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In this issue:


NPCA
Precast... The Concrete Solution

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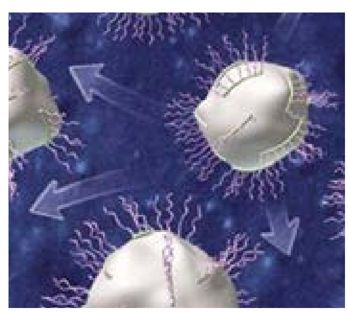

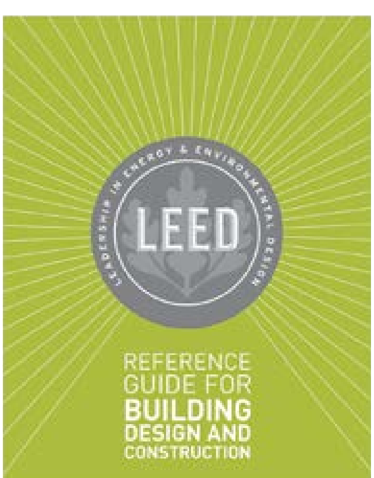

ON THE COVER:
A total of 44 supersized precast concrete box culvert sections weighing a combined 2,710 tons, placed in only four days with one crane, served as a highway extension in Ontario to provide safe passage for vehicles above and wildlife below.

Photo courtesy of Anchor Concrete Products Ltd., Kingston, Ontario.
www.anchorconcrete.com

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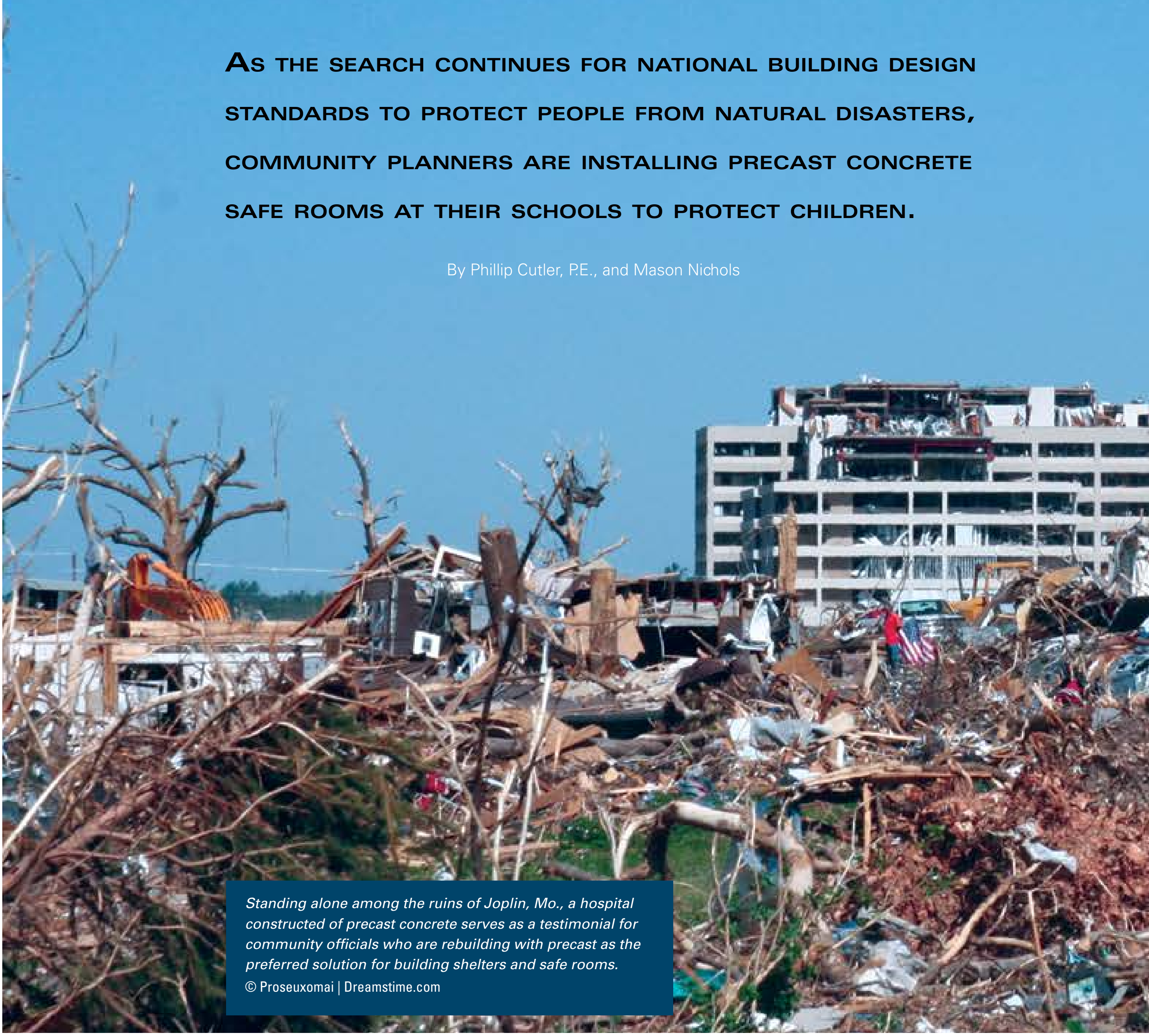
NPCA
Precast ... The Concrete Solution

Joplin Tornado Devastation: Two Years Later

As the search continues for national building design standards to protect people from natural disasters, community planners are installing precast concrete safe rooms at their schools to protect children.

By Phillip Cutler, P.E., and Mason Nichols



Standing alone among the ruins of Joplin, Mo., a hospital constructed of precast concrete serves as a testimonial for community officials who are rebuilding with precast as the preferred solution for building shelters and safe rooms.
© Proseuxomai | Dreamstime.com

Since the 2011 tornado, precast concrete safe rooms have been constructed in several Joplin elementary schools to protect the children.
© Dustine | Dreamstime.com

It has been nearly three years since Joplin, Mo., experienced the wrath of Mother Nature. The city was hit by an EF5 tornado, a monster twister (see the sidebar "Fujita Tornado Intensity Scales Explained"). Joplin was literally leveled by the storm. More than 160 people lost their lives on that horrific day, and the city is still recovering and rebuilding from the devastation.

This time, let's rebuild smarter with precast concrete

As part of this rebuilding, city planners, community officials and directors of construction are planning for the future, and precast concrete will be part of that future. Precast concrete is being chosen as the preferred solution in the building of high-wind shelters or precast concrete safe rooms for schools.

According to Mike Johnson, director of construction for Joplin Schools, there were plans for 11 safe rooms in all to be constructed with cast-in-place concrete. "They were cast-in-place because of the job opportunities it would offer the local work force." Johnson said. "There are no precast companies here in the immediate area, so we bid it both ways on our first batch of safe rooms to see which was more cost effective. And it was a slam dunk, the precast [bid] came in well under the cost of cast-in-place. That's how we wound up with precast. We looked at it both ways and precast won the day."

The Joplin School District has partnered with Nabholz Construction Services as the construction manager for its 11 high-wind shelters. These projects will result in a safe room at each of 10 Joplin elementary schools. Some of these precast concrete structures will also serve as an auxiliary gym facility, a student locker room and high school concession services.

"Nabholz has eight precast storm shelters under construction and one that is constructed of load-bearing masonry," said Jeff Gattis, senior project manager with

Nabholz Construction Services. The remaining two shelters are in the final stages of design. A prestressed concrete construction with numerous special connections and reinforcing make up the shell.

The safe rooms are built to FEMA 361 guidelines (see the sidebar "Precast Concrete Safe Rooms are FEMA Compliant"), plus local codes as determined by the architect and project engineer, added Gattis. The guidelines and codes are also integrated into the spec depending on the safe room location.

Precast concrete provides a safe haven

Safe rooms must be safe, and so the big question is what precast concrete brings to the table. "Plant controlled production of the shell ensures high concrete strengths, and one-component wall systems can provide integrated insulation and finishes at both faces," explained Gattis. "Concrete provides a weight and durability advantage, which, along with prestressed reinforcing, results in a wall-and-roof system that meets the requirements for the shelters – and does so economically."

Precast allows for the structure to be built in a controlled environment while site preparation is being completed. Ideally the completion of site prep and the off-site precast construction is completed around the same time so that the erection can start immediately. "These 8,000-sq-ft structures are being erected inside of two weeks, which is great for the project schedule," said Gattis.

"This project is one that the Nabholz team is very proud to be a part of," continued Gattis. "The town of Joplin was so devastated by the tornado. Being a part of a team that helps to provide a safe haven for the kids of Joplin and the surrounding community is very fulfilling." The precast producer for the project was Prestressed Castings Inc. in Springfield, Mo.

If we intend to protect citizens – and particularly our vulnerable school children – from the horrifying death

▲

Nabholz Construction Services erects the precast panels for a high-wind shelter at a Joplin elementary school. The shelter can also serve as an auxiliary gym, a locker room or a concession facility.

Photo courtesy of Nabholz Construction Services (www.nabholz.com) and damage experienced in the Joplin tornado, we need to rebuild storm-damaged cities with stronger, more durable infrastructure. Precast concrete safe rooms are just one of the stronger, safer and smarter solutions precast can provide storm-prone areas. Find more precast solutions at precast.org or contact a local precast manufacturer at precast.org/find. ps

Phillip Cutler, P.E., is NPCA's vice president of Technical Services.

Mason Nichols is NPCA's communication coordinator.

Precast Concrete Safe Rooms are FEMA Compliant

By Evan Gurley

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. The two design guidelines are FEMA 320 and FEMA 361.

FEMA 320 outlines the design criteria for the development of residential safe rooms (16 persons or less), while FEMA 361 covers the development of public and community safe rooms (more than 16 people).

Using the FEMA guidelines as a standard, design and construction professionals led by the International Code Council (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.

Due to the implementation of the ICC-500 standard and other national, state and local protection initiatives, FEMA identified a need to distinguish between a "safe room" and a "shelter," as the terms have been used almost interchangeably in the past. While FEMA and ICC criteria are both designed to ensure life-safety protection, only units meeting FEMA criteria provide "near-absolute" protection from extreme wind events. Therefore, FEMA refers to the term "safe room" as all shelters, buildings or spaces that are designed to the FEMA criteria. Buildings, shelters or spaces designed to the ICC-500 standard are termed as "shelters." So all safe rooms designed to the FEMA criteria meet or exceed the ICC-500 requirements.

Design basics

Residential and community safe rooms designed to meet FEMA 320 and FEMA 361 criteria follow these basic principles:

• FEMA 320

- Located in an area that is quickly accessible
- Built in an area where flooding will not occur
- Readily accessible from all parts of the home, business or critical facilities (building or facility occupied by large numbers of people)
- Free of clutter and obstacles
- Adequately anchored to resist overturning and uplift (if specified by design)
- Built with connections that can resist failure
- Built with walls and roof that can withstand windblown objects (designed for 250 mph winds)
- Designed to resist a 15-lb wooden 2x4 in. board traveling horizontally at 100 mph and vertically at 67 mph (ASCE 7-05).

• FEMA 361 (additional criteria to FEMA 320)

- Designed for all cases as partially enclosed buildings
- Special life-safety protection elements when occupancy is 50 or more people

Evan Gurley is a technical services engineer with NPCA.

Fujita Tornado Intensity Scales Explained

By Phillip Cutler, P.E.

To put an EF5 tornado in perspective, we need to take a look at the wind power it can generate. Regularly, we hear about earthquakes and likely have a much better understanding of the ratings for the strength of earthquakes based on the Richter scale. It is a very simple rating scale and is based on a logarithmic function using powers of 10. Simply put, a 5.0 on the Richter scale is 10 times stronger than a 4.0.

In contrast, the rating for the strength of a tornado is not as easy to understand, because it is based on the Fujita Tornado Intensity Scale (see Tables 1 and 2). The Fujita scale is based on the amount of damage a tornado could potentially produce.

For example, an F0 tornado is referred to as a "gale force" tornado and has a sustained wind speed of approximately 73 mph (think about how it feels to stick your arm out the window of a car traveling on the Interstate). As we progress up the Fujita Scale, you begin to get some relative perspective on the destructive power of wind as their velocities increase. F4 and F5 tornados accounted for only about 1% of all tornados that occurred between 1950 and 1994. EF5 tornados, like the one that destroyed the city of Joplin, are extremely rare weather events.

Enhanced Fujita Scale

As most measurement equipment in use today would likely not survive the destructive force inside an F3 tornado, the EF Scale was developed. The EF Scale, or Enhanced Fujita Scale, is based on estimates of the maximum wind speeds in the various categories. An EF5 tornado signifies total destruction for most structures in its path.

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Table 1. Fujita Tornado Intensity Scale

SCALE	WIND ESTIMATE (MPH)*	TYPICAL DAMAGE
F0	< 73	**Light damage.** Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	**Moderate damage.** Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	**Considerable damage.** Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	**Severe damage.** Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	**Devastating damage.** Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	**Incredible damage.** Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

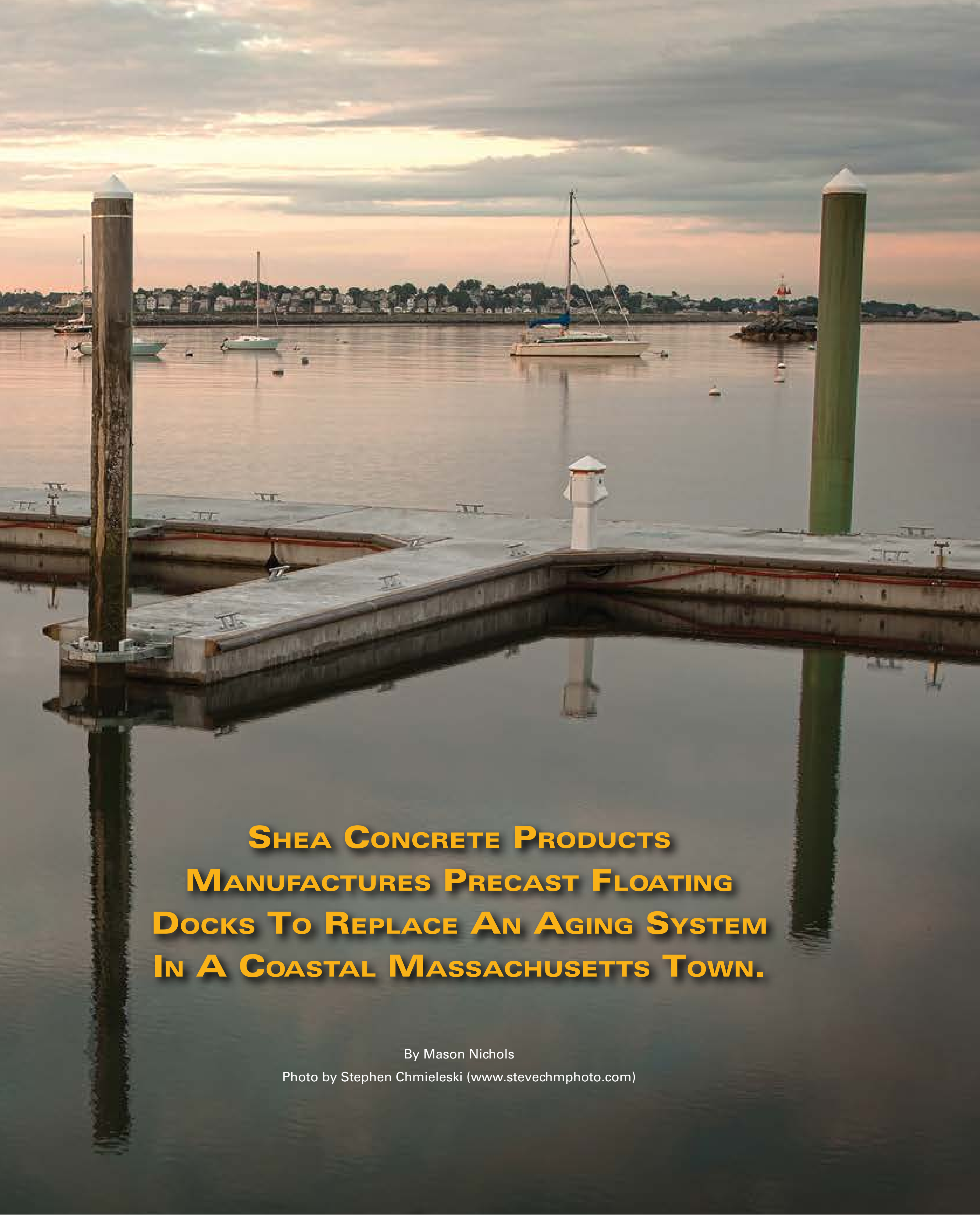
**NOTE: Do not use F-scale winds literally. These precise wind speed numbers are actually guesses and have never been scientifically verified. Different wind speeds may cause similar-looking damage from place to place – even from building to building. Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.*

Table 2. Enhanced Fujita Scale

FUJITA SCALE**			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	**4**	**166-200**
5	261-318	262-317	5	200-234	**5**	**Over 200**

***NOTE: The Enhanced Fujita Scale still is a set of wind estimates (not measurements) based on damage. Its uses three-second gusts estimated at the point of damage based on a judgment of eight levels of damage. These estimates vary with height and exposure. Important: The three-second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures using a directly measured, or "one-minute mile," speed.*

IN ANY WEATHER



Shea Concrete Products Manufactures Precast Floating Docks To Replace An Aging System In A Coastal Massachusetts Town.

By Mason Nichols

Photo by Stephen Chmieleski (www.stevechmphoto.com)

PRECASTER: Shea Concrete Products, Amesbury, Mass.
PROJECT: Floating Docks and Dock Fingers
LOCATION: Lynn Seaport Landing Marina, Lynn, Mass.

Stiff winds, brutally cold temperatures and severe storms are a fact of life in the Northeast, which can experience some of the harshest weather in the United States. Along the oceanfront, conditions are often more volatile, where the combination of crashing waves and swirling winds creates an environment seemingly unfit for any building material.

Late in 2012, the coastal town of Lynn, Mass., petitioned Marinetek, a Finland-based manufacturer of harbor products, to replace its aging dock systems located within the town's seaport marina. An important question for both the town and contractor became, "Which solution will provide the durability and functionality necessary to withstand the elements and get the job done right?"

The answer? Precast concrete.

To accomplish the task, Marinetek partnered with Shea Concrete Products, a precast concrete manufacturer with three locations in Massachusetts. According to Greg Stratis, manager, Shea Concrete Products was able to secure the job thanks in large part to the respect it has earned throughout its more than 60 years in the industry.

"Marinetek was referred to us because they had heard very good things about Shea," said Stratis. "The job was also close to one of our production plants, so they gave me a call to see if I'd be interested in putting together a number for them."

Stratis also stressed that Shea takes an interest in unique projects and is not afraid of tackling them, so when the opportunity for this project came along, the company jumped on it.

To manufacture the docks, Marinetek supplied Shea with the forms and engineering necessary to complete the project. Stratis appointed a small, experienced group within his production team to pour the forms, following the strict guidelines and checklists Marinetek designated for the process.

Though the largest piece manufactured was 9 ft wide by 50 ft long and weighed more than 50,000 lbs, only a small percentage of each dock was actually made up of concrete. The remaining portion consisted of large Styrofoam blocks designed to give the docks buoyancy, enabling them to float. Dave DeRose, production manager for Shea Concrete Products, described the production process in detail.

"These things are massive, you know, but the actual thickness of the wall was only 2 to 2.5 in. on the side, and the top was roughly 4 in. thick," said DeRose. "We were just encasing these enormous blocks of foam inside concrete."

If even the slightest error had been made during the manufacturing process, the effect on the functionality of the docks would have been devastating. If, for instance, one of the side walls had been poured too thick, the entire dock could have been compromised. Despite the possible issues associated with the project, DeRose echoed Stratis' sentiments, stating, "We take on a lot of different jobs like this. We like challenges."

With so little room to work inside of each of the dock's walls, Shea selected a self-consolidating concrete mix to complete the job. This allowed them the flexibility to achieve the flow necessary to fill the form to Marinetek's exacting specifications. "What we ended up doing was modifying our SCC mix to not be a straight self-consolidated, but also not be a straight conventional mix," DeRose said. "It was kind of a hybrid. We got our flow down the walls in order to get the concrete where it needed to go."

For each dock, the production team began by pouring a cover of concrete directly on top of the Styrofoam block. This resulted in the placement of a generous coating of wet concrete on top of the foam, which was also woven through the dock's reinforcement system. Once the team felt comfortable with the top coating, it would then begin to fill the side walls by pouring concrete directly on top of the original layer. The modified SCC mix would then flow down the walls and into place, where a 1-in. pencil vibrator would work to ensure that the mix filled the form to its required thickness.

In order to protect the manufactured docks from the elements, galvanized rebar and corrosion inhibitors were used throughout the process. Additionally, the bottom of the Styrofoam blocks – which remain exposed in order to help achieve the buoyancy necessary for flotation – were coated by Marinetek with a special material designed to prevent damage caused by marine organisms.

Even after each dock was poured, the strict nature of the quality control process continued to dictate the

After arrival on site, many of the docks had to be floated by tugboats to their destinations, where they were lifted and lowered into place.

Photos courtesy of Shea Concrete Products (www.sheaconcrete.com) path of the project. DeRose explained that the standards required by Marinetek were more difficult to achieve than those associated with standard Shea products. "Where our stuff, we will pick at 2,200 psi, we couldn't touch Marinetek's until it reached 80% of its total strength, which was the 6,500 psi they wanted in 28 days," he said. "We had to be at 5,000 in order to be able to pick these."

Once the docks were completed, each was placed onto a flatbed trailer for transportation to the Lynn Seaport Marina. After arriving on site, a crane lifted and lowered each dock into the ocean, though for many of the docks, small tugboats were also used to get them to their eventual destinations.

"For this job, we weren't able to set up a crane in such a spot that it could reach, say, dry land and then also reach its final resting spot," Stratis said.

Overall, from November 2012 to February 2013, Shea manufactured 42 docks for delivery to the marina in Lynn, including 14 main docks and 28 dock fingers. By May, all of the docks were in place, and Shea had already been petitioned to complete similar projects at other locations in Massachusetts and Connecticut.

While Stratis referenced the durability of precast concrete as critical to the prolonged resilience of the docks, he also noted the benefits of networking in ensuring unique jobs such as these are completed correctly. "Networks like NPCA are great places to contact other precasters if you have questions on how to make specialty products," he said. "I talked to Jefferson Concrete about this project before we began. You learn through people in the organization that you network with."

DeRose noted that everyone involved in the process had to be "on their game" in order for the project to be completed successfully. Thanks to a solid group of individuals working on the docks and a dedication to strict QC, the team was able to produce a high-quality product that met the standards specified by Marinetek.

Stratis agreed, stressing his confidence in the team at Shea as critical to completing the project satisfactorily and on schedule. "Some precasters are comfortable with unique projects because they have the right skilled laborers in place," he said. "I wouldn't want to tackle a project like this if my employees weren't educated."

In completing the dock project for the Lynn Seaport Marina, Shea Concrete Products exhibited the "never back down" mindset Stratis exudes when speaking about his company, a mindset the company shares in common with the very product it manufactures.

No matter what the conditions, precast – like Shea Concrete Products – is up for the task. PS

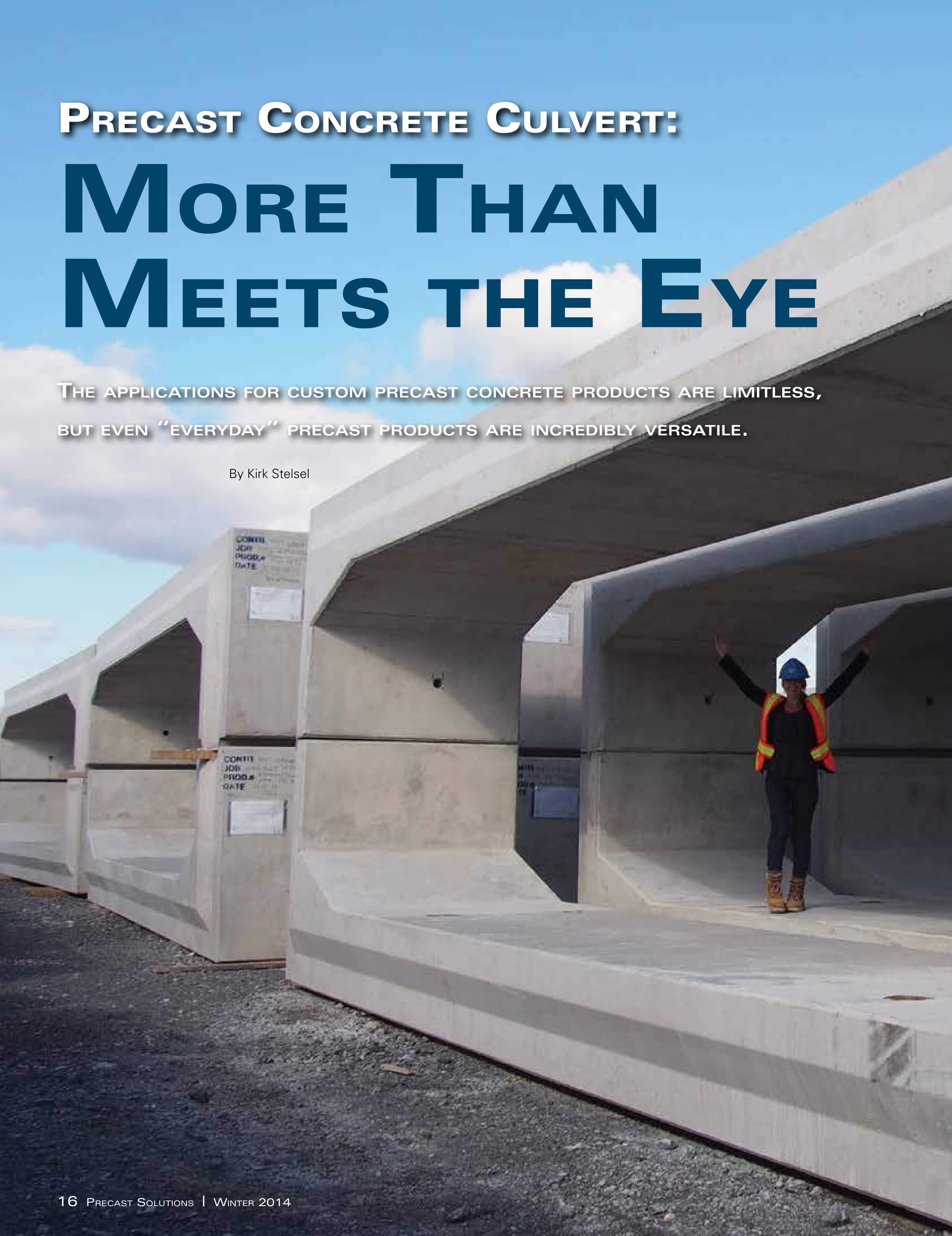
Mason Nichols is NPCA's communication coordinator.

Precast Concrete Culvert:

More Than Meets the Eye

The applications for custom precast concrete products are limitless, but even "everyday" precast products are incredibly versatile.

By Kirk Stelsel



Anchor Concrete Products Ltd., located in Kingston, Ontario, manufactured innovative, two-piece "clamshell" culverts for a supersized highway project in the province.

The Nature Conservancy in Tennessee used a modified box culvert from Oldcastle Precast in Lebanon, Tenn., to create an artificial bat cave as part of its efforts to save the Little Brown Bat from a population-devastating fungus.

In the 1980s, Transformers[i] burst on the scene as a must-have toy thanks to some ingenuity and creativity. They are, after all, "more than meets the eye."

While precast concrete products may not transform into robots with affable personalities and a penchant for saving the human race, looks can be deceiving all the same. For example, retaining wall blocks are made for holding back earth, but use them for amphitheatre-style seating at a Boy Scout camp and suddenly you have a way to help a mourning father create a lasting memorial for his son (precast.org/memorial). Walls are just walls, until the military uses a precast wall system to simulate an Afghan Village and provide life-saving training for soldiers in a realistic setting (precast.org/village). And box culverts make great bridges, but with a few modifications, they also help save threatened Little Brown Bats from rapid extinction (precast.org/bat). The options are limited only by what you and your local precaster can dream up.

Going with the (natural) flow

Precast concrete culverts in particular can be used in countless applications – some expected and some unexpected. Replacing aging short-span bridges with precast culverts is a no-brainer. Precast culverts install fast, provide the highest level of strength and durability, are less dependent on backfill, require little to no maintenance, can withstand more aggressive compacting and are manufactured locally. But what about bridges that span natural waterways? A 3-sided culvert or a box culvert with modifications creates a critical passageway that restores stream-bottom habitat, and removes obstructions to the natural flow of fish and other aquatic species. Suddenly a piece of concrete allows fish to reach food or breeding grounds.

"We supply a lot of box culverts with precast tapered retention sills or baffles 6 in. to 12 in. high," said Mike Worden, president of Concrete Systems Inc. (CSI) in Hudson, N.H. "The contractors can put soil material, stone or rock and reconstruct a natural streambed so it's

good for the fish and helps maintain existing low flows and stream continuity for the movement of aquatic life."

The Summer 2013 issue of *Precast Solutions* details important efforts such as this in the Great Lakes Basin (precast.org/passage). Precast concrete box and 3-sided culverts are ideal for undoing damage caused by man-made dams and stream diversions, as well as to replace perched culverts or those made with weak, inferior materials.

Clay Prewitt, general manager of H2 Pre-Cast Inc. in East Wenatchee, Wash., has found success converting road crossing jobs to precast, including those that specify stream restoration. And according to Mark Wieser, vice president of Wieser Concrete Products Inc. in Portage, Wis., the original spec often calls for cast-in-place concrete, but converting that to precast is a common occurrence in Wisconsin.

"There was a project last year that had four different box culverts on it for stream crossings under a street that was designed with an aluminum arch that we converted to precast box culvert," said Wieser. "The contractor really liked that because of horrible soil conditions on the site. The footings he would have had to construct in those soil conditions for the aluminum arch were cost prohibitive."

In addition to the benefits for wildlife, the time and cost savings makes precast culverts the go-to solution for smaller towns and rural areas.

"I've built 72 precast culverts for bridge replacements for small municipalities, and I was working on 73 today," said Mike Bean of M.A. Bean Associates LLC in Sanbornton, N.H., a construction company that works frequently with CSI. "I would guess that 75% of my work is design-build precast bridges, because precast works. You just can't beat it – it saves time and it lasts for a hundred years.

"You can't pour concrete like that in the field. They're fast, they fit, there are no imperfections, it's strong, it's long-term and the price is feasible for these small municipal towns that can't afford another way."

Concrete Systems Inc., located in Hudson, N.H., manufactured a 40-ft-wide and 7-ft-tall rigid frame bridge that is skewed 25 degrees to meet site conditions.

The use of 3-sided culvert pieces manufactured by Sanders Pre-Cast in Whitestown, Ind., created an underpass on The Monon Trail, a popular pedestrian and cyclist trail in Indianapolis.

Tunnel vision

Safe passage for aquatic life is one example, but now take the same product and place it on a popular urban greenway and you have an underpass for foot and bicycle traffic. One example is located on the Monon Trail in Indianapolis, built with 3-sided culvert from local precaster Sanders Pre-Cast Concrete Systems Inc. in Whitestown, Ind.

Back in New Hampshire, Bean worked with CSI to convince the city of Manchester to convert a similar job to precast box culverts based on speed of installation, durability and functionality. "Originally, the DPW had specified a metal pipe for the bike path tunnel. I said to the city engineer, 'If you want a metal pipe I'll give it to you, but I think you should take a look at this first,'" Bean said. "I showed him a picture of the Delta Dental Root Canal in Concord [a similar precast box culvert pedestrian underpass CSI had supplied] and said, 'How about a 14-ft-square, 140-ft-long box culvert?'"

All of the precast sections – culvert, monolithic headwalls and sloped culvert sections – were manufactured by CSI and delivered and installed in one day, saving precious time and money. "We took a lot of pride in this project," Bean said. "The city wrote me the nicest letter thanking me for the valued engineering bid."

Outside the United States, precast culverts are an equally popular product. In Ireland, Croom Concrete, located in Limerick, used precast box culvert to create an underpass for a farmer to herd his cattle to and from a milking parlor. The precast solution saves the farmer up to two hours daily, and now cows and motorists alike avoid unnecessary danger.

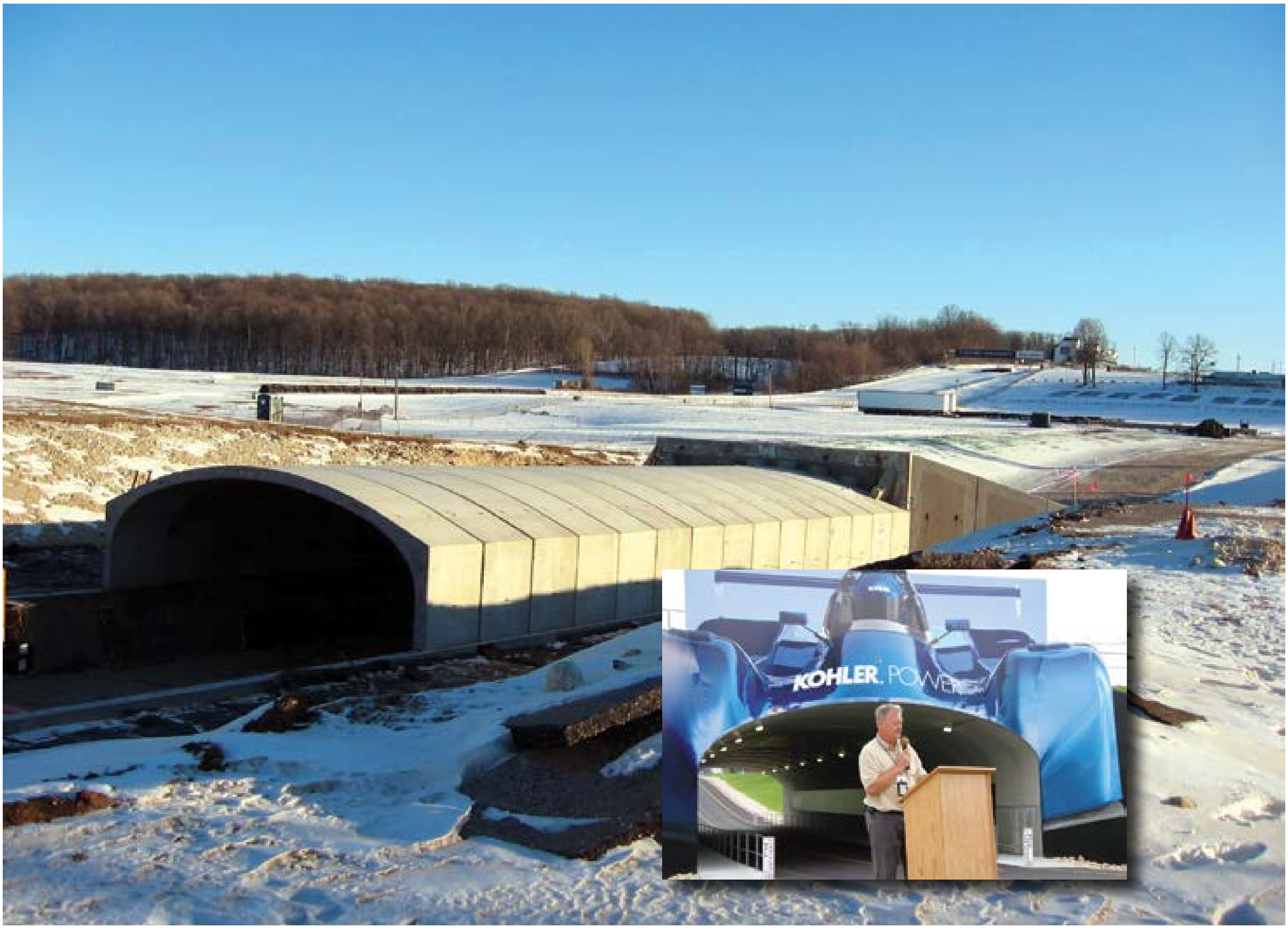
In Canada, Anchor Concrete Products Ltd. manufactured a supersized, clamshell-design precast box culvert for a highway extension in Ontario. In total, 44 sections of precast culvert with a combined weight of more than 2,710 tons were placed in just four days. The design includes a cantilevered joint that allows the contractor to place pieces with only one crane and eliminates the labor and equipment needed to pull the pieces together. The large underpass – 11.5 ft high at its tallest point – will ensure not only safe crossing for wildlife underneath, but minimize potentially fatal collisions on the road above.

In Wisconsin, Wieser Concrete has done its fair share of unique precast culvert installations as well. Rather than creating a safe passage for bicyclists or animals, a local police station needed a way to ferry prisoners. With a precast box culvert, it can now access a new jail across the street without using public surface streets. Shifting to military needs, box culverts are being used to simulate the mountain caves soldiers are likely to encounter in Afghanistan and other war zones. And, for race fans, precast concrete provides underground access to the infield of the Road America racetrack in Elkhart Lake, Wis.

The list of one-off culvert projects for Wieser Concrete is long. "One of the more unique ones was for a large hospital that was doing an expansion and needed to get materials and supplies from one side of the street to the other," Wieser said. "The construction schedule had this taking place in January in Green Bay [brutally cold weather for construction] and they didn't want the road closed for more than a few weeks. There were also obstructions that prevented overhead access for a portion of the area."

Wieser Concrete solved the dilemma with box culvert sections that were installed without extending the project's completion schedule. Some were manufactured with steel bottom plates so they could slide into position on steel rails with a small dozer due to the overhead obstructions.

Croom Concrete, located in Limerick, Ireland, has worked on many unique culvert projects, including this cattle underpass that saves the farmer two hours each day and avoids a dangerous crossing on the road above.



Wieser Concrete, headquartered in Maiden Rock, Wis., provided infield access to a racecourse using 3-sided culverts.

Inset: The infield entrance is adorned with a large graphic of a racecar, adding to the aesthetics at the Road America.

A notch above, below grade

Natural waterways are not the only water that needs to be managed. Highly urbanized areas have turned one of nature's greatest gifts into a major problem. Rainwater is not able to naturally percolate into the soil during storms, thanks to roads and parking lots. The deluge can overload the capacity of local treatment plants and, in the case of cities with combined sewer overflows (CSOs), dump millions of gallons of untreated sewage into local waterways.

One answer is to use the same precast concrete products that transport people, wildlife and materials above ground, and simply move them underground to temporarily hold the water for either managed release or beneficial reuse. In New Hampshire, CSI is currently manufacturing twin-cell monolithic culverts – 144 sections in total – for a CSO project.

Wieser Concrete manufactured 160 precast culverts for detention of stormwater under a Walmart parking lot. "There were 134 arches weighing 26 tons apiece and with a 32-ft span," said Wieser. "They put them together in two rows side by side and basically built a big pond under the parking lot."

In addition to various tanks and even underground garages, H2 Precast has used its 3-sided product to create wine cellars for clients. No matter how unusual or challenging the need is, Prewitt has found the same reasons as his peers for customers using precast.

"The 3-sided structures go in quite a bit faster," said Prewitt. "With some other products, there are a lot more pieces that have to be bolted together and assembled."

Made to order

Whether it's any of the applications mentioned previously or others such as mine shafts, fire cisterns, vaults, wet wells, pump stations or more, precast culverts are being used to meet the need. But to truly live up to the Transformers analogy, precast culverts must also transform.

Any precaster who manufactures culverts will have standard sizes, but that's just the beginning. Need custom strength? Adjust the mix or wall thickness. Want

an additional aesthetical flair? Consider an arched look or custom headwalls and wingwalls with integral color or finishes achieved by form liners or post-production treatments. Does your site present specific challenges due to location, grade or use? That's no problem – your local precaster can work with you to solve job-site issues.

"We manufacture box culverts and 3-sided culvert sections with skewed end sections and/or skewed interior sections for curved alignments or when small-span bridge crossings are not perpendicular to the roadway," Worden said.

In Wisconsin, Wieser Concrete's customizations also run the gamut from skewed ends to corners in the run and access openings. But some jobs require more unique modifications than others. "One of the more unique ones was for steam piping for a large hospital, and the floor was sloped to one side with a small trough in it so any leaks or moisture had somewhere to go," Wieser said. "The floor was also broom-finished so they could walk in it."

Culverts are just one of the many versatile products precast concrete manufacturers offer, and perfectly represent the multipurpose nature of precast products and their ability to solve challenging construction problems. Precast concrete may not save the earth from an alien invasion of deadly robots as other Transformers undoubtedly would, but they are definitely "more than meets the eye." Contact a local precaster today at precast.org/find to see how precast concrete can help you on your next job.

Kirk Stelsel is NPCA's director of Communication.

(Endnote)

[i] Begun in 1984, "Transformers" is an animation/comic book/video game/film franchise co-produced between the Japanese Takara Tomy and American Hasbro companies based on alien robot toys.

More than 160 pieces, including 134 three-sided arches, were manufactured by Wieser Concrete's plant in Portage, Wis., for a stormwater detention system.

Chemical Admixtures for Concrete: What's Next?

Amazing advances in admixture technology over the past 20 years will give way to even greater innovations for the precast concrete industry.

By Terry Harris and Ara A. Jeknavorian, Ph.D.

There can be little doubt that some of the most significant changes in concrete material technology are attributed to advancements in chemical admixtures for concrete in the past 20 years. The precast concrete industry has been at the heart of the new engineering properties enabled by chemical admixtures such as moving from 4-in. slump concrete to self-consolidating concrete (SCC). Before we look at what may be ahead in chemical admixtures, let's take a look at where we've been and where we are now.

A little history

Admixtures have been used in concrete and mortar since at least the Roman Empire. The Romans found that certain materials such as milk, blood and lard, as well as organic materials such as molasses, eggs and rice paste allow greater workability in cementitious mixtures.

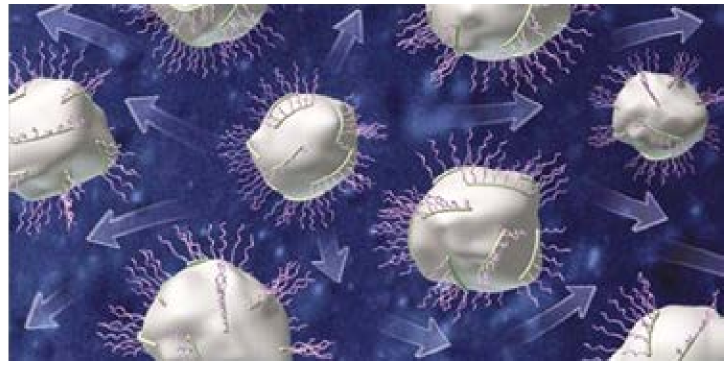
While the first patent for calcium chloride in concrete goes all the way back to 1873 in Germany, modern admixture technology started with basic air-entraining agents, retarders, accelerators and water reducers in the 1930s in North America.

However, it was not until the 1950s that these types of products began to see widespread use in concrete. ASTM first published its C494 standard in 1962, now titled "Historical Standard: Standard Specification for Chemical Admixtures for Concrete," which set performance criteria for five types of admixtures: A, B, C, D and E. Types F and G, high-range water-reducing admixtures, were not added to the C494 standard until 1980. In 1962, only 36 states required or allowed the use of admixtures in concrete.

ACI Committee 212 publishes the "Report on Chemical Admixtures for Concrete," which did not include high-range water reducers (HRWRs) in their document until 1981. While the 1970s saw a sharp increase in the use of admixtures in concrete, a 1982 survey found that only 71% of the concrete produced in the United States contained water-reducing admixtures, and that less than 2% contained HRWRs.

In 1979, the first corrosion-inhibiting admixture was introduced to help mitigate the impact of chloride salt (NaCl) attack on steel reinforcement. Almost 20 years later (1996), shrinkage-reducing admixtures followed and helped to address cracking issues associated with autogenous drying in high-performance concrete.

The 1980s and '90s continued to see increased use of admixtures in concrete, which included significantly more frequent projects specifying the use of HRWRs as the placement benefits of higher slumps and improved



durability of lower water-cementitious material (w/c) ratio concretes were realized.

Still, the biggest change in concrete in North America occurred with the introduction of a new HRWR technology that greatly expanded the plastic and hardened properties of concrete and, in the case of SCC, created a new concrete terminology.

Polycarboxylates and SCC

In the mid 1990s, polycarboxylates[i] in HRWR admixtures were introduced in North America, thus initiating a dramatic paradigm change in our understanding of how to design and use highly workable concrete mixtures. Because of the flexibility, enhanced workability, workability retention with minimal set retardation, and very good finishing characteristics, the acceptance curve for these admixtures was much shorter than anything previously introduced.

The biggest change in concrete occurred with the introduction of new HRWR technology that greatly expanded the plastic and hardened properties of concrete and, in the case of SCC, created a new concrete terminology.

Shortly after the introduction of polycarboxylate-based HRWRs, concrete producers began experimenting with SCC in all segments of concrete production; however, nowhere was SCC more rapidly accepted than in the precast market. The ability to fill a mold quickly without vibration, while still maintaining or even improving the plastic and hardened properties of the concrete, made SCC a perfect match for precast concrete producers.

Precasters began using terms like slump flow, viscosity, filling ability, passing ability and rheology to describe this revolutionary type of self-consolidating and non-segregating concrete. Unlike earlier HRWR technologies such as naphthalene ($C_{10}H_8$) and melamine sulfonate (CH_3SO_2O) condensates, which have fixed-chemistry and limited-performance capability, polycarboxylate technology is highly flexible, meaning that the polycarboxylate polymer can be designed and optimized for a wide range of performance requirements, from high early strength to extended slump life to SCC.

With the emergence of SCC, another class of chemical admixtures – viscosity-modifying admixtures (VMAs) – has been commercialized to address the need for improving the water tolerance and segregation resistance of this highly flowable concrete. The rapid acceptance of VMAs prompted the inclusion of a new admixture category, Type S, in the ASTM C494 standard to assure users that VMAs have no impact on common concrete properties (workability, set, strength and shrinkage).

Where are we now?

A list of the most recent chemical admixtures relevant to precast concrete is as follows:

- *General Purpose polycarboxylate-based HRWRs* – A HRWR for high flow (≤10 in.) and/or low w/c ratio concretes (≥ 0.40). These superplasticizers would not necessarily be applied for a special performance such as high early strength or self consolidation.
- *High Early Strength* – A polycarboxylate-based HRWR designed and formulated to enable increased strength at early ages.
- *Extended Slump Life HRWR* – These admixtures are typically blends of different polycarboxylates, which are engineered to activate or increase slump at different times. The goal of these polycarboxylate-blended products is to maintain concrete mixtures at target workability levels until concrete is placed and consolidated without delaying set times. Several HRWR products have been recently introduced, comprised solely of slowly activating polycarboxylates, which can be added to almost any concrete mix to extend slump life as desired.
- *Rheology Modifying Admixtures* – These admixtures are designed to impart lubricity to the concrete, especially at very low slumps, resulting in improved formed finish, increased productivity and improved surface texture.
- *Viscosity Modifying Admixtures (VMAs)* – Viscosity modifying admixtures are most commonly used in SCC when the batch-to-batch variations in

aggregate gradation, particle shape and density, and water content make it difficult to consistently produce a stable, non-segregating SCC mix. VMAs function by building a network structure within the pore water that helps minimize water and paste movement, especially once the concrete is in a static state. VMAs have also been used with conventional concrete mixes where the concrete mix may have a tendency to segregate.

- *Shrinkage Reducing Admixtures (SRAs)* - SRAs help provide some measure of reducing the potential for autogenous shrinkage cracking with high-performance concrete (w/c ratio < 0.40).

Where do we go from here?

Polycarboxylate HRWRs will continue to be the dominant admixture technology, especially in precast concrete. As a result of continually improving the dose efficiency of polycarboxylates, they are already penetrating into normal water-reducing and water-reducing/retarding chemical admixtures. Engineering or designing polycarboxylates to create or modify a specific performance attribute of the concrete mix will also likely be expanded.

Other products that may be on the horizon:

1. *Universal Air-Entraining Admixtures* – The search continues for "set it and forget it" air entrainment. Some work has been successful, and so admixture providers may not be far away from a product that will allow precast manufacturers to add an admixture to achieve a specific air target and be far less sensitive to the many factors that affect air content.
2. *HRWRs* – Polycarboxylate technology will continue to be exploited to push the concrete performance envelope. New polycarboxylate-based HRWRs can include admixtures that allow for higher levels of water reduction without compromising concrete workability; admixtures with shrinkage reducing capability; and admixtures for high early strength.
3. *SCM Activators* – In the push to use more fly ash and slag in precast, admixtures will be required to offset the early strength loss experienced when using fly ash or slag.
4. *Nanotechnology*[ii] – This has become quite the buzzword in many industries, and the concrete industry is no exception. A few products, based on aqueous suspensions of nano silica and nano C-S-H, have already been commercially introduced into the concrete market. These products are designed to significantly improve early strength (< one-day) development. The benefits from nanotechnology are realized from the very high surface area that nano particles provide versus ordinary portland cement.
5. *Internal Curing Admixtures (ICAs)* - Controlled release of ICAs for high-performance concretes (> 0.40 w/c ratio) is expected to help mitigate cracking due to autogenous drying shrinkage. The combination of ICA and SRA could represent an interesting synergistic approach to controlling cracks in low w/c ratio concrete.

While the past 20 years have seen amazing changes in the precast concrete industry, new innovative chemical admixtures are coming on stage to meet the increased demand for sustainable concrete, faster construction cycles and growing shortages of quality raw materials.

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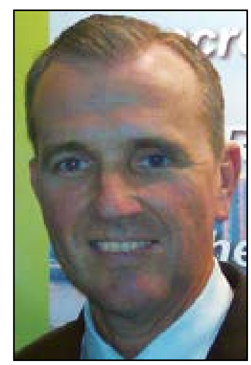
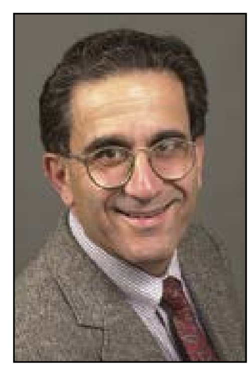
Dr. Ara Jeknavorian of Jeknavorian Consulting Services is an independent consultant serving the concrete construction industry and is an expert in cementitious systems and chemical admixtures for concrete. He served a 34-year career with the Construction Products Division of W.R. Grace in Cambridge, Mass., and spearheaded the introduction of polycarboxylate-based superplasticizers to the North America concrete market.


Terry Harris

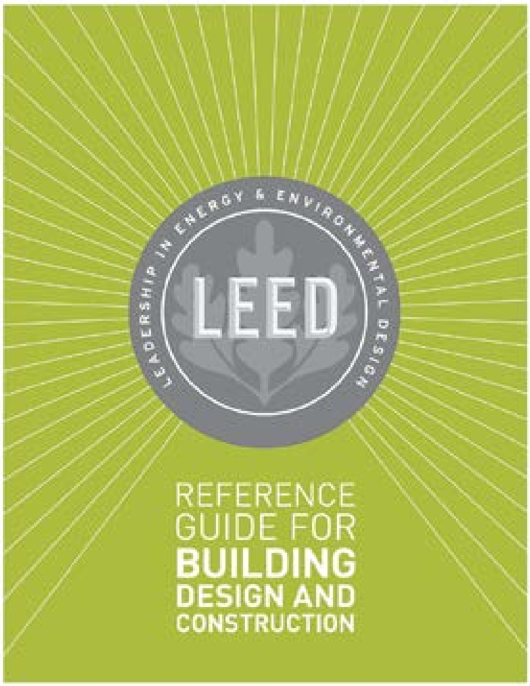

Ara Jeknavorian

Reference: "History of Chemical Admixtures," *ACI International*, April 1984, by Richard C. Mielenz

(Endnotes)

i Polycarboxylates, in particular, are gaining wide acceptance as dispersants in admixtures. The polymer chemistry can be used to customize admixtures by regulating flow rate, drying time and other variables to meet the needs of specific construction jobs. Admixture makers say the new chemistry supports strong and durable concrete at lower admixture usage levels than traditional dispersants such as ß-naphthalene sulfonate and lignosulfonates.

ii Nanotechnology is the engineering of functional systems at the molecular scale. For a discussion of nanotechnology, see "The Next Big Thing in Concrete is Not Big at All" in the January-February 2014 issue of *Precast Inc.* magazine.



LEED v4 is Here

With USGBC's increased emphasis on reduction of carbon emissions, LEED v4 has toughened up energy-efficiency and building-product prerequisites that will affect new construction.

By Claude Goguen, P.E., LEED AP

Since its unveiling in 2000, Leadership in Energy and Environmental Design (LEED) has become a part of building construction vernacular in the United States and around the world. The U.S. Green Building Council (USGBC) runs LEED, which is designed to save money, energy and water resources, and to promote healthy, sustainable and environmentally friendly buildings.

A growing number of agencies support LEED benchmarks, including construction industry associations; state, federal and local governments; private organizations; and engineers and architects across the globe. Today's new structures routinely include requirements for material suppliers and contractors to construct buildings that qualify for the maximum attainable LEED credits.

No. 1 international green-building certification program

From its humble beginnings in the late 1990s, LEED has grown more rigorous in its requirements. It is now recognized internationally as the main third-party certification for green buildings, currently certifying 1.7 million sq ft of building space every day. More than 54,000 projects are participating in the current version, LEED 2009, totaling more than 10.1 billion sq ft of construction space.

While some in the construction industry embrace LEED, others find its rating system unnecessarily complex and unfairly exclusive to certain building products. But love or hate it, LEED increasingly dictates new project materials, methods and designs.

After a couple of years of deadline extensions and

San Francisco's iconic Transamerica Pyramid, a 40-year-old structure featuring white precast-quartz aggregate panels, is one of the most famous LEED Platinum buildings in the United States. Its Energy Star score of 98 means it is among the top 2% of high-performing energy-saving structures in the country.
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CREDIT CATEGORIES

- INTEGRATIVE PROCESS
- LOCATION AND TRANSPORTATION (LT)
- SUSTAINABLE SITES (SS)
- WATER EFFICIENCY (WE)
- ENERGY AND ATMOSPHERE (EA)
- MATERIALS AND RESOURCES (MR)
- INDOOR ENVIRONMENTAL QUALITY (EQ)
- INNOVATION (IN)
- REGIONAL PRIORITY (RP)

six public comment periods, 86% of USGBC members voted to approve the latest version, LEED v4. According to the USGBC, the launch of LEED v4 is "designed to drive innovation in every aspect of the building lifecycle."

The USGBC is taking a phased approach to LEED v4. This means that rather than requiring all projects to comply immediately, it is giving the marketplace time to become familiar with the basis of its concepts and theories. Project teams can register their projects under LEED 2009 until June 1, 2015.

What's changed?

Those familiar with previous versions of LEED will recognize the same fundamental structure (prerequisites and credits, 100 base points, regional priority credits and pilot credits); however, LEED v4 has more emphasis on USGBC's goal of reducing carbon emissions, and this means increased energy efficiencies across the board. Consequently, LEED v4 had adopted ASHRAE[i] standards.

LEED v4 is technically more rigorous, with major changes including:

1. Expanding compliance for LEED market sectors to include: data centers, warehouses and distribution centers, hospitality projects, existing schools, existing retail, and new compliance for mid-rise projects
2. A separate new credit category for Location and Transportation (smart growth principles including reuse of existing structures and pedestrian-friendly designs) and a new Environmental Site Assessment credit
3. A new prerequisite for water metering and new credit for water cooling towers
4. A construction Demolition and Waste Management prerequisite
5. A reworked Materials and Resources section with a focus on waste reduction and reuse
6. Revised credit weightings with point distribution that will more closely tie the rating system requirements to the priorities articulated by the USGBC community
7. New prerequisites and new, rearranged and merged credits across LEED categories, including changes in the rating systems
8. Changed point values for each rating system, with LEED points associated with each credit and option of the rating system

Under LEED Building and Design, USGBC's increased emphasis on carbon reduction (global warming) will be seen in designs, material selection, modeling and project delivery methods. These changes have resulted in controversy, especially the new credit to minimize human health risks (Building Product Disclosure and Optimization, and Material Ingredients).

Using precast concrete to meet the demands of LEED v4

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

- *Site Development – Protect or Restore Habitat* (formerly SS 5.1): The requirement is to preserve and protect from all development and construction activity 40% of the green field area on the site (if such areas exist). 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 to manage the runoff.

- *Heat Island Reduction:* Precast concrete has a higher solar reflectance than many other materials, which is beneficial in reducing the heat island effect.

- *Building Product Disclosure and Optimization –* Environmental Product Declarations:
  Multi-Attribute Optimization
  This credit rewards the use of products that comply with one of a few criteria including products sourced (extracted, manufactured, purchased) within 100 miles of the project site. Precast concrete manufacturers are often located within short distances from the project.

- *Building Product Disclosure and Optimization – Sourcing of Raw Materials:*
  Leadership Extraction Practices
  This credit awards points based on the use of products that meet at least one of six responsible extraction criteria for at least 25%, by cost, of the total value of permanently installed building products in the project including recycled content. Precast concrete includes pre- and post-consumer recycled content mostly through the use of supplementary cementitious materials and reinforcing.

- *Construction and Demolition Waste Management:*
  Reduction of Total Waste Material
  Do not generate more than 2.5 lbs/sq ft of construction waste on the building's floor area. The use of precast concrete significantly reduces construction waste, because it arrives on site ready to be installed.

- *Regional Materials:* The "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 Standard 55-2010, "Thermal Comfort Conditions for Human Occupancy."

- *Precast Enclosures:* Precast enclosures will contribute due to concrete's thermal mass properties.

Environmental Product Declarations

LEED v4 also awards credits for the use of Environmental Product Declarations (EPDs) for products and Life Cycle Assessments (LCAs) for whole buildings as a way to demonstrate transparency and superior environmental performance. Similar to a food nutrition label, an EPD reports environmental impacts such as carbon footprint, acidification or ozone depletion potential. EPDs list quantified life-cycle product data, and the product or brand producer owns the labels. In essence, EPDs are eco-labels, and many believe they will be required for all building products in the future.

Product Category Rules (PCRs) govern how LCAs and EPDs are written. The PCRs are developed for a broad product type such as vinyl siding, asphalt roof shingles or precast concrete. NPCA is working with two other industry partners to create a North American PCR for precast concrete.

The green building industry is continuing to grow, and LEED has been a big part of that growth. LEED v4 ushers in a major emphasis on carbon reduction, and with it come new requirements for increased energy efficiency in all aspects of new construction. PS

Claude Goguen, P.E., LEED AP, is NPCA's director of Technical Services and Sustainability. For questions about this article, please contact Claude at (317) 571-9500 or cgoguen@precast.org.

(Endnote)

[i] ASHRAE = The American Society of Heating, Refrigerating and Air-Conditioning Engineers

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