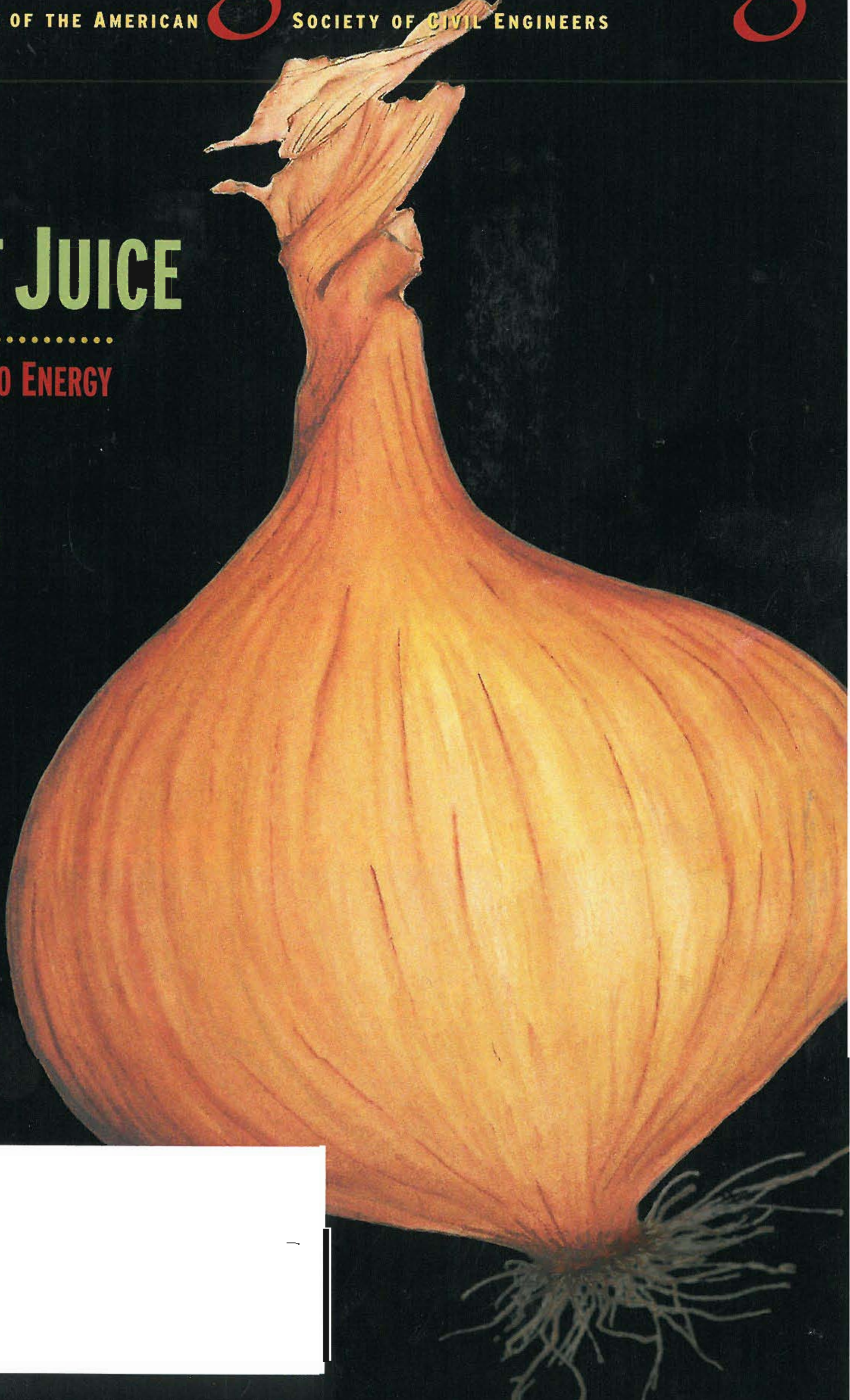
OCTOBER • 2010

Civil Engineering

THE MAGAZINE OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS



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STRUCTURES

Steel-and-Glass Carousel Features Aquatic Theme, Nontraditional Design

A NEW AMUSEMENT RIDE proposed for New York City's Battery Park will turn the traditional design of a carousel on its head. The SeaGlass Carousel attraction will replace the metal canopy at the top of a traditional carousel—the ring-shaped structure high above the turntable into which are connected the poles and mechanical linkages that enable the horses and other animal-shaped seats to move up and down—with a unique open design, explains William B. Gorlin, P.E., S.E., M.ASCE, a vice president of McLaren Engineering Group, of West Nyack, New York. McLaren is responsible for the structural, mechanical, and electrical engineering of the new carousel ride, which was designed by New York City's WXY Architecture + Urban Planning.

The horses themselves also will be replaced with translucent fiberglass carriages shaped like fish or other sea creatures. Riders will sit in these carriages as they move up and down and swivel on short steel poles rising from one of three smaller turntables incorporated into the main turntable. In some cases the carriages will be mounted on static poles rising from the main turntable. The poles in all cases will attach to just the undersides of the carriages; they will not pass through the shapes as they would with a traditional carousel horse. "Mechanically and structurally, there's nothing overhead except for the roof of the surrounding building, which is independent of the fish," says Gorlin. The mechanisms that raise and lower the fish or rotate the turntables will be completely concealed from view, Gorlin adds.

The building that will surround the carousel represents another unique feature of the SeaGlass project. This spiraling, nautilus-shaped pavilion of steel and glass has been designed by WXY and will be engineered by the New York City office of the international firm Buro Happold. The sea creature carriages were designed by New York City–based George Tsypin Opera Factory.

The carousel will be located near the U.S. National Park Service's Castle Clinton National Monument, which once housed New York City's aquarium—the inspiration for the aquatic theme of the new attraction. Construction of the carousel is expected to begin this year and to be completed by the early autumn of 2011, says Pat Kirshner, the director of operations and planning for the Battery Conservancy, the nonprofit educational corporation that is working to rebuild and revitalize Manhattan's Battery Park region. The conservancy is funding the $12-million project and will operate the ride once it is completed; New York City's Department of Parks

The riders will, as this model depicts, sit inside translucent fiberglass carriages shaped like fish or other sea creatures. Some carriages will move up and down and swivel on short steel poles rising from smaller turntables in the main turntable; others will be mounted to static poles on the main turntable.

THE BATTERY CONSERVANCY

and Recreation, which owns and maintains Battery Park, will maintain the carousel.

The use of steel members 10 in. in depth and of extensive bracing elements throughout the ride's assembly will ensure that the ride is sufficiently stiff to limit vibration and sway during operation, notes Gorlin. The design features a steel-framed cylindrical structure 46 ft in diameter and 8 ft in depth. The carousel assembly will be centered in a concrete basement level on a ring bearing 5 ft in diameter that will be surrounded by a trio of concentric rings in the form of casters rolling on circular tracks. The tracks will be composed of hardened steel plates 1 in. thick and will be supported on a reinforced-concrete raft foundation 20 in. thick. A series of rubber tires powered by four electric motors will rotate the carousel assembly; the rubber tires will also help to isolate vibrations as the turntable structure spins, Gorlin notes.

All of the power and control wiring will pass through a central slip ring and will be fed to the ride via a system of fixed conduits and plastic cable chains, Gorlin adds.

The lower platform of the main turntable will be framed mostly by W 10 × 26 beams and channels 10 in. in depth and will be surrounded by a rectangular steel tube 10 in. in depth that follows the platform's perimeter. Vertical steel pipe columns $2\ ^7/_8$ in. in diameter as well as X-shaped diagonal bracing that, Gorlin notes, was chosen to resist the dynamic twisting loads imposed as the turntable spins will connect the upper and lower platforms.

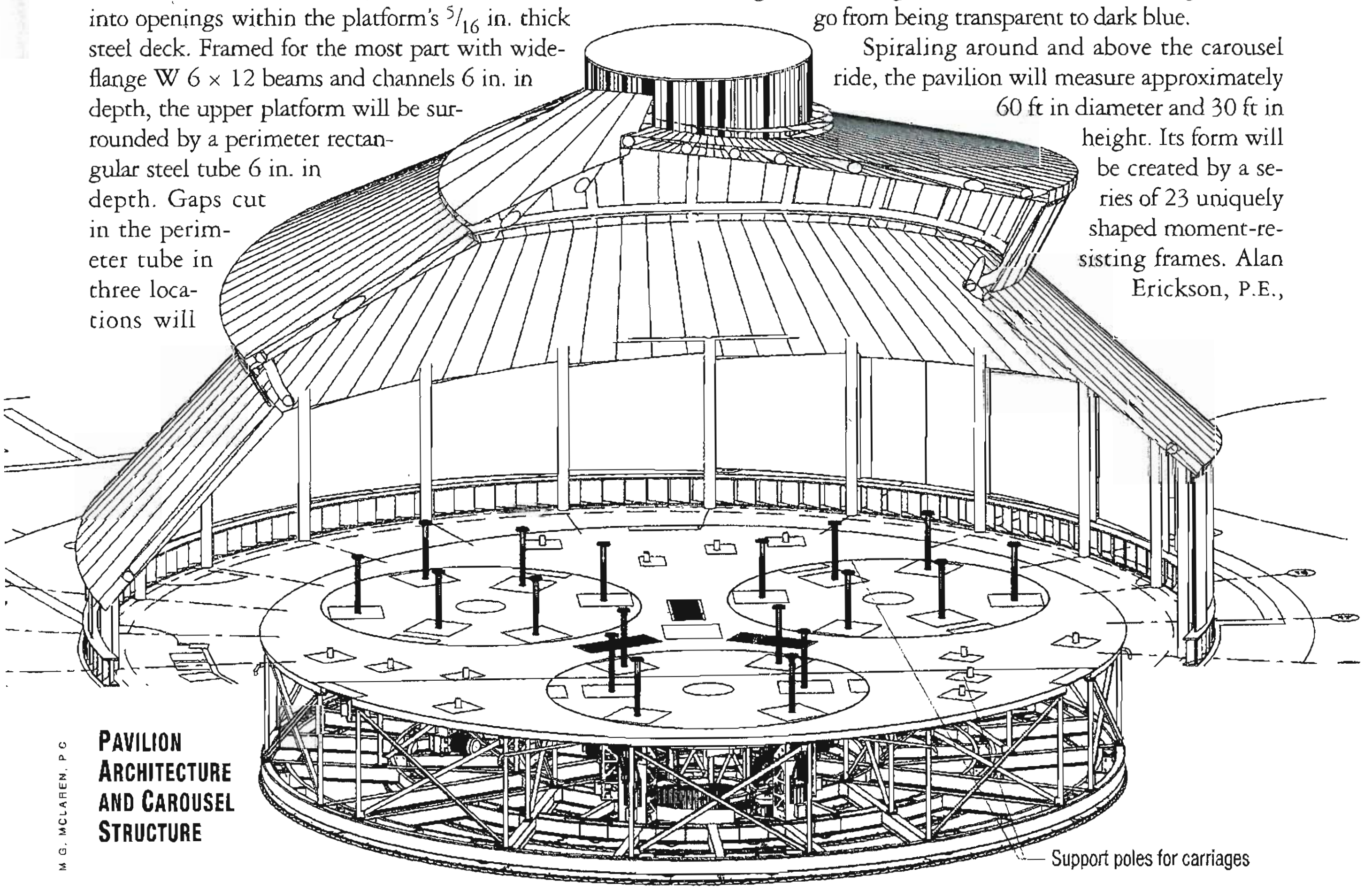
The upper platform will be located at grade and will feature three smaller turntables, each 17 ft in diameter and set into openings within the platform's $^5/_{16}$ in. thick steel deck. Framed for the most part with wide-flange W 6 × 12 beams and channels 6 in. in depth, the upper platform will be surrounded by a perimeter rectangular steel tube 6 in. in depth. Gaps cut in the perimeter tube in three locations will accommodate a water collection drip pan system below the turntable.

In elevation, each smaller turntable will feature a mushroom-shaped design. The circular platforms will cantilever from central mechanisms 5 ft in diameter that will be attached to a ring bearing mounted into the larger turntable assembly, Gorlin says. Electric motors will power the smaller turntables, each of which will swivel in an arc of up to 270 degrees rather than complete a full circle. An electrically driven chain mechanism also will swivel the carriages on each small turntable in opposing arcs of up to 135 degrees. Thus three carriages will swivel in one direction, and three in the other, explains Gorlin. Motors within each smaller turntable assembly will enable the carriages to move up and down independently by as much as 2.5 ft. Together, these systems will generate up to 25 axes of motion, providing the riders "with a feeling of random motions through the space, somewhat like what a school of fish might experience," Gorlin notes.

There will also be 12 sea creature carriages attached to the upper platform of the large turntable that will move with the entire assembly. These will not swivel or move vertically. One of the carriages will be designed for universal access.

A key goal of the design team was "integrating the pavilion architecture and the ride" in a multimedia experience, notes Layng Pew, a WXY principal. A combination of audiovisual effects within each carriage and on the interior of the pavilion will enhance the experience. The effects, says Pew, will include projected scenes of undersea life, and to give riders a feeling of descending into the sea, walls of "smart glass" will go from being transparent to dark blue.

Spiraling around and above the carousel ride, the pavilion will measure approximately 60 ft in diameter and 30 ft in height. Its form will be created by a series of 23 uniquely shaped moment-resisting frames. Alan Erickson, P.E.,



M.G. MCLAREN, P.C

PAVILION ARCHITECTURE AND CAROUSEL STRUCTURE

a senior structural engineer for Buro Happold, refers to these frames as half-moment frames because each stepped frame will radiate from a central compression ring, following the pavilion's nautilus shape. Thus the frames will not connect together directly to create a traditional moment frame system. The architecturally exposed structural steel members that form the half-moment frames, a series of connecting supports between the frames, and the compression ring itself will all take the form of hollow structural steel pipe sections 7 in. in diameter.

Given the complexity of the pavilion's spiraling form, the use of rounded pipe sections made it easier to design the connections and resolve the orientations of the structural members, adds Cristobal Correa, P.E., a Buro Happold associate principal.

The compression ring will measure roughly 10 ft in diameter and will help to form a clerestory near the top of the pavilion. There will also be an oculus at the top. The pavilion's facade will feature both glazing and curved, engineered stainless steel panels that will span the distances between the half-moment frames.

Gaps in the glazing will help to naturally ventilate the attraction. Because of the open nature of the attraction, a number of water collection troughs and pipes have been designed to convey water to a sump system in the basement level, notes Gorlin. And to protect against possible flooding in that level, some of the carousel machinery and the electrical systems will be elevated.

The poor soil conditions at the carousel site, which feature unclassified organic clays and fill to a depth of approximately 200 ft before bedrock is reached, initially led to concern that the New York City building codes would require an expensive piled foundation system. But Buro Happold worked closely with the geotechnical engineer—the New York City office of Langan Engineering & Environmental Services, based in Elmwood Park, New Jersey—in determining that the soils could support the carousel pavilion with a raft foundation. During a seismic event, the building might settle by several inches, but given the rigid raft foundation and the insignificant height of the carousel pavilion, such settlement "would not create a collapse" with safety implications, notes Correa.

The carousel's upper platform will be surrounded at grade by a reinforced-concrete slab 6 in. in depth and will be supported in key locations by concrete columns extending from the basement level.

The project has been an especially exciting one because "structural engineers don't usually get a chance to build things like this—a ride for kids," concludes Erickson. —ROBERT L. REID

STRUCTURES

U.K. Museum to Encompass Roman Bath Ruins

A MUSEUM NOW UNDER construction in the English cathedral city of Chichester, near the southern coast of the United Kingdom, has been designed to carefully encompass the remains of an ancient bathhouse that dates to the first century AD, during the Roman occupation of Britain. Construction of the Chichester District Museum began in April and is expected to be completed by the autumn of 2011. The nearly £7-million (U.S.$11-million), 1,300 m² project will feature a reinforced-concrete building more than twice as large as the district's current museum facility, and this new structure will not only incorporate the Roman-era ruins but also showcase other aspects of the area's history and heritage.

The remains of a Roman-era bathhouse were discovered in the 1970s and were recorded and surveyed. The site was then backfilled with sand to protect the ruins. Once the new museum has been constructed around and above the site, the bathhouse remains will be reexcavated.

The remains of the Roman baths were first excavated in the 1970s, at which time they were recorded and surveyed; the site was then backfilled with sand. "Where archaeology is to be left in situ after a dig, this is the preferred approach, as it protects the remains for the future," explained Dan Wilkinson in written answers to questions from *Civil Engineering*. Wilkinson is an associate of Techniker, the London-based firm that is responsible for the structural engineering of the new, three-story museum. The museum's designer is the London-based firm Keith Williams Architects, and the archaeological consultant on the project is Development Archaeology Services, Ltd., of Chichester.

"Once the heavy construction is over, the area of the remains will be carefully excavated to reveal the archaeology once more," said Wilkinson. The remains are located on the southern side of the site approximately 2 m below grade and consist primarily of masonry pillars that once supported the bathhouse floor and formed a subfloor void for the heating system, says Keith Williams, the founder and design director of Keith Williams Architects.

To minimize the possibility of damaging the remains, the foundations of the new building will be restricted to an area equivalent to just 3 percent of the building's footprint and will feature a relatively small number of large, reinforced-concrete piles that will be 450 or 600 mm in diameter and will be bored into the underlying clay to a depth of 27 m. This system was preferred over the more traditional use of a large number of piles with smaller diameters, Wilkinson said. Portions of the reinforced-concrete