Smart Flood Walls / Rockaway Boardwalk / Buoyant Buildings

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ON THE COVER:

A Walk on the Precast Side: After Superstorm Sandy wreaked havoc on the Rockaway Beach Boardwalk in New York, the New York City Economic Development Corporation needed a resilient building material to construct its replacement. Their solution? Precast concrete. By upgrading the 5.5-mile boardwalk with precast, visitors will be able to enjoy it for the next century. Learn more about the project on page 18.

Photo courtesy of Daniel Avila, NYC Parks.

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STRONG

Staying SAFE With Precast

An innovative solution powered by precast concrete could make **flooding a thing of the past.**

By Mark Crawford





These renderings depict how the SAFE Foundation System works. Using the system, floating communities are unaffected by flooding and earthquakes.

Though Mother Nature is beautiful, she can pack a powerful punch. Flooding and earthquakes, which can destroy communities with little warning, are a constant threat around the world. Climate change and rising sea levels are making flooding more frequent and severe – in fact, some scientists believe that sea levels could rise six feet or more by 2100.¹ In the U.S. alone, from 1980 to 2016, 26 flooding events totaled more than \$110 billion in damages, or \$4.3 billion per event.²

So what does society do in response? Create expensive barriers? Move to higher ground and abandon coastlines? Simply accept flooding as an act of nature and rebuild, time after time?

Instead, what if a city could rise and float over incoming floodwaters and return intact to its original level after the water recedes? That's exactly what Greg Henderson, founder and CEO of Los Gatos, Calif.-based Arx Pax, proposes with his patented SAFE Foundation System. Using the system, a floating community simply rises when flooding strikes or remains stable in the event of an earthquake. The SAFE System improves the resiliency of structures in coastal areas and flood zones by building them over water.

The SAFE Foundation System depends on precast concrete to create long-term resiliency. Thanks to precast concrete components, Henderson's solution features a lifespan of approximately 100 years, creating unmatched resiliency in challenging environmental conditions.



The Evergreen Point Floating Bridge, which uses a system similar to the Arx Pax solution, is designed to handle a 20-foot drop in water level.

AN INNOVATIVE, THREE-PART SYSTEM

"No matter how green your building is, it's not sustainable if it cannot withstand an event," Henderson said. "As an architect and builder, I knew there had to be a way to build more responsibly in areas subject to earthquakes, floods and rising sea levels."

The SAFE Foundation System isolates destructive forces so they do far less harm. Arx Pax's patented, three-part system offers a unique combination of architecture and engineering technologies. It is designed to float multi-story buildings, roads and utilities in just a few feet of water. Built on precast concrete pontoons, the system is scalable and can support not only homes, but taller commercial buildings covering an area of several city blocks.

During his architectural studies at the University of California, Berkeley, Henderson studied the houseboats in Mission Bay and how they were impervious to earthquakes and floods. This led him to examine Evergreen Point Floating Bridge, which carries Seattle drivers across Lake Washington to the suburbs.

He realized his vision of a floating, self-adjusting environment could draw on the already-proven technologies used to design floating concrete bridges and runways. Evergreen Point Floating Bridge was built on 20 acres of pontoons – 70 of which were recently replaced. "We are taking everything they have done, all the construction and concrete mix designs, all the same engineering principles, and scaling it down," Henderson said.

The idea is straightforward:

- Dig a shallow, permeable depression (containment vessel) and let it fill with water.
- 2) Build a floating concrete foundation roughly the size of the containment vessel on top of the water.
- 3) Construct the community on top of the foundation.

If a flood occurs, the community simply rises. If an earthquake strikes, the buildings are unaffected by the violent shaking of the earth below because the community is floating on a shallow pool of water and is uncoupled from the earth.

The precast concrete components that line the containment vessel and float the foundation are critical to the success of the system.

"Precast is a fantastic product," Henderson said. "Whenever you can move a construction process from the field to an indoor site, you improve quality, efficiency and reliability, and reduce



Precast pontoons for the Evergreen Point Floating Bridge were produced at one of two dry docks.

costs. A controlled environment is essential for delivering consistent, highly reliable products as well as carrying out secondary operations such as applying epoxy coatings."

PRECAST MAKES IT HAPPEN

The first step is excavating a 10-foot-deep depression or pool that connects to a nearby river or bay, or fills with groundwater. In order for the containment vessel to respond to the hydraulic forces in the area, the sides and bottom must be permeable. This is accomplished with U-shaped precast blocks that are crib-locked along the walls and interlocked and embedded across the floor. This creates enough permeability so the pool can fill naturally with groundwater or inflow from the tides.

The second step is constructing the floating base. Large, 8-footby-20-foot precast concrete pontoons are assembled into groups and locked together to make a broad, stable platform. When completed, the platform will float in about eight feet of water. Tethered securely to the containment vessel, the platform will not drift away during severe flood events.

"We are using exact drawings from the bridge for the pontoons to explain SAFE to building departments," Henderson said. "The same size, built the same way, anchored the same way. We know it works.

"Once the building officials understand the basic idea, we then present our construction documents that include our precast 'kit of parts."

Henderson added that the SAFE System currently calls for 7,500-psi portland cement, but Arx Pax is experimenting with different mixes to further enhance the solution.

Once the floating construction surface is ready, contractors build the community on top, complete with roads, landscaping and utilities. For added security, the buildings are attached to anchor points on the pontoons.



Arx Pax is designing resilient precast pontoons that can be shipped via traditional transportation methods.

MOVING FORWARD

Henderson's pilot project – a 1.5-acre mixed-use application – is lined up for a flood plain in San Francisco Bay. He's hopeful the project will be approved in about one year. Once given the green light, construction will take two years. In the meantime, he is busy dealing with technological, regulatory and financial challenges. As funding comes in, he plans to start building high-quality reusable molds for the precast pontoons.

Henderson will also continue experimenting with concrete mixes.

"We want to show everyone that we are intent on improving the process at every step," he said. "For example, we will determine the minimum wall thickness required for the pontoons, based on mass and amount of water displaced. We are also looking at the possibility of using UHPC (ultra high performance concrete) for its strength, longevity and resistance to seawater."

The SAFE Foundation System is an eye-opening alternative to the reactive "rebuild and retreat" model. Instead of retreating or

rebuilding in the aftermath of a flood, Henderson's system allows developers and engineers to be proactive in environmentally critical areas. Also, because it is scalable and uses local resources, the system can be set up anywhere flooding occurs.

"We're helping developers, architects, aid organizations and governments rethink how they can build, rather than just react to disasters," Henderson said. "We are looking for strategic partners around the world who share this vision. It is important to valueengineer this system and get it out into the world for the people who need it."

Arx Pax is also considering a pilot project with the Republic of Kiribati – a small, low-lying island nation in the Pacific Ocean that floods every year – to improve the resiliency of its structures. In addition to floating communities, plans could call for floating farms (the country loses considerable farmland due to flooding) that also collect and store rainwater.

The SAFE Foundation System enables more affordable housing and more sustainable construction techniques by separating





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U.S. Sales, Parts & Service Since 1985 the buildings, infrastructure and open spaces of communities from destructive natural forces. It is critical to the Arx Pax mission to partner with precast concrete companies that want to be problemsolvers and long-term partners in improving social conditions around the world.

"Every year we see communities, homes and lives destroyed by flooding," Henderson said. "Instead of spending billions on rebuilding after disasters, we can build responsibly and sustainably so communities will last for generations. High-value projects are now possible in unbuildable areas, creating more opportunities for profitable, resilient communities.

"By working in harmony with natural forces to protect communities, we can provide the next level of sustainability for generations to come." **PS**

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

Endnotes

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Lange Store

Effective coordination, **communication and teamwork proves key** to the success of two large-scale precast concrete stormwater projects.

By Sara Geer





Oldcastle Precast's largest stormwater detention system to date provides a total storage volume of more than 800,000 cubic feet.

Precast concrete projects have many moving parts that must be organized appropriately to meet customer needs. And when a project involves designing, manufacturing, transporting and installing hundreds of precast products, the added complexity also requires effective communication and teamwork from all parties involved. This was especially true for Gillespie Precast and Oldcastle Precast and the developers, crane operators and construction crews they worked with to ensure their recent, largescale stormwater projects were completed successfully.

A DESIGN-BUILD MASTERPIECE

Confidence in the housing market has increased to an all-time high.¹ As confidence continues to grow across the U.S., Orange County, Calif., is experiencing rapid population growth.² As a result, Oldcastle Precast installed a precast concrete stormwater detention system there, which was its largest to date.

Oldcastle worked with general contractor Landsea Holdings Corp. to provide a stormwater solution for a new community development in Lake Forest, Calif. The development features single-family and senior housing along with a 10,000-square-foot ground floor commercial space and a public park with trails. The Storm Capture stormwater detention system installed to mitigate the area's stormwater runoff consists of 320 units that were manufactured in Oldcastle Precast's Perris, Calif., plant. The units create 10 basins, providing a total detention storage volume of 820,886 cubic feet.

According to Philip Felton, vice president of sales for Oldcastle Precast, each unit was based on a clamshell design with a 7-foot base and a 7-foot top. Basin No. 5, the first system installed, has an inside height of 14 feet and was designed to withstand 16 feet of backfill. It can hold up to a 10-year storm event.

"Oldcastle's engineers worked with the owner and its design team to provide a solution for the project's deep cover requirements," Felton said. "Subsequently, the units were specially designed and manufactured to withstand heavy loading conditions."

As part of the contracted services, Oldcastle Precast designed, manufactured, delivered and installed all the precast components. The units were shipped on flatbed delivery trucks to the job site and installed over two and a half weeks, which "demonstrates the speed of construction precast offers," Felton said.

Another key to the success of the project was effective project management from the early design phase through installation. According to Mary Scott, project manager for Oldcastle Precast,



The massive stormwater system is designed to hold up to a 10-year storm event.

communication was extremely important since the project underwent many changes and redesigns. However, having one person in charge of coordinating every part eliminated unnecessary confusion and made the project a success.

"It was a tough job at first because I went into it not knowing the Storm Capture portion of it, just precast concrete," Scott said. "But engineering was on top of their game getting the drawings done and the production team was on top making sure the vaults got built in the timeframe that we needed based on the developer's schedule."

Along with the stormwater system, Oldcastle also manufactured and delivered large biofiltration units to address the water quality requirements for the project. Scott said since Basin No. 4 is now manufactured, the project will be completed this fall.

"Precast made this project a success because it was a design and set project," Scott said. "It takes a lot more manpower and time to form a product on-site rather than communicating the plans ahead of time and building the product. It took everyone coming together to get this project done and it went very smooth."

AN ARCHED SYSTEM

The arch is a basic design element made popular by the Romans. It maintains its strength and shape over time by resisting compression and in turn eliminating tension.

Taking this design feature and combining it with their precast concrete and environmental expertise, former precasters John and Rich Rotondo, structural engineers and owners of Rotondo Environmental Solutions in Alexandria, Va., spent years researching and developing a new underground stormwater product. What emerged was the StormPod Stormwater System – a modular, single-chambered precast concrete arch structure.

"What prompted us to create the arch system design was to compete with plastic," John said. "The arch system's geometric compression shape keeps strength while reducing the amount of concrete used in manufacturing, which in turn reduces labor costs.

"The system is also large enough to allow a contractor or owner to walk through. Many plastic systems tend to be smaller in size."

With these benefits and more in place and the structural design of the product finalized, the Rotondos next needed to show local contractors and department of transportation officials how the system worked. But instead of doing a job that required just a few products to be manufactured and installed, the Rotondos went big, partnering with Gillespie Precast on a project requiring 372 units.

FAIRMONT HEIGHTS HIGH SCHOOL

In 2015, the Prince George's County Board of Education approved a contract to build a new, modern public high school in Capital Heights, Md. Construction began mid-year and the project included three phases. The first phase entailed placing the underground infrastructure for the new development. Like many regions in the U.S., stormwater runoff needed to be kept at pre-development condition. Therefore, a detention structure was specified to not only hold the water back, but meter it out slowly. The StormPod Stormwater System proved to be the best choice Advertisement



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Gillespie Precast manufactured nearly 400 stormwater units for a new high school in Maryland.

to meet both needs. Gillespie Precast's plant in Chestertown, Md., manufactured all 372 units.

Jim Talbott, Gillespie Precast president, said the job was unlike anything the company had ever done before.

"Gillespie was selected because Rotondo Environmental Services felt comfortable that our team would be able to see this job through to the end with the attention to detail and a quality product that was needed to ensure their first job was a success," he said.

Each of the 372 StormPod units is 8 feet wide by 16 feet long and consists of a base slab and top arch that are bolted together the day after they are poured. The arch unit is poured right-side up and the base slab is poured upside down to give the unit a smooth surface. The mix design included synthetic reinforcement fibers that provided additional strength and support. Talbott said because Gillespie does not regularly use synthetic fibers in production, the self-consolidating concrete mix design had to be modified to flow properly with the high dosage of Euclid Tuf-Strand fibers.

"With the help from the fiber supplier and our admix supplier, the first few weeks we were continuously tweaking our mix to improve the flow through the thin sections of the arch forms," Talbott said.

According to Rich Rotondo, the form maintains tight tolerances since the arch unit and base slab join together along a tongue and



Each of the 8-foot-wide, 16-foot-long units consist of a base slab and top arch that are bolted together the day after they are poured.

groove system to form one module. Any deviation to either piece would cause fit issues throughout the entire project.

Another challenge Gillespie faced was finding an acceptable way to store the units in the yard. In addition to working on this project, the company was experiencing a busy summer, so every square foot of yard space had to be used. The solution was to stack the units two high.

General contractor Grunley Construction Company bought the modules and Total Civil Construction was the site contractor hired to complete the StormPod system installation. Because the base and arch are attached on each module, installation time is cut in half, increasing productivity and quality. The modules can also be linked together to form a larger structure.

"When the products are put together, the void that is on top is then filled with a No. 57 stone that allows water above the structure to filter down through and not sit on top," Rich Rotondo said. "It drains down through, which is a big deal, especially concerning durability of a structure of this magnitude."

Talbott said the success of the project was achieved in large part due to reviewing the project scope with all staff members involved – from dispatch to the plant manager. The open communication between Gillespie and Rotondo Environmental Solutions also helped to ensure accuracy throughout.

"Since John and Rich come from the precast industry, they understand our challenges and they think of everything they can to make their products easier to produce, handle and install," Talbott said. "They are a great partner to have."

Construction on the new high school was completed this summer, which means the class of 2017-2018 started the school year in a new, state-of-the-art building with only the worries of exams, projects and social interactions, while precast concrete lays underground and will support the framework for learning for decades to come. **PS**

Sara Geer is NPCA's internal communication and web manager, and is managing editor of Precast Inc.

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Precast Offers to New York Bo

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New Life ardwalk

By replacing a 5.5-mile-long wooden boardwalk with a precast concrete structure, Rockaway Beach visitors will enjoy a new boardwalk **for the next century.**

By Bridget McCrea







Millions of visitors make their way each year to the Rockaway Beach Boardwalk in New York to take a walk, ride a bike, snap a few photos of the sunrise or simply feel the warm ocean breeze. But when Superstorm Sandy ripped through the area in 2012 – causing tremendous damage to the Mid-Atlantic and Northeast – it took much of the 5.5-mile-long Rockaway Beach Boardwalk with it.



Curves are incorporated into each precast panel to emulate ocean waves.

"What was once an idyllic stroll has been twisted into an obstacle course of frayed wood planks, twisted metal frames and demolished summertime memories," Irving DeJohn wrote in the New York Daily News.¹ "The area between Beach 110th St. and Beach 88th St. is post-apocalyptic. Concrete frames stretch into the horizon and not a single plank of wood remains.

"The demarcation line between utter ruin and a manageable repair is near Beach 86th St., the site of a jetty."



Fortunately, it didn't take long for the municipality to realize the value of quickly rebuilding the iconic structure. Only this time, instead of wooden planks, the boardwalk would be made of precast concrete – a material designed to stand up to the test of time, the elements and Mother Nature.

"As part of the reconstruction effort, the city really wanted to make an effort to build a stronger, more resilient boardwalk," said Dan Colangione, vice president of capital programs for the New York City Economic Development Corporation, which was responsible for project delivery on behalf of the New York City Department of Parks & Recreation.

"There was a major, citywide effort here in New York for better resiliency following Superstorm Sandy, and the boardwalk was one of the first projects that got underway following the storm," Colangione added.



Nearly 5,000 precast concrete panels compose the new Rockaway Boardwalk in New York.

GOING HEAD-TO-HEAD WITH MOTHER NATURE

Recognizing the unpredictability of Mother Nature, and with the desire to keep the new Rockaway Beach Boardwalk in service for at least another 100 years, the NYCEDC set its sights on building a more resilient structure. According to Colangione, the previous structure was "somewhat of a hodgepodge," built on concrete footings that were driven into the sand. The deck was made of wood, and several of those segments had been repaired over time and replaced with precast concrete.

"Overall, the boardwalk has been a signature feature of the Rockaways for many, many decades and generations," Colangione said. "It's part of the fabric of the community as really an important resource for both residents and visitors, and serves as a focal point for how they live and interact and do business with one another."



According to the New York City Department of Parks & Recreation, more than \$140 million was invested to repair and restore Rockaway Beach, which suffered a direct hit from Sandy.² As part of this work, intact sections of boardwalk were repaired, damaged beach buildings were renovated with new boardwalk islands constructed around them, public restrooms and lifeguard stations were installed to replace destroyed facilities, and interim shoreline protection and anti-erosion measures were created.

"We chose to use [precast] concrete materials because they were more durable, both in terms of maintenance and also due to their ability to withstand potential storm forces," Colangione said.

Other advantages of precast included speed of manufacture and delivery, and the fact that all the pieces could be produced in a controlled environment and delivered to the project site for final installation.

TWEAKING THE DESIGN

The design phase for the new structure kicked off in 2013. Colangione said it was an accelerated process, with the design of various phases being completed at different times.

"The project was broken out into phases with the goal of minimizing disruption to the community as much as possible and also being able to open segments of the boardwalk as soon as possible," he said. "We didn't want to get in a situation where all 5.5 miles of the boardwalk were closed for a number of years, and we were actually able to deliver segments of it on a semi-regular basis to the community based on the aggressive schedule that we outlined."

Slaw Precast of Lehighton, Pa., played a key role in helping the city meet its aggressive schedule. After winning the project, the precaster set out to manufacture nearly 5,000 slabs to reconstruct the lengthy boardwalk.

Robert Slaw, president, said the company "redesigned the new structure to be a bit better" than its original design by using prestressing and three different mixes. The latter resulted in an architectural finish that helps delineate between bike lanes (which are tan in color) and walking lanes (beige), plus a blue mix – embedded with glow-in-the-dark rocks – to spell out, "Rockaway." The idea for the Rockaway text came from area residents who wanted the boardwalk to be visible to airplanes that were landing at John F. Kennedy International Airport.

TIGHT TIME CONSTRAINTS

For the duration of the boardwalk project, Slaw Precast poured 19 large precast slabs each day.

"It was a huge undertaking," said Slaw, whose team was working under time constraints set by the project's owner. "The whole project was pretty challenging, but we beat the deadline and ensured that every section was able to be opened up to the public on the predetermined timeline."

Designed for at least 100 years of use, the new boardwalk incorporated a mix made with slag for durability and sulfate resistance.

"We used a low-sulfate mix and a corrosion inhibitor admixture," Slaw said. "It was a very good mix for the application and for the saltwater environment where the boardwalk is situated."

For the project, precast concrete added an aesthetic quality that its wooden predecessor couldn't touch. For example, Slaw said his company



A blue mix - embedded with glow-in-the-dark rocks - spells out "Rockaway" on the path.



incorporated white and beige aggregate into the mix to ensure a good blend with the sand and other environmental elements.

"You can't really do this with any other material," Slaw pointed out, adding that the 5.5-mile-long, 40-foot-wide structure also includes a wavelike geometry. "It was supposed to mimic the ocean's waves, and a lot of people thought it would be difficult to achieve. But we did it using wavy forms and it worked out very well."

STANDING THE TEST OF TIME

Colangione said NYCEDC took additional steps to ensure the boardwalk would stand the test of time and not be taken down by the next superstorm or hurricane. The boardwalk was raised out of the flood plain based on the new Federal Emergency Management Agency maps that were developed post-Sandy, which included adjusted flood elevations.

"We also added sand retaining walls along the 5.5 miles of the boardwalk to help control sand erosion that's happening on the beach in order to protect the community," he said.

The Army Corps of Engineers also placed an additional 3.7



Thanks to a design that includes resilient precast concrete, the new boardwalk will be in operation for the next 100 years.

million cubic yards of sand at Rockaway Beach, thus restoring it to a height and width not seen in decades.³

GREAT RESULTS

Walk out onto the new-and-improved Rockaway Beach Boardwalk and you'll see dozens of people milling about, enjoying the new structure, the adjacent beach and the various shops and restaurants that have reopened since Superstorm Sandy left its destructive footprint on the area. Displaying similar levels of resiliency as the area that surrounds it, the new precast concrete boardwalk is a centerpiece for the community.

"Millions of people go to the boardwalk throughout the year – mainly during the summer – from various neighborhoods here in New York City," Colangione said. "The entire project was a great success, and we're all really enjoying it." **PS**

Bridget McCrea is a freelance writer who covers manufacturing, industry and technology. She is a winner of the Florida Magazine Association's Gold Award for best trade-technical feature statewide.

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Specifier Q&A

This issue, Precast Solutions magazine sits down with **Dan Campbell** of **Las Vegas Engineers** to discuss his involvement with precast concrete products and projects.

Name: Dan Campbell Title: Principal Structural Engineer Company: Las Vegas Engineers



Q: What is your field of focus and what particular products do you specialize in?

A: I am a structural engineer celebrating more than 30 years of business in Las Vegas. Working in Las Vegas has provided me with an incredible opportunity to diversify my skillset and work on projects in a multitude of industries. I have worked on projects such as the Statue of Liberty at the New York-New York Hotel and Casino in Las Vegas and "O" by Cirque du Soleil at Bellagio.

Q: What are the benefits of using precast concrete products?

A: There are many benefits to using precast concrete, such as providing clients with a more timely and cost-effective approach to completing their project. However, I am most amazed with how wall and floor panels can be integrated into the primary structure.

Q: What are some unique or interesting projects on which you specified precast concrete?

A: Most recently, I had the pleasure of working on the T-Mobile Arena in Las Vegas. This arena is the destination for live sporting and entertainment events such as concerts and UFC matches. It's also home to the NHL's new team, the Vegas Golden Knights. I oversaw the engineering of the seating planks and raker beams for the arena. This project was unique because the arena was built on the Strip between massive hotels. The area of the job site was congested, which was a major factor in selecting precast concrete.



Campbell was responsible for engineering the precast seating planks and raker beams for the T-Mobile Arena in Las Vegas.

Q: How have you seen precast concrete evolve? How do you see it continuing to impact your work?

A: In more than three decades, I have seen it evolve from precast to posttensioned to segmented post-tension, and now I am beginning to analyze how to maximize composite methods. I see precast continuing to evolve, providing simpler solutions to some of the challenges that structural engineers face most often. **PS**



Campbell explained that precast concrete offers clients a more timely and cost-effective approach to completing projects.

For more information on Las Vegas Engineers visit **lasvegasengineers.com**



Walls Get Smarter With Precast Concrete

Space-efficient telescopic precast concrete walls **keep floodwaters at bay.**

By Shari Held



The extremely tight tolerances afforded by precast concrete make the Smart Walls system possible.

Today, Jorge Cueto holds a doctorate in civil engineering, owns an award-winning, patented innovation and is the founder of Smart Walls Construction LLC in Amherst, N.Y. He's also earned a \$225,000 Small Business Innovation Research grant from the National Science Foundation and the University at Buffalo's School of Engineering and Applied Sciences Outstanding Young Alumnus Award.

But just six years ago, Cueto was in a very different situation. While his consulting/construction business in Bogotá, Colombia, was successful, he and his business partner were faced with shrinking profit margins.

"The problem was we weren't doing anything new," Cueto said. "The only way we could compete was to drop our prices. That creates a non-sustainable business model."

In pursuit of change, he applied for and won a Fulbright Scholarship and headed to the University at Buffalo in 2011 to pursue his Ph.D. and acquire the additional knowledge needed to research and develop a novel idea.

EUREKA!

Cueto was playing around with an umbrella while working on an assignment when a groundbreaking idea hit him: He'd create a telescopic wall system for bridges and buildings. This initial idea more fully materialized a year later while he watched coverage of the one-year anniversary of Hurricane Sandy.

"As a civil engineer, you are taught to use your knowledge to help society," Cueto said. "I envisioned telescoping walls that could be raised when needed and retracted after the danger of floodwaters has gone."

Another plus with a telescopic wall system is it boasts potential for commercialization.

"Smart Walls addresses a national need for flood control and the system shows promise," said Dr. Amjad Aref, a professor in the civil engineering department at the University at Buffalo and one of Cueto's academic advisors. "The fact that it's an on-demand product sets it apart from anything else."

PRECAST: THE ONLY SOLUTION

Making his concept a reality was the next step. Concrete was always Cueto's top choice for his Smart Walls system. Besides corrosion and other drawbacks, metal was too expensive, and one of Cueto's goals was to keep the product affordable to provide protection for more people. In addition, the components need to be precise.

"If there's one thing these walls need, it's precision," Cueto said. "They nest inside each other. If the tolerances are off, the



When deployed, each of the wall sections telescopes into the next, creating a barrier

system won't work. The only way you can achieve those tight tolerances is with precast."

Cueto's next consideration was choosing the best concrete. The wall system needed to be resilient enough to withstand the impact of coastal waves. Using traditional steel rebar-reinforced concrete would make the wall sections too thick and too heavy to handle. Ultimately, fiber-reinforced ultra high performance concrete proved to be the answer for the hollow boxes Cueto envisioned for Smart Walls.

"One of Jorge's goals was to make the fabricated pieces as thin as possible while remaining very durable and resistant to abrasion due to water impact and erosion," said Gregory Nault, P.E., S.E., a UHPC specialist for structural engineering applications for Ductal at LafargeHolcim.

UHPC is reinforced with metal fibers and exhibits a structural strength up to 10 times higher than traditional concrete. It doesn't break under pressure and its service life can reach two to three times longer than traditional concrete. Any cracks that form are infinitesimal, so the concrete isn't likely to sustain any water damage.

"The material quite honestly can last hundreds of years with zero maintenance required," Nault said.

A CUSTOMIZABLE APPROACH

The Smart Walls system is housed in a foundation or base box that remains underground and holds the hollow, rectangular wall sections. The width of the base box is 18 inches, with each box smaller in width and length than the one below it. When deployed, the wall sections telescope into one another to create a barrier.

Once installed, the Smart Walls system is virtually invisible, allowing unobstructed views when not in use. Smart Walls can be raised during threatening weather conditions and lowered once the danger is over and storm waters recede. This innovative solution takes stormwater protection to another level.

Another key feature of the Smart Walls system is it's customizable to fit the sizing needs of any project. Taller, more expansive barriers can help cities escape damage from hurricanes, while a 2-foot-high barrier can protect a homeowner's property from 12 inches of floodwater.

"One foot of floodwater is just enough to make your life miserable," Cueto said. "The beauty of this technology is that it allows customers to say what they need."

A manual system works best in situations where there are a limited number of walls that rise only two or three feet above ground. The walls are light enough that two people could raise them in a timely manner. A Smart Walls system comprised of taller sections or a substantial number of sections can be raised by a crane. The system can also be fully automated so that it rises and lowers with the touch of a button and can be retrofitted with automation at any time.

Although Cueto had developed a gasket to keep Smart Walls watertight, when the walls are raised, 6-inch gaps are created between the boxes and adjacent walls. To close the gaps between boxes, the automated version is designed with hinged flaps that extend laterally as the wall system rises. For the manual version, the solution is to slide metal plates between the walls.

Depending on the tidal force, the gaps may not need to be covered at all.

"We're not building a swimming pool," Cueto said. "When we use telescoping walls for coastal storm surges, the wall breaks the wave and stops the water from going to the other side. A 6-inch gap won't make that much difference."

PUTTING IT TO THE TEST

"With software technologies, you can go back into production and then issue an update," Cueto said. "As civil engineers, we don't have that luxury. We need to do a lot of development and testing with structural systems because people's lives are at stake."

As part of the requirements for fulfilling the NFS grant, Cueto had to prove the technical feasibility of his Smart Walls concept. To do that, he created a prototype consisting of deployable boxes that measured 18 inches wide, 3 feet long and 3 feet above ground. Each Smart Walls section in the prototype weighed approximately 250 pounds. Four straight Smart Walls and four curved Smart Walls were used in the enclosure prototype.

In June, the Hinsdale Wave Research Laboratory at Oregon State University conducted a series of tests on Cueto's prototype to determine the effectiveness of the flaps, plates and gaskets. It was a technical success.

Next, researchers tested the individual walls. They applied tsunami-force waves to determine what it would take to make the walls break. All but one held firm. The curved walls withstood the tsunami waves better than the straight walls.

"That's when we first realized Smart Walls could be used against tsunamis," Cueto said. "I'm so excited about this new use."



GOING COMMERCIAL

Now Cueto faces a challenge bigger than any of the technical hurdles he's overcome so far. To successfully take Smart Walls to the commercial market, he must persuade people to accept a revolutionary concept. That's tough at any time, but especially when the product involves public safety.

Cueto's target market is coastal cities in need of storm surge protection.

"Our whole Smart Walls system is in pursuit of increasing the resiliency of cities so they can withstand the natural hazards of storm surges or floods without even stopping their operations," Cueto said.

So far, he's seen interest from municipalities nationwide, including Gowanda and Buffalo, NY.; Miami/Dade County, Fla.; Tulsa, Okla.; Fort Worth, Texas; Norfolk, Va.; Boston, Mass.; Pittsburgh, Pa.; and Keansburg, N.J.

But the ultimate test doesn't lie within the confines of a lab. Currently, Cueto is searching for a pilot project or two, talking to the resiliency offices and other entities in New York City, Houston and Newport, Ore. He's also been invited to make a presentation to the Army Corps of Engineers. He hopes to have a pilot project completed within the next two years.

"That is the best validation of the momentum that Smart Walls is picking up," Cueto said. "It will be up to the team to capitalize on all these opportunities and deliver the best technology for flood protection." **PS**

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

While lab tests have been successful, Cueto's goal is to secure pilot projects for the system.

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