Museum Rises // Tower of Voices // Making the Most of Solar Energy // Rethinking Repaving

precast solutions

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ON THE COVER:
The new Flight 93 Memorial combines precast concrete and wind chimes to create a serene tribute to the victims of Flight 93.

Photo courtesy of PennStress

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WHAT'S INSIDE

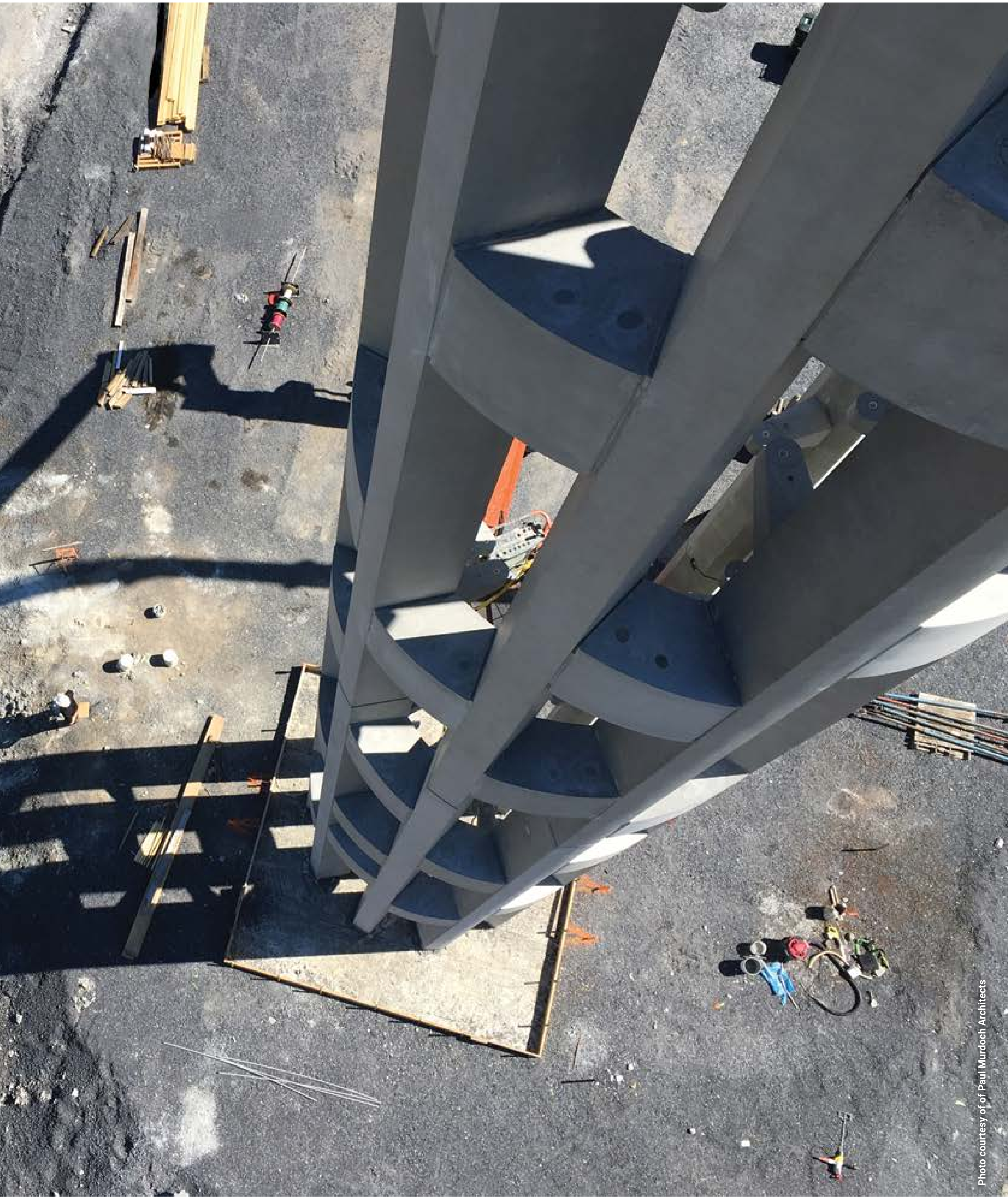


Photo courtesy of of Paul Murdoch Architects

Specifier Q&A

This issue, Precast Solutions hears from Joseph Biondo, FAIA, a design principal with Spillman Farmer Architects, based in Bethlehem, Pa.

Photos courtesy of of Spillman Farmer Architects

What is your background and area of focus?

Spillman Farmer Architects is an interdisciplinary practice of design professionals focused on the delivery of innovative building solutions based on human-centered design. Since 1927, we have been working closely with people and communities to deliver high-quality, effective, and inspiring places to live, work, play and learn. Our design process empowers people to make responsible, thought-provoking and inspiring decisions related to the built environment. Through this process, we explore each project's unique opportunities for honest, expressive solutions specifically suited to a building's site and use.

Joseph Biondo, FAIA

Spillman Farmer Architects used precast concrete to provide the City of Easton, Pa., with a new City Hall.

Surface textures were added to Easton's City Hall precast concrete facade to provide a striking look.

What type of projects does your company focus on?

Our office participates in a broad spectrum of building types – nearly every building type you would find in a neighborhood, campus or city. We are the consummate generalists of architecture, planning and design. That broad base of experience enables us to have an intrinsic quality of thinking and problem solving that transcends new trends in design.

What are some interesting projects on which you specified precast concrete?

We have many interesting precast projects which include cultural arts, civic, office and distribution centers. The most notable are the ArtsQuest Center and the City of Easton's City Hall and Transportation Center. Beyond aesthetics, both buildings utilize precast panels in a hybrid structure. The system provides both gravity-load-bearing and horizontal bracing for the structural steel frame. Varying surface textures add to the unique qualities of the buildings.

The center combines steel, glass and precast concrete to create a unique appearance for a performing arts venue that hosts films, concerts and other visual arts events.

The ArtsQuest Center in Bethlehem, Pa. uses precast concrete panels that are both gravity-load-bearing and horizontal bracing for the structural steel frame.

What benefits do you see in using precast concrete?

Precast concrete is manufactured in a controlled environment, which enables exceptional quality control and construction scheduling.

How have you seen precast concrete products evolve?

Although concrete and precast concrete have been familiar systems with long standing histories, we continue to be curious about them and their methods of assembly. We continue to push the boundaries of the precast systems; their forms, structural capabilities and textures. Our priority is to develop an architecture that is rational, leveraging a distinct, precise and honest building vocabulary that shows clear evidence of how and why it was made. **PS**

AN ICONIC NEW MUSEUM RISES AT "THE GOLDEN DOOR"

Lady Liberty prepares to lift her lamp to a new generation with a museum that rises from the earth like a beacon to immigrants and tourists alike.

By Deborah Huso

Photo courtesy of © Legacy1995 | Dreamstime.com

Photo courtesy of Phelps Construction

Crews work on the new Statue of Liberty Museum, which is scheduled to open in May 2019.

It's one of the most iconic structures in the world – Lady Liberty triumphantly raising her torch above New York Harbor. The statue was once the first sight of arriving immigrants in the era when Ellis Island processed the majority of would-be Americans, and today it hosts 4.3 million visitors who crowd onto Liberty Island each year to see her. But given limited access to the statue itself in the wake of new security measures post 9/11, 80% of visitors to Liberty Island never enter Lady Liberty's pedestal.

The new Statue of Liberty Museum, scheduled to open in May 2019, is set to dramatically change the visitor experience on Liberty Island, even for those unable to enter the statue. The museum will house the Statue of Liberty's original torch, which Lady Liberty held aloft until 1986, and will also offer a dramatic view of the statue from its gallery.

A NEW MATERIAL FOR A NEW AGE

The nearly complete 26,000-square-foot museum features walls of precast concrete that provide structural support, insulation, and the building's facade. It is also the first building project undertaken on the 14.7-acre Liberty Island since the Statue of Liberty-Ellis Island Foundation (SOLEIF) assumed responsibility for preserving the statue in the 1980s. Once complete, after more than two years of construction, the $70 million structure aims to achieve LEED Gold certification for environmental sustainability with precast concrete occupying a

Unique forms were used to create precast concrete panels with 4-inch-deep fin profiles to cast shadows for the new museum's facade.

Workers begin installing precast concrete panels on Liberty Island to create the Statue of Liberty Museum.

central role in the achievement.

"The building was conceived to be a garden pavilion," said Dan Piselli, AIA, project architect for the museum and director of sustainability and senior associate at FXCollaborative. "It's trying to link the past and the future."

The place where the new museum stands had always been empty, despite the original plan for a boat dock in that location. The new museum, which will offer a viewing platform for the statue as well as the lower Manhattan skyline, is designed to occupy the vacant space and merge with the natural world around it, hence its sloped green roof with angles and tiered areas for plantings as well as the building's precast walls.

"The precast walls symbolize the ground being raised," Piselli noted. "When designing the walls, we looked at the Palisades across the river in New Jersey as inspiration."

The design team originally intended to construct the museum from cast-in-place concrete with granite cladding to complement the granite walls of the fort on which the Statue of Liberty stands. The cost of granite proved to be prohibitive. Not to mention the logistical challenges of the project given its island location in New York Harbor.

"The cost of barging all those concrete trucks out there would have been enormous," said Doug Phelps, president of Phelps Construction Group, which served as the project's general contractor. He also wanted to minimize the amount of actual work that needed to be done on the island.

"Precast was a very good decision," he said. "If you're barging 10 panels onto the island and they get delayed two hours, so be it. If you're barging 16 concrete trucks and they get delayed, you could lose the whole pour."

The use of precast not only reduced the number of workers and activity on-site but

also saved the project some $700,000 in time and materials. FXCollaborative had previous experience with precast and felt it could ultimately address aesthetic goals similar to granite. That said, the design team did not look to emulate granite.

"We like to treat materials in an honest way on their own terms," Piselli explained. "We did not try to match the color of the granite."

Instead, the enormous precast panels became a reference to the heaviness of the ground. They also complement the brown-gray of the island's seawall, the fort and statue, and the pre-existing concessions and administration buildings.

While the design-build team initially considered using only architectural precast for the museum cladding, Robert Pabst, vice president of sales for project precaster High Concrete Group, convinced them to fully leverage precast technology to provide not only the structural support, but also the thermal envelope with vapor and water barrier.

BREAKING THE MOLD

High Concrete's carbon-cast high performance insulated wall panels comprise the museum's structure and facade, which consists of an inner wythe, R-21 insulation and an exterior wythe. A carbon-fiber grid performs as a shear connector between the inner and outer wythes of concrete. High Concrete manufactured each composite panel in a controlled environment at their factory in Denver, Pa., and all were complete and ready for installation upon arrival on Liberty Island. Along with the panels, High Concrete produced 4-inch-deep fin profiles that cast shadows, creating a vertical striation that not only darkens the color of the building but also reinforces the design concept of it being lifted out of the ground.

While one of the cost and efficiency benefits of using precast is typically the ability to take advantage of repetition in the molds, that was

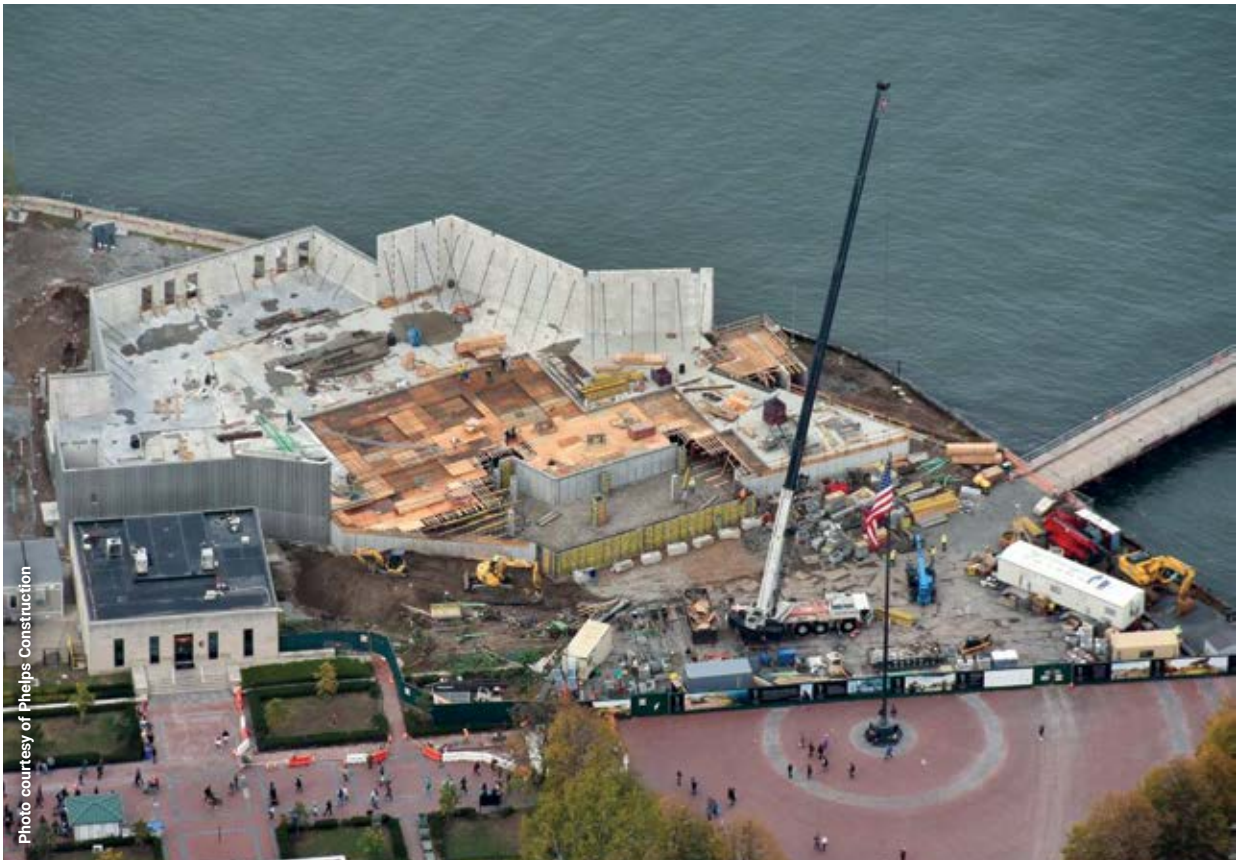


Photo courtesy of Phelps Construction

Rendering courtesy of FX Collaborative

more challenging on the Statue of Liberty project given the varying sizes of the 143 panels involved.

"The building itself was not square," Pabst noted. "It was a polygon. Plus, the sloping green roof design drove the tops of the panels to slope as well, creating a lot of unique pieces."

To address this issue, the design-build team worked with the precaster to evaluate "form families" and find a solution to use the same form with some modifications to create the unique pieces. After months of collaboration and mock-ups, they were able to find the solution, manufacturing all the unique panels using 10 form families, employing

A rendering of how the completed Statue of Liberty Museum will appear. The museum will house the original torch Lady Liberty held until 1986.

blockforms, bulkheads and form inserts to make individual adjustments as needed.

High Concrete's employees poured roughly three panels a day over the course of 10 weeks.

"We definitely tried to leverage the forming technology to get a lot of value but at the same time have design flexibility," Piselli explained.

The largest panel is about 29 feet long, almost 10 feet wide and 2 feet thick, weighing more than 60,000 pounds. The smallest panels were about 20,000 pounds.

Once cured, the panels were sandblasted to provide a textured finish and expose some of the stone in the aggregate. The dark and rough-hewn features of the panels,

along with the angular roof lines and green roof, make the museum appear to rise out of the earth.

To comply with FEMA's order on floodplain management issued in the wake of 2012's Hurricane Sandy, the museum stands 10 feet above sea level, well above 500-year flood levels, and five feet higher than the floodwaters of Sandy. Meanwhile, the lowest wall panels feature vertical slots designed to allow storm surges to pass through and under the building to dramatically reduce potential impacts from another major hurricane.

Precast concrete panels offered a relatively simple way to get an opening under the building to allow water to flow in and out while also providing structural support. The structure features a stacked panel design. The museum sits on top of a precast podium with all the mechanical infrastructure on top of that. Some of the upper panels connected to the podium are designed to withstand wave action as well, according to Phelps.


Rendering courtesy of FX Collaborative

STAGING AND SUSTAINABILITY

Rather than staging at the job site, High Concrete transported the panels on special rack frame trailers from Pennsylvania to a staging area in Jersey City, N.J. – generally only one panel per trailer given their massive size. Four trailers at a time were moved onto a barge and taken to a temporary dock at Liberty Island, where a single truck transported each trailer to the construction site for installation. Phelps rented two barges with tugboats to accommodate the transport across New York Harbor.

Once on the island, a jockey truck took each trailer off the barge to the job site, where a crane lifted and put the precast pieces in place, each connected to the other with steel plates, steel dowels and non-shrink grout. At the height of construction, the job involved two barge trips per day, transporting 10 to 12 panels – an eight-week process.

"The kind of precast system we used – the insulated sandwich panel – is very good in terms of helping reduce energy use in the building," said Piselli.


Rendering courtesy of FX Collaborative

Sloped green roofs give the building an appearance that it rose from the ground.

The insulated panels with composite connectors help reduce thermal bridging. And the sandwich panel itself allowed for additional insulation, R-21 overall, higher than local building codes require. The precast panels also offer thermal mass.

"With a sandwich panel, there's precast outside and then insulation, and then more precast inside," Piselli pointed out. "In addition to insulation, the internal precast buffers against temperature swings and reduces the buildings HVAC load."

LESSONS LEARNED

Piselli's team learned a lot from the project, since it was the first time FXCollaborative used precast as a structural material.

"If you want to design with structural precast panels, you have to understand what goes inside the panel to understand the [design] limitations," he noted.

And although he found precast helpful in conducting a lot of off-site construction, he appreciates that the size and weight of the panels created complexity due to the island's logistical challenges.

Intense collaboration on the part of the entire design-build team, including High Concrete, was critical to the Statue of Liberty Museum's project success. High Concrete Group worked with the architect for more than a year to address all the benefits and challenges of working with precast.

"You really need to make a concerted, collaborative effort to understand all the performance criteria before you offer the product to the market," Pabst said of the collaboration. "That takes a lot of effort."

But when he looks at the nearly finished museum today, he said, it sends chills down his spine to know he worked on an iconic project that's going to be there forever. **PS**

Deborah Huso is a freelance writer specializing in construction, real estate, finance and agriculture.

Tower of Voices:

A Lasting Tribute to the Heroes of Flight 93

Precast concrete and wind chimes provide a touching monument at the center of Flight 93 Memorial Park.

Mark Crawford

On Sept. 9, 2018, the National Park Service dedicated the Tower of Voices, an amazing monument that is the centerpiece of the Flight 93 National Memorial, a new national park in Somerset County, Pa. It was in this open field on Sept. 11, 2001, that United Airlines Flight 93 crashed after passengers stormed the cockpit, preventing the terrorist hijackers from attacking a key U.S. target – quite possibly the U.S. Capitol Building – making it hallowed ground.

Set among rings of trees, the Tower of Voices is a 93-foot tall precast concrete memorial that features 40 wind chimes – one for each crew member and passenger who died during the heroic struggle. As wind blows through the open structure of the monument, the 40 tones are meant to convey the serenity and nobility of the site and remind visitors of the final calls those passengers placed to loved ones.

More than 1,000 architectural and design firms competed for the honor to design the national memorial. In 2005, the project was awarded to Beverly Hills, Calif.-based Paul Murdoch Architects, in association with Nelson Byrd Woltz Landscape Architects. Murdoch and his team collaborated with the National Park Service and family members of the Flight 93 heroes to design the 2,200-acre memorial.

The Tower of Voices monument has 40 wind chimes, one representing each crew member and passenger who died during the heroic struggle on Flight 93.

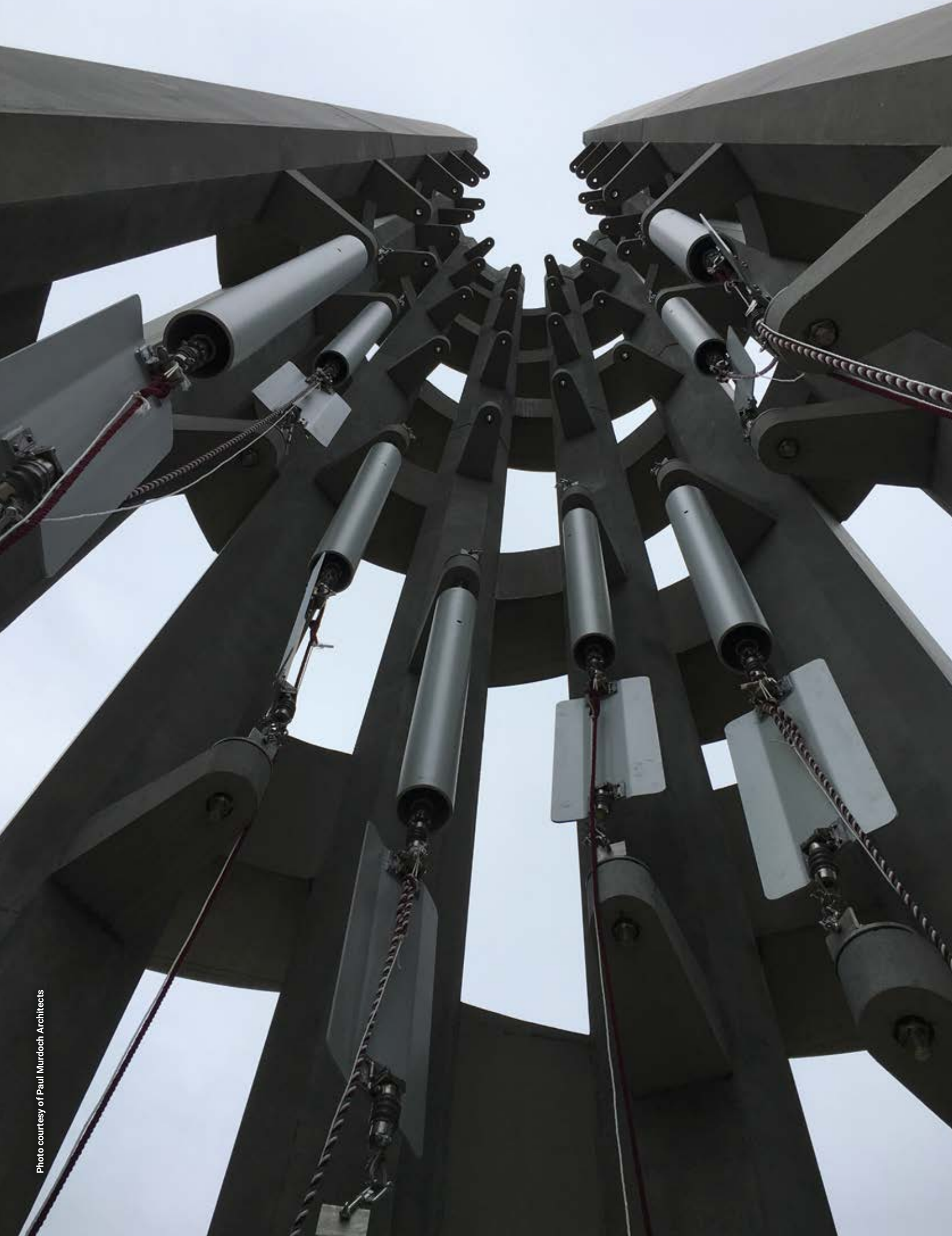


Photo courtesy of Paul Murdoch Architects

Crews assemble the reinforcement for the precast concrete columns and beams that make up the Tower of Voices Monument.

CREATING THE CHIMES

Designing a 93-foot-tall musical instrument holding 40 wind chimes – the largest in the world – was an immense technical challenge for Murdoch's team.

As a unique musical feature, the tower required a complex and innovative design process, including the cross-collaboration of experts including a musician, chimes artist, acoustical engineer and wind consultants. The size and complexity of the 40 chimes, and the variability of wind directions and velocities at the site, required an interactive process of testing and simulation to determine a final design.

"A back-and-forth process encourages input from each specialization to inform interdependent decisions and testing," Murdoch said. "This required musical tuning theory to establish the right tones, chime mock-ups for 3D recordings, computational fluid dynamic modeling to test tower shapes and simulate site conditions, and acoustic simulation in a sound lab to digitally test chime configurations in final tower volumes."

The team worked on the chime design for more than two years. The 8-inch-diameter aluminum tubes have half-inch-thick walls, vary in length from 5 to 10 feet and weigh up to 150 pounds. The length of each chime depends on the musical note and frequency it is designed to play. The chimes ring when they are struck by stainless-steel strikers that respond to sails moved by wind coming through the tower's open structure.

BUILDING THE TOWER

The chimes are supported by the C-shaped precast concrete tower, which opens toward the public plaza. The tower consists of approximately 274 tons of concrete and steel, or 141 cubic yards of concrete and 49,000 linear feet (9.25 miles) of reinforcing steel. The plaza is constructed on an earthen mound and surrounded by 208 trees, planted in concentric circles surrounding the monument. The arrangement of the trees is symbolic of the sound waves from the chimes. A lighted stone path winds through the trees, leading to the tower.

Twenty-five micro piles support the weight of the tower and the forces acting on the tower due to wind. Each micro pile consists of a 3-inch diameter, continuous high-strength steel rod grouted inside a 7-inch diameter steel casing that extends 83 feet below the surface of the plaza. The final 15 feet are embedded in bedrock. Each micro pile supports up to 160,000 pounds. The 25 micro piles are held together by a heavily reinforced 20-foot-by-20-foot-by-4-foot concrete cap. The total capacity of the cap is 4 million pounds. The piles, pile cap and tower are


Photo courtesy of Paul Murdoch Architects


Photo courtesy of Paul Murdoch Architects

protected with a grounding system extending from the foundation through the structure to the top of the cap and extending to each chime assembly.

The tower consists of 53 precast pieces produced by PennStress in Roaring Spring, Pa. The 16 column pieces, 35 beam pieces and two caps ranged in weight from 816 to 31,000 pounds. Precast concrete was selected for the tower walls because of the precision required for the complex and unusual shapes of the components. In fact, they were so unique that the steel forms fabricated specifically for the project will likely never be used again.

Russell Dickson, PennStress vice president of engineering, said despite the company primarily focusing on structural precast projects, there was no hesitation in providing the architectural precast elements.

"As soon as we realized what the project was and saw that precast was a major part of it, there was not an option to not do it," he said. "This was a project in our backyard and really does mean a lot to us as a company."

The high compressive strength of precast used in this project, roughly 7,000 psi, also improves the resistance of the structure to severe weather conditions, especially the freeze/thaw cycles of winter. Using precast also allowed the team to design and fabricate the components during the winter months.


Photo courtesy of Paul Murdoch Architects

Custom formwork was used to create the 53 unique pieces that make up the tower. Pieces ranged from 816 to 31,000 pounds.

Photo courtesy of Paul Murdoch Architects and Arup USA

Once the precast concrete segments were delivered to the site, they were linked together with connectors to form an open C shape that optimizes air flow through the tower walls to activate the chimes.

"The tapered column shapes were designed using computational fluid dynamics to study wind flow through the tower," Murdoch said.

The team spent more than 9,000 hours in development, design, logistics, multiple trial assembly procedures and casting sequencing to get to the point of on-site erection. Other digital and physical models were used to determine geometries and connections. PennStress used 3D printing technology to create prototypes to better understand the structural relationships between the tower columns and beams.

Photo courtesy of PennStress

Photo courtesy of Paul Murdoch Architects

The precast concrete pieces form a "C" shape that opens out to a public plaza. As the wind blows, chimes will ring out as a solemn remembrance of what happened on the site.

Photo courtesy of Paul Murdoch Architects

The result is beam shapes that curve to delineate the round footprint of the tower. The 20-degree angle of the connecting beams between the columns represents the angle of the branches of the hemlock trees that surround the crash site.

"The beam-to-column connections were challenging in terms of sloped/curved geometry, reducing the number of patches and alignments," Murdoch said. "There are approximately 844 Lenton connectors and 6,708 stirrups in the structure that splice discontinuous bars together."

PennStress decided that the slenderness of full-length columns

made them too susceptible to damage during shipping and erection. Instead, diagonal joints at varied locations roughly mid-height helped the columns blend in with the diagonal joints of the beams. Pockets and splines at the joints also aligned the column pairs vertically. In addition, it applied specialty coatings prior to shipment.

"Both water-repellent coating and anti-graffiti protection were required for the precast," he said. "Initial mock-up testing demonstrated a significant alteration to the desired light gray color of the concrete. After additional research and testing, we chose PROSOCO Blok-Guard Graffiti Control ll, which affected the appearance of the concrete the least."

A LASTING MEMORIAL

Constructing the Tower of Voices was funded by an approximately $6 million grant from the National Park Foundation. Visible from the highway, the tower marks the gateway to the national park. Murdoch hopes visitors to the memorial will reflect on the experience in deeply personal ways.

"We very consciously tried to create an openness to the experience and interpretation for everybody, and not to try to dictate what they would feel, but to let everybody have different angles of experience," he said.

Dickson said the entire company is proud of the way the project came out not only because of its complexity, but also what it means to the community.

"To think of what the 40 individuals did on that flight, anything that we could do to help remember them is a tremendous honor for us," he said. "That is something everyone here understands, and we don't forget that we're doing this for the 40 individuals who gave up their lives to save many others."

Collectively, the chimes produce an original "song" every time the wind blows through the tower.

"There are no other chime structures like this in the world," said Flight 93 National Memorial superintendent Steve Clark. "This unique structure completes all the major components of our permanent memorial in a most beautiful way. Not only is it the first thing visitors see and hear when they arrive at the memorial, it will also provide an opportunity for reflection as they depart." PS

Mark Crawford is a Madison, Wis.-based freelance writer who specializes in science, technology and manufacturing.

The Tower of Voices marks the gateway to Flight 93 Memorial National Park.

FLIGHT 93 NATIONAL MEMORIAL WINS WORLD ARCHITECTURE NEWS CONCRETE IN ARCHITECTURE AWARD

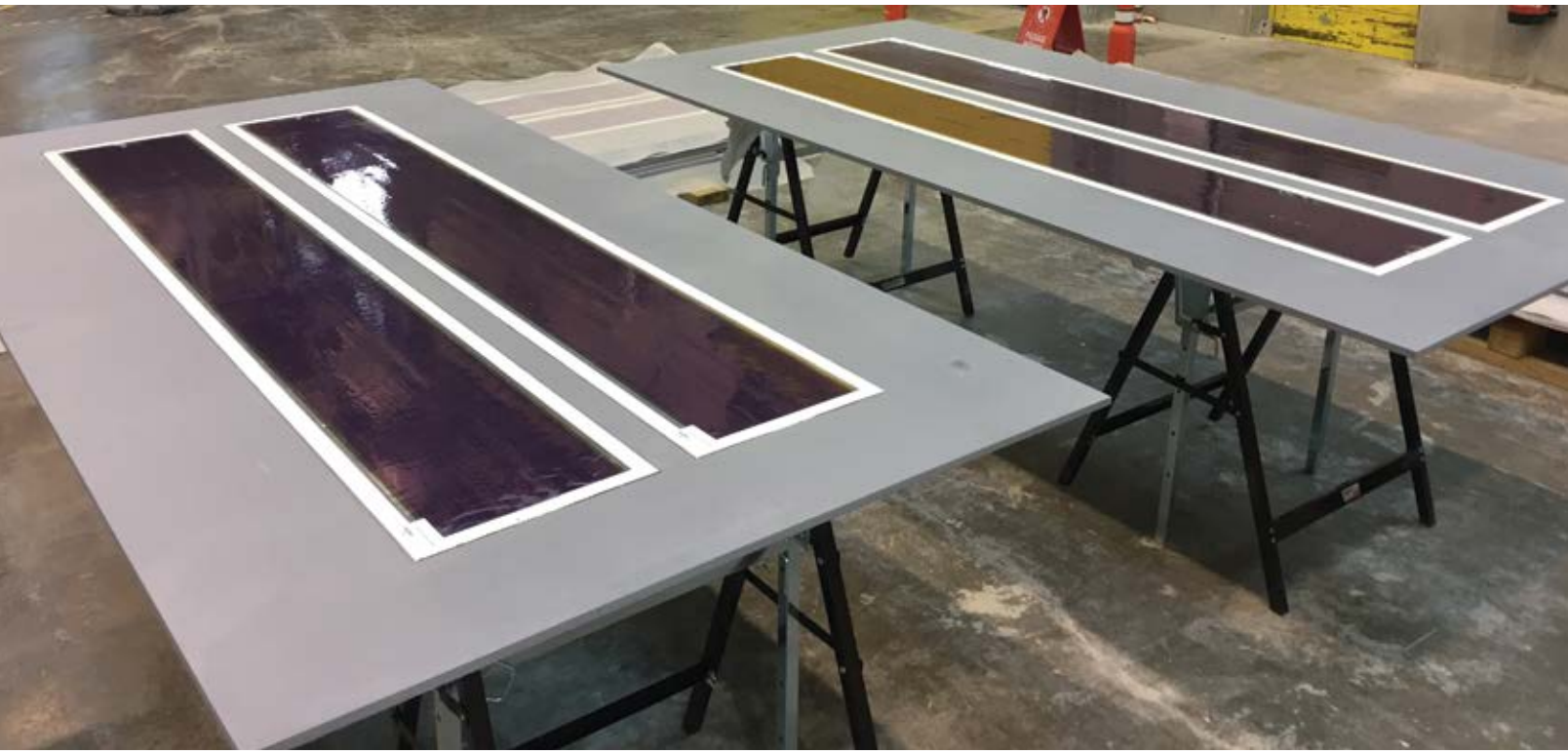
Here are some of the comments from jury members who selected this project for the 2017 World Architecture News Concrete in Architecture Award:

"It's stunning. The concrete is used perfectly to capture the kind of gravity and the momentous thing that it is there to commemorate. That's where concrete really shines in the use of this scheme. They've used it very particularly; it is quite a responsibility and they've taken it completely seriously."

"It's a wonderful use of the concrete from a technical point of view and I think it's been used very appropriately. It is a backdrop, it is solemn and quiet, yet bold, beautiful and dramatic. I love the color and the contrast of the different textures and where they are placed."

"A grand and fitting vision which envelopes a hugely significant site. Concrete as monument reflecting a sense of permanence. Lighter-built elements interplay, allowing optimism to lift above the mass of concrete."

Photo courtesy of Paul Murdoch Architects



Making the Most of Solar Energy

Experimental facade system by LafargeHolcim and Heliatek has the potential to produce superior energy-generating, energy-saving buildings.

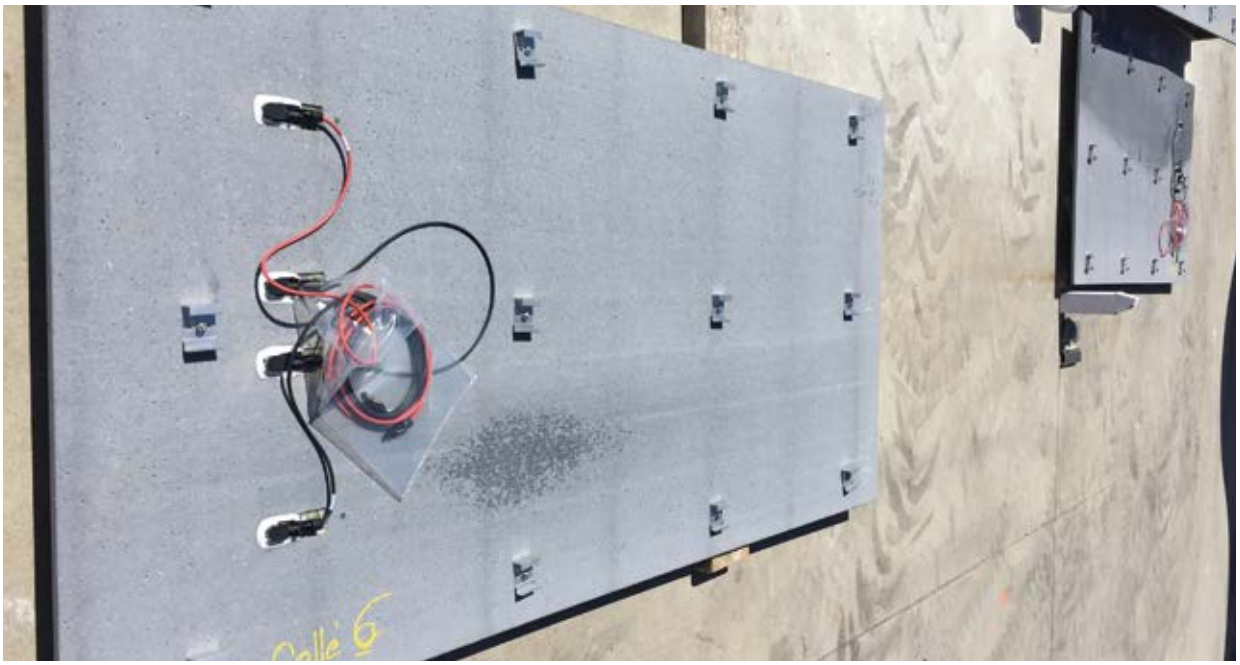
By Shari Held
Photos courtesy of LafargeHolcim and Heliatek

An experimental product in Europe is combining solar panels with precast concrete wall panels.

Solar energy – it's the most readily available and least expensive source of energy worldwide. In the U.S., homeowners and others who may have scoffed at the idea 20 years ago are now embracing it. By the end of 2018, more than 2 million solar systems are anticipated to be installed in the U.S.[1]

We're accustomed to seeing solar panels on rooftops, but in the not too distant future, our buildings could be clad from top to bottom in building-integrated photovoltaic (BIPV) facade systems. The energy savings could be substantial when you consider that commercial and residential buildings combined used nearly 39% of the United States' total energy consumption in 2017.[2]

Development of an innovative, photovoltaic (PV) facade technology is taking shape in Europe. The effort is spearheaded by Paris-based Ductal, a technology of LafargeHolcim Ltd., headquartered in Zurich, Switzerland, and Dresden, Germany-based Heliatek GmbH. The two companies have partnered to produce a PV precast concrete facade system with an energy-



The solar-energy-generation system is built into the precast concrete panels, meaning construction companies and installers won't have any equipment boxes or wires to install on-site.

generating potential that surpasses traditional rooftop BIPV panels.

"The three parameters that determine when this product will be useful or efficient will be the location, the orientation and the height of the building," said Carlos Piles, head of Ductal Europe. "The higher the building, the more efficient the panels will become."

The partners first presented the concept in Paris at Batimat, the international construction/building elements exhibition in November 2017. They completed the first pilot project for the unnamed product in September 2018. The product and the process of creating it are still in the experimental phase.

A PRODUCTIVE PARTNERSHIP

LafargeHolcim's Ductal, an ultra high performance concrete (UHPC), has been in the marketplace for years. Ductal is used for rainscreen cladding solutions, custom-built applications like facades, roofs, sunshading or brise soleil as well as for a building's structural elements. But, two years ago, the company started thinking about developing an innovative, energy-generating precast building facade featuring its Ductal precast panels. The basic concept was to marry Ductal's UHPC precast panels with PV technology. This would allow the facade to harvest solar energy on-site that could then be used to heat and cool the building.

"We understood that today, photovoltaic panels were merely being used on the roof," Piles said. "That is only 20 percent of the building. We felt that using photovoltaic technology in the facade would be much more effective for energy-generation."

LafargeHolcim had the precast side covered. As luck would have it, BATIMAT, the leading international trade fair for the building industry, brought LafargeHolcim together with Heliatek.

Piles said there were several criteria LafargeHolcim looked for in a partner. First of all, it wanted a partner that was both willing and able to participate for the long term. In addition, the prospective partner had to produce organic PV film because LafargeHolcim was interested in a light weight, thin PV film solution to match the characteristics of its Ductal panels. Ductal UHPC concrete is reinforced with organic fibers rather than bulky rebar. That allows the panels to measure less than 5/8 of an inch.

Heliatek's HeliaFilm fit the bill, measuring .04 inches thick and weighing just over 0.2 pounds per square foot. The partner's PV film technology also needed to be upgradable so the aesthetics, such as film colors, could be modified or customized. And, most importantly, the film technology had to be highly efficient when it came to solar energy gain.

"So, within those four parameters, we realized the best partner was Heliatek," Piles said.

GREEN AND SUSTAINABLE TO THE MAX

It is a big plus when partners share a similar environmentally friendly philosophy.

HeliaFilm is touted as the greenest PV solution worldwide. It contains no heavy metals or toxic materials and uses just 20 grams of carbon dioxide per kilowatt hour produced. It

The panels will be offered in a variety of sizes and colors for residences and buildings that hope to be energy-efficient and aesthetically pleasing.

takes only .035 ounces of organic material to produce one square meter of HeliaFilm. The production process consumes very little energy – with a less than three-month energy payback period. The lifetime cycle impact of HeliaFilm is five times less than crystalline PV elements used in traditional cladding systems. In addition, HeliaFilm contains only 1% inorganic material, making it easily disposable.

"What we are trying to do here is reduce energy consumption by producing a concrete-based product that can produce energy for the building." Piles said. "We chose Heliatek for its sustainable position as well."

Concrete is known for being one of the most resilient and durable building materials. It can also be manufactured using industrial byproducts and/or some of the most common aggregates and minerals. At the end of its long lifespan, it can be recycled. Piles estimates the Ductal/Heliatek panels will have a lifespan of 50 years or more.

BENEFITS FOR ALL

It's not just the planet that will benefit from BIPV facade panels. Architects will have another design option to meet the growing demand for residences and buildings that are energy-efficient, low-maintenance, built to last and aesthetically pleasing. Plans are for the panels to be available in a variety of sizes and colors, including yellow, blue, white, black and green. The PV precast facade panels will be produced in standard sizes ranging from .59 in. by 3.9. ft. by 3.9 ft. to .59 in. by 3.9 ft. by 11.8 ft.

"But if an architect wants to have facade panels 30 centimeters wide and 3 meters long (11.8 inches wide and 9.84 feet long), we can deliver it," said Kathrin Wiertelarz, Ph.D, system application engineer for Heliatek. "That's no problem. The technology gives us a wide space of possibilities."

Another plus is the panels can be applied on both new construction and existing buildings as well as residential, commercial and institutional and public buildings.

Construction companies and installers will benefit from the ease of installation. The solar-energy-generation system is built into the precast facade panels, so there are no equipment boxes or wires to install on-site. That means less installation time and no steep learning curve.

"We are not changing the way installers operate today," Piles said. "It's a plug-and-play solution, so they can install it the way they would install a rainscreen facade today. They just fit the panels on the horizontal and vertical rails."

Homeowners and building owners will reap the biggest benefit of all as the facade will literally pay for itself through energy produced. These BIPV facade panels can potentially double the energy-generation levels of roof-based solar systems. BIPV facade panels provide another plus that owners might not think about.

"Horizontal rooftop solar panels have to be cleaned and maintained to achieve 100 percent efficiency," Piles said. "Since they will be placed in a vertical position, owners won't need to maintain the Ductal panels."

GETTING DOWN TO BUSINESS: RESEARCH AND DEVELOPMENT

Heliatek was charged with finding the most efficient way to deliver this new product while containing costs and not slowing down precast production.

According to Wiertelarz, several key challenges had to be overcome. One was to find an adhesive solution that worked with both the UHPC and the HeliaFilm. Another was to determine how to best integrate the HeliaFilm and the Balance-of-Systems (BOS) electrical components such as cables and inverters into the precast manufacturing process. In addition, Heliatek was responsible for devising an experimental lab to produce the prototype and a system for testing the prototype's overall durability and performance.

"The manufacturing process is very demanding on our sensitive HeliaFilm," Wiertelarz said. "We had to experiment with different setups to implement this production logic without any loss of the aesthetic value of

our film or spending too much time in the production line."

Another challenge was finding time in LafargeHolcim's busy production schedule for two experimental, one-week test runs. The first took place in February 2017. The second was conducted in October 2017. After each trial run, LafargeHolcim and Heliatek weighed the pros and cons and tweaked the process.

FIELD TESTING

To date, LafargeHolcim has produced nearly 50 square yards of the Ductal/Heliatek facade. Thirty square yards were used for its first pilot project at the LafargeHolcim Research Center in Lyon, France, this September. Next up will be a 239 square yard installation in early 2019, again at the LafargeHolcim Research Center.

"The idea is to start commercializing this product in Europe by summer 2019," Piles said.

The full production process is straight-forward. The component containing the HeliaFilm and the BOS electrical equipment is placed in the bottom of a steel mold in a horizontal position. A layer of Ductal UHPC is poured over it and allowed to cure. The panels are released from the mold, packaged and shipped.

"We have a specific process that allows complete integration of the organic photovoltaic film with the concrete in one day," Piles said.

Currently LafargeHolcim and Heliatek are collecting data and measuring and analyzing results. The partners will be looking at a variety of factors, including how durable the panels are and how well they perform under different weather conditions, as well as how efficient the system is at harvesting solar energy. They will also refine some of the connections and the electrical junctions in the box. Meanwhile Heliatek is increasing the capacity of its production line so it can produce approximately 1 million square meters of HeliaFilm by 2020.

"Today the idea is that this product is mainly for the energy gain of the building," Piles said. "But in the future, it could be connected to a power station or to a power grid. Who knows?" **PS**

Shari Held is an Indianapolis, Ind.-based freelance writer who has covered the construction industry for more than 10 years.

Endnotes

[1] news.energysage.com/8-facts-solar-energy-2017/
[2] www.eia.gov/tools/faqs/faq.php?id=86&t=1

By combining a PV facade system and precast concrete panels, a building will be able to generate much more solar energy.

Rethinking Repaving

As states continue to look at ways to efficiently repair roads, Indiana is testing a new product in an urban environment.

By Matt Werner

NPCA File Photo

Every commuter has experienced it at some point. Cruising along an interstate when you come to a grinding halt as crews are patching pavement. Suddenly the expressway becomes a stress-way. Precast concrete paving slabs were developed to alleviate those stressful daytime lane closures, and several states have started using the product to ease traffic jams on the interstate. While some states have been using the paving slabs for years, others are just now getting into the game and have been pleased with the results thus far.

TEST PROJECT IN INDIANA

Indiana prides itself on being called the "Crossroads of America" with four major interstates spanning the state. Like other states, Indiana has been dealing with deteriorating roads and bridges,

The Indiana Department of Transportation is testing removable urban paving slabs on a stretch of historic road in Richmond, Ind.

but recently invested heavily into its infrastructure.

As more projects are coming online, the Indiana Department of Transportation is looking at ways to improve the process and is testing precast paving slabs in both interstate and urban settings.

As INDOT was looking at possible projects, U.S. 40 in Richmond rose to the top of the list. For starters, it's a 100-year-old section of the historic National Road US Route 40 that never had a major reconstruction project. It was also a project INDOT had been talking about for nearly 20 years.

"We're on the low-risk side of the scale," said Robert Gill, project engineer with INDOT. "We don't want the first panel we place to be on Interstate 70 and it not work out. Nobody likes that idea."

Half the road was going to be shut down as part of the project anyway, so it made sense for INDOT to try paving slabs.

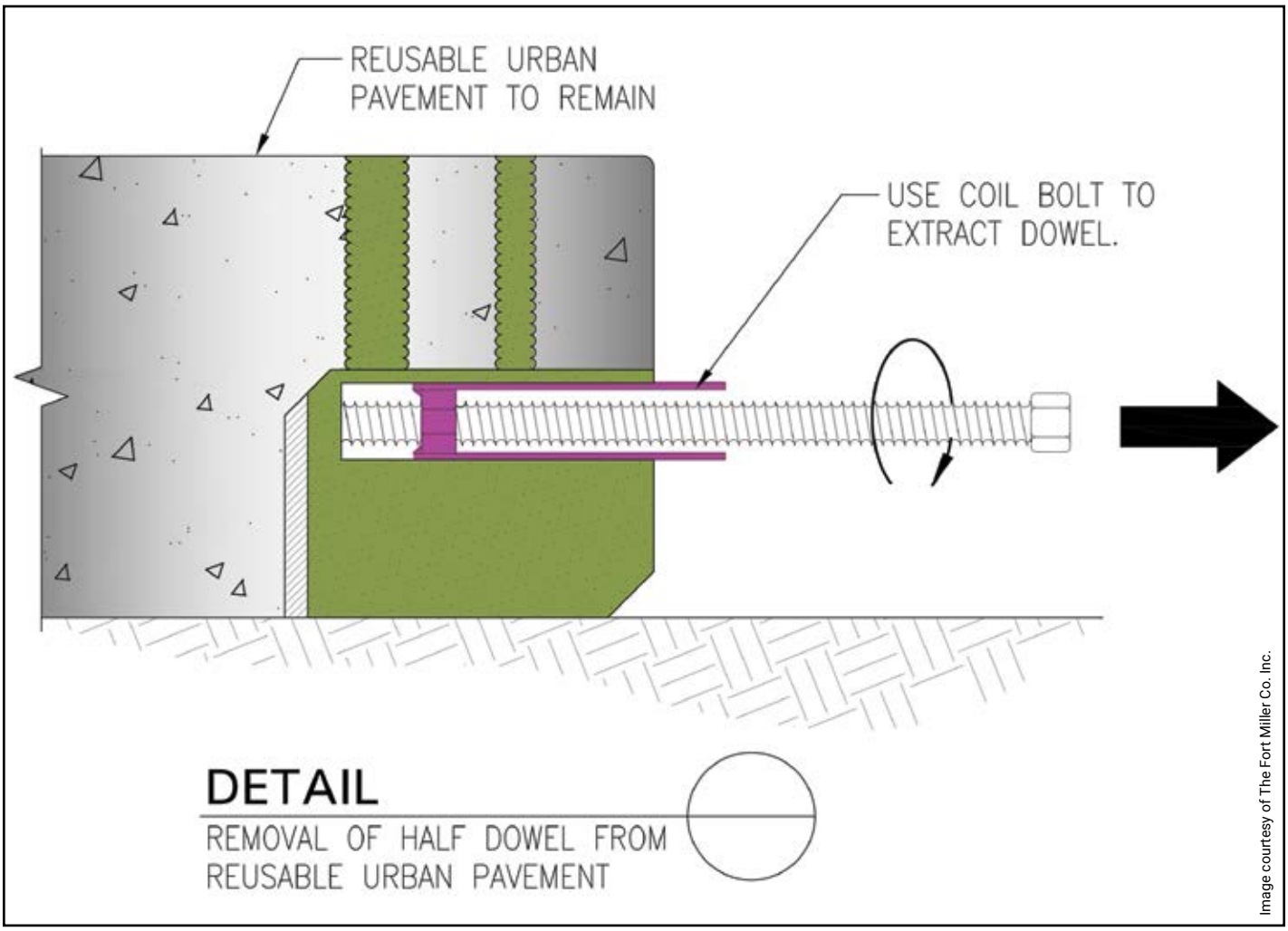


Image courtesy of The Fort Miller Co. Inc.

This graphic showcases the Super-Dowel system that makes these panels removable.

"If a panel shows up and there's something wrong with installation, construction or anything, we were already taking the lane so it doesn't cost us long term," Gill said. "If something doesn't go quite right, we have time to adjust. It's an experiment; so let's experiment with it."

CHOOSING THE PROJECT

It's easy to say paving slabs are the perfect remedy for interstate projects, but what do you do when you've got a project in an urban setting with utilities underground?

Sure, crews can cut into the slabs to get the work done, but that can be an intensive process. Enter removable urban paving (RUP) slabs that are designed to allow utility companies to easily remove slabs, access their lines and reinstall the same slab back in its original location.

Dan Moellman, P.E., senior product engineer with Fort Miller, said the RUP slab is new, with the project in Richmond being its second use. Moellman's team did a presentation for INDOT and other interested parties prior to the project.

"There were a lot of skeptics in the room," he joked. "People wondered if it would be completed in the required time frame. Nobody in Indiana had done this before, and they need an entrepreneurial vision to tackle this new technology."

Gill noted that several parties had to buy into the project for it to be a success.

"The precast industry has to say, 'Yes, we want to be involved with this project,'" he said. "The contractors have to build up their installation expertise; the utilities have to be on board. It's not like I can just say, 'Well, we know what we're doing, go to it.'

"There's more to it than that, and so far we've had that response."

Photo courtesy of The Fort Miller Co., Inc.

Photo courtesy of The Fort Miller Co., Inc.

Crews can easily remove the precast concrete paving slabs should utility work need to be done in the area.

Moellman was hoping for just a few intersections since it was going to be a test project. Instead, INDOT decided to do six-tenths of a mile of U.S. 40 through the heart of Richmond.

"We were thinking it was just a starter project," he said. "Everything was coming together, and I kept wondering if it was actually going to happen because it was such a huge project. They wanted to do a showcase project, and that really kicked it off and got things going."

JOYS OF URBAN CONSTRUCTION

What makes the RUP slabs good for urban projects is that instead of having to cut into the slab, crews can saw on the joint lines and pull the slab out of the ground thanks to Fort Miller's Super-Dowel, developed and patented by Peter Smith, Fort Miller's vice president of market development and product engineering. Smith is also the developer and patent holder for the Super-Slab system.

"When you saw through the joints, the Super-Dowel pipe dowels are cut in half," Moellman said. " You can drill out and access the four coil lifting inserts and remove the slab. Each Super-Dowel has an internal nut welded to each end. With the slab removed, engage the nut in the half-dowel remaining in the pavement with a threaded rod and remove the half-dowel. Clean the hole and epoxy in a new Super-Dowel. Remove grout from bottom slots and grout ports on the removed panel. Regrade bedding material, reinstall the slab and grout in place to re-establish load transfer. Typically, on continuous slab installations, you cast dowels into one slab and have them meet with the bottom slots on the next slab. That works fine if you don't have to remove them."

Gill is quick to note how problems with underground utilities are far too common with urban construction projects.

"For this one, there was a 100-year-old bank of phone lines that would have taken a year to move to the elevation the project would have

Photo courtesy of The Fort Miller Co. Inc.

The slabs can be installed efficiently while limiting disruption to the traveling public.

required had we used a traditional paving job," he said. "So by using these slabs, it saves us a year in waiting."

Even though the panels are removable, many of the utilities in the area moved their lines outside the pavement area to minimize future work. Gill likes that INDOT is getting experience in removing the paving slabs, but this project is also allowing utility companies to gain experience as well.

RUNNING SMOOTHLY

Fort Miller contracted the job to Norwalk, Ohio-based Norwalk Concrete Industries to produce more than 1,100 panels that were needed for the project.

NCI President John Lendrum said they had never produced paving slabs before, but they were eager to learn about it.

"This project was a good opportunity for us to get into production of paving slabs and learn what it takes to make slabs on a large-scale basis," he said. "So we really looked at this as an opportunity for us to learn."

Since NCI typically produces utility vaults, this project created some additional challenges for its team. For instance, the tolerances were much tighter than they were accustomed to, and the design of the slabs were unique with some being trapezoidal and having cutouts for manholes or other existing utilities.

"It was good to set up a project with some experienced production leaders and quality control people," Lendrum noted. "We trained with Fort Miller, and they helped us set up for production so that certainly helped, and it worked out well for us."

The sheer number of slabs created a logistical problem for the NCI team as well.

"Just the logistics of how you move fresh slabs and don't damage them, storing them to prevent them from being damaged," Lendrum said. "When you've got 1,100 slabs, you have to have proper documentation of what you're doing, how you store them. All those things are very important."

In addition to ensuring a proper mix and reorganizing the production area for maximum efficiency, NCI had another thing to factor – the cold weather. The majority of the slabs were cast during the harsh winter months so blanketing and proper curing of curing the slabs was equally important.

"We did our training on the front end well," Lendrum added. "We finished the project with a remarkably low number of errors and problems."

Since there was so much engineering and training on the front end, the installation has gone extremely smooth. At the start of the project, crews estimated installing around 40 panels per day, but on their best days, they can get close to 50.

Gill noted the biggest challenge is scheduling the installation around other activities like ensuring not too many streets are closed at one time since the project is near a fire station.

"The panels have gone in as well as we could have hoped," he said. "We feel like it's as good as we can expect if not better than we expect."

WIN-WIN PROJECT

By all accounts, the project has been a success for all parties.

In addition to saving the public on travel time, Gill noted the quality control and durability of precast slabs is greater than most concrete patching jobs which use an accelerated-curing concrete, that can deteriorate quicker.

"With panels, those are made a week ago, a month ago, so you don't need to use accelerated concrete," he said. "We don't have to worry about set time because it cured ages ago. What that allows is that we can come out on a Monday night, take our lane, cut our hole, place the panel, grout it up, and we're good to go.

"You never have a daytime restriction."

Lendrum liked getting into precast paving slabs and hopes to add them to his company's product line, but the project was also beneficial for his younger employees.

"The most immediate return is focusing our production people on accuracy and productivity," he said. "That's something we can readily transfer to the other products we're making. We see some gains in that regard because of all the training we did.

"It's a great way to take some young people, get them promoted and move them up in our plant."

INDOT is looking at a few other test projects, and Gill has enjoyed talking shop with a lot of visitors – a benefit he really didn't see coming.

"The whole point of this project is experimental engineering so we're not talking about budgets or politics or anything like that, we're talking engineering," he said. "And that's been really nice. It's been a pretty rewarding project so far.

"It's not every day you get to do an urban reconstruction project on a 100-year-old road." PS

Matt Werner is the managing editor of Precast Solutions magazine and NPCA's communications manager.

Photo courtesy of The Fort Miller Co. Inc.

More than 1,100 slabs were produced for the project.

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