitrate and sulfate. The result is cleaner air and building surfaces.

The cost of adding TiO_2 to concrete translates into about a 50% increase versus the cost of ordinary cement. In a cost/benefit analysis, however, increased material costs are balanced by less building maintenance over the life of the structure. Besides buildings like the Jubilee Church, photocatalytic cement is used or being proposed for highway pavement, concrete pavers, traffic barriers, precast roofing tiles, concrete building entrances and other architectural precast concrete products.[1]

Bonus points besides beauty

Self-cleaning concrete has big benefits in addition to its good looks. By keeping the building's surface whiter, photocatalytic concrete maximizes its ability to reflect the sun's heat and thereby reduce the associated heat gain. In this way, precast buildings reduce the heat island effect in urban areas.[2]


© Brian Eagen | Dreamstime.com

Completed in 2003, the white precast concrete "sails" of the Jubilee Church in Rome incorporate self-cleaning concrete technology even though the primary purpose of the precast's brilliantly white surface is to minimize interior heat gain.

Photocatalytic concrete offers building professionals a unique opportunity to reach their sustainable development goals while potentially improving the value of their investment. Research on photocatalytic technology has been progressing for more than three decades, and we can expect this material technology to improve with time.

Self-cleaning buildings and roads are not science fiction. A clean building is not only aesthetically pleasing, but with the help of photocatalytic agents, precast concrete structures will provide us with a brighter future. ps

For more information on this topic or any other precast concrete related topic, contact Claude Goguen, NPCA director of Technical Services, at cgoguen@precast.org or at (317) 571-9500.

Resources: Portland Cement Association, Self-Cleaning Concrete (www.cement.org/tech/self_cleaning.asp)

[1] For more photocatalytic precast concrete applications, see "Five Ways Precast Helps Save the Earth," *Precast Solutions,* Summer 2012.

[2] See Green Piece: "Heat Islands are No Tropical Paradise," *Precast Inc.*, March-April 2012.

How Smart Specifiers Assess Competing Product Claims

Dog-eat-dog competition between construction materials is a good thing – and may the best product win. But when concrete material research data are used out of context in derogatory product claims, experienced specifiers can separate fact from fiction.

By Sue McCraven

During really bad snowstorms, when temperatures hover around 32 F and cars spin off into the ditches, just staying on the road is a nerve-racking challenge. Maneuvering your vehicle behind a giant scraper truck that is shooting out deicer salt and sand is not a bad strategy for staying alive when the concrete pavement is a sheet of ice. But wait a minute! Isn't that calcium chloride ($CaCl_2$) that the scraper truck is spewing all over the concrete roadway? And didn't the last sales pitch you heard use material research data to claim that concrete mortar dissolves when soaked in a pure (liquid brine) $CaCl_2$ solution?

What's the issue here? Does this mean $CaCl_2$ always deteriorates concrete? Obviously not. Does this research data translate into a rationale that precast concrete paving slabs and drainage structures are a poor choice for highway specifications? Not at all. Here's where a specifying engineer relies on industry standards to assess concrete's durability in a cost/benefit analysis of available construction materials.

How to filter competing product claims

For the specifier, what does our dicey driving example say about using out-of-context research data to trash competing products just to secure a winning bid? Common sense tells us that statements about the corrosive effect of $CaCl_2$ on concrete need to be based on real-world applications: the history of concrete pavement's in-service performance and its proven durability in cold-weather regions where road deicing salts are commonly used.

More importantly, all research database claims of concrete deterioration need to be understood in context

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with the specific mix design used in the studies. Without knowing the water-cementitious material (w/c) ratio, compressive strength, air content, presence/absence of permeability-reducing materials, and cement type that led to the test data, engineers understand that product salesmen cannot apply these same data, carte blanche, to the real world, where $CaCl_2$ and concrete pavement are engaged in a salty symbiosis for driver safety.

> **FACT:** Real-world field performance has shown that air-entrained concrete pavement does not need added protection from deicers.

At this point in our discussion, it should be obvious that using out-of-context research data to digress into deceptive claims about the durability of any competing construction material or product – precast concrete or otherwise – is a waste of time and energy when directed at a knowledgeable audience. Exaggerated product sales pitches look particularly bad to specifying architects and engineers who are not taken in by the inflated hoopla of claims and counterclaims.

Remember college research? Two examples

Let's get down to a more specific example of how marketers use research data out of context. Let's say material research data indicate that concrete mortar deteriorates in solutions of acids[1] or oils at high concentrations and in conditions of continuous exposure. This result should come as no surprise to any civil engineer if, in fact, the 1 in. x 1 in. x 4 in. mortar samples tested had w/c ratios $\geq$ 4.0 and a mix design with no silica fume or admixture to increase concrete impermeability. Does this research prove that the precast concrete grease interceptor in service at your local Freddy's Fried Chicken restaurant/grease outlet can be expected to deteriorate rapidly? Hardly.

Another research report[2] may use provocative photos of deteriorated 6 in. x 6 in. x 30 in. concrete beam samples exposed to sulfur-rich soils in Sacramento, Calif. These photos are properly used to demonstrate the visual inspection system (used since 1940) to apply a numerical rating system (from 1 to 5) to identify degrees of deterioration (1 = looks pretty good, 5 = sweep it up). Used out of context, this "evidence" can be a bit startling to those unfamiliar with research protocol. Setting the gory photos aside, this study actually reports that air entrainment and a low w/c ratio, in particular, "was an overriding factor in sulfate resistance." Will precast concrete components specified for use in sulfur-rich settings disintegrate? No way.

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[1] See Reference 4.

[2] See Reference 5.

Specifying engineers prefer precast concrete because, dollar for dollar, it has a proven history of strength, durability and a long service life for owners. Precast concrete stands up to adverse conditions for decades of reliable service without replacement or expensive repair.

Photo courtesy of Bartow Precast, (www.bartowprecast.com)

How engineers view research - 3 steps

A smart specifying architect or engineer knows that the best way to assess derogatory claims from competing products based on research data is to recall research realities from his or her university days:

1. *First, engineers know that researchers often use "the upper end of the possible range of concentration for each chemical agent" in their testing,* because they are eager to discover what happens at extreme conditions. Researchers are curious by nature, and the upper limits of what is possible (remember the fun of blowing things up in the lab?) in the laboratory make for interesting data and eye-catching graphs. But these high-range data points are not intended to describe typical performance in actual field conditions.
2. *Second, engineers evaluate research reports in their entirety with seasoned perspective, and are not influenced by a well-delivered sales pitch based on some unearthed data.*

For example, most concrete material research summaries on the effects of aggressive chemicals on cement mortar will usually conclude with a statement indicating that it might be a pretty good idea to increase curing time and decrease the w/c ratio. B.S.C.E.s know a quality concrete mix has more relevance to service life than data that reflect extreme test conditions. If you commonly specify municipal underground wastewater tanks and pipes, for example, you may have heard product pitches about an industry study[3] that describes "slow disintegration of concrete exposed to vegetable oils." In fact, the actual purpose of this report is to list available protective treatments (coverings/coatings) that mitigate chemical attack in specific corrosive environments. When specifying for durability over a long service life, the critical element is always well-designed and impermeable

[3] See Reference 2.

concrete based on an informed mix design for specific site conditions.

3. *Finally, the important questions an astute specifying engineer or architect asks about any laboratory study on concrete deterioration include: "Were the research samples, exposure levels and corrosive-element concentrations representative of quality precast concrete products under typical service conditions?* "Does the research data represent today's precast concrete mix designs that meet industry codes[4] for corrosive environments – durable concrete produced with low w/c ratios, the recommended type of cement, perhaps 5% silica fume, and other technological advances in admixtures and supplementary cementitious materials (SCMs) to increase impermeability?

> **FACT:** In the end, specifying for product durability (a long, low-maintenance service life for the owner) is all about a concrete mix design for specific exposures.

Specifiers want proven field performance for clients

An informed and experienced response to unfounded claims of product deterioration focuses on precast concrete's actual performance and its durability in the field – how you have found precast concrete performs in service. Are owners happy with the performance of precast concrete products specified for their projects? Yes.

What do owners like about precast concrete? Discerning owners and clients prefer precast concrete because it has a proven history of production quality, structural integrity and durability. Precast stands up to adverse conditions for decades of reliable service without replacement or repair. Importantly, precast concrete is the proven premium product that arrives on site as a structural element.

Are you always present during installation?

Do you always have the time to be on site when the vaults, pipes or holding tanks are installed? There is one building material you can depend upon. Precast concrete underground products, for example, will not deflect, warp, crack or break in service like other materials[5] where actual product performance, structural integrity and service life depend in large part on the whims of the local contractor in complying with specified installation procedures. Field-experienced engineers know that compliance with soil-lift heights and backfill/compaction specifications requires more time than a quick, haphazard installation. And we all know that few contractors enjoy spending extra time on site – and collecting less money for their efforts.

So let's see the research data and let the product claims fly. Smart specifiers employ a reality filter for hyped-up money-saving and durability promises from competing construction products. On your highly cost-competitive building projects, don't overlook a product's history of performance in your material cost/benefit analysis. And may the product with the best durability and service life for the owner end up in your project specifications. PS

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

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[5] See Reference 6.