Liberty Island Pavilion

The Structural Engineer as Sustainability Consultant

By Panagiotis Koklanos, P.E., LEED AP

Figure 1: Site View of Pavilion from Ferry Dock.

In New York Harbor, where the East and the Hudson rivers converge, stands *La Liberté éclairant le monde* ("Liberty Enlightening the World") – The Statue of Liberty. A gift to the United States from the people of France, commemorating the 100th anniversary of American Independence, the statue is the masterwork of sculptor Frédéric Bartholdi, depicting *Libertas*, the Roman goddess of freedom. In her right hand she holds a torch; in her left hand, a tablet on which is carved the date of the Declaration of Independence. A broken chain lies at her feet. Since her dedication in 1886, she has become an icon of freedom, of the United States and of the American dream.

Each day thousands of people ride the ferry across the harbor to Liberty Island to experience this enduring symbol of American sovereignty and of triumph over adversity, and the majority of them purchase mementos of their visit.

Until April 2010, most of the island's gifts and souvenirs were housed in a large tent directly behind the statue. Food concessions (and another small gift shop) were in a separate location, several hundred feet away, on the northwest side of the island. Now, as a result of a 2008 U.S. National Park Service (NPS) mandate, all retail operations on the island have been consolidated into a single 6,400-square-foot all-steel pavilion adjacent to the original dining plaza. Together, the plaza, pavilion, and concessions building provide a centralized area for dining, shopping, and socializing, conveniently located near the ferry entrance. Removal of the tent has restored views along the scenic walkway from the ferry to the statue *(Figure 1)*.

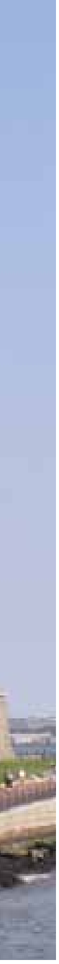
The new retail pavilion is likely to be the last building constructed on Liberty Island in the foreseeable future and, if the construction team achieves its sustainability goals, will be only the fourth Leadership in Energy and Environmental Design (LEED®) Platinum building ever constructed on national parkland.

Structural Engineer Serves as Sustainability Consultant

The contract to erect the pavilion was awarded to Evelyn Hill, Inc., the island's retail and food concessionaire. President Brad Hill chose Acheson Doyle Partners Architects to design the lightweight, low-profile structure. It had to be robust enough to weather the harsh environment of New York Harbor and resilient enough to endure heavy foot traffic year-round. In addition, to meet NPS regulations for structures on historic sites, it had to be easily deconstructible at the end of its service life; to satisfy NPS sustainability requirements, it had to achieve a minimum LEED Gold certification.

Weidlinger Associates – already the project's geotechnical, civil, and structural engineering consultant – took on the additional responsibility of sustainability consultant because of their experience on LEED certified projects. The firm's Sustainability Initiative combines support for LEED accreditation with research on green/innovative materials, best practices, and the support of renewable energy systems. This initiative nurtures an environment in which sustainability considerations permeate every phase of design and construction.

While it is rare for a structural engineer to act as the sustainability consultant, this organizational structure produced synergies that were significant to the project's success. Sustainability objectives were emphasized at weekly meetings, and decisions were expedited that reduced the pavilion's environmental impact. Knowledge of the recycled content, recyclability, and local availability of building materials and the energy involved in construction processes helped greatly in reducing the pavilion's carbon footprint.



Mr. Hill's commitment to the sustainable design of the structure was apparent from the project's outset. He readily consented when the team suggested he pursue a LEED Platinum rating, despite a resultant increase in construction costs and a lengthened project schedule.

Description of the Structural System

The retail pavilion's primary structural system is a conventional steel braced frame with wide flange (W) beams and hollow structural section (HSS) concentric braces, field-bolted to HSS columns. The roof, which is composed primarily of a 1.5-inch metal deck with rigid insulation, is supported on a 16-foot-by-16-foot column grid to minimize the depth of the ceiling. The elevated first floor of the pavilion, which is approximately four feet above grade, consists of Forest Stewardship Council (FSC) certified structural plywood supported by light-gauge metal floor joists, which are in turn supported by W-shaped girders. The first floor is supported by columns spaced on a 32-foot-by-32-foot grid. The foundation of the pavilion consists of groups of three steel minipiles at each column, which are all topped by a steel pile cap. Each pile cap is made up of a series of heavy W8s, shop-welded together in such a way that each beam is centered over a minipile *(Figure 2)*.

Steel pile caps were chosen in lieu of the conventional concrete pile caps because of the difficulty and high cost of transporting large quantities of concrete to the island via barge. The implementation of a larger column grid at the foundation level necessitated the use of deep transfer girders at the elevated first floor, but minimized the number of piles required to support the pavilion structure, resulting in significant cost savings.

Figure 2: Pavilion Plaza Exterior at Sunset.

Materials and Constructability

To minimize the lifecycle impact of the pavilion, the team established aggressive sustainability criteria for the following materials: the structural steel and light gauge steel framing, the aluminum storefront mullions and doors, the infill copper panels throughout the façade, the slag cement for concrete, the synthetic gypsum wallboard for the building's interior partitions, the ceramic floor tiles and ceiling grids, and even the toilet partitions and accessories.

All connections made at the site for the entire pavilion frame were bolted, eliminating the need for field welding. This bolted-frame erection method shaved weeks off the aggressive construction schedule and will support quick disassembly and material salvage at the end of the structure's service life. To ensure the building's durability, each component directly exposed to the elements, including the first-floor framing, full-height columns, metal roof deck, and steel pile caps, was hot-dip galvanized. Through on-site recycling, the project team achieved its ambitious goal of diverting 95% of construction waste and debris (by weight) from disposal to landfills.

Water Use Reduction

Though potable water is in ample supply in the New York City area and therefore not a regional priority, the owner and design team were committed to reducing the pavilion's water demand. Sloped roofing insulation covered with a white EPDM membrane was used to channel rainwater to drains and leaders that run within architectural column encasements and beneath the elevated plywood floor. These drains empty into two 7,500-gallon custom-steel, horizontal, above-ground collection tanks at the rear of the pavilion. This system reduces the stormwater flow rate and quantity during severe storms. The collected rainwater is used for sewage conveyance, reducing potable water demand. Overflow from the storage tanks is treated through a mechanical filtration device to remove pollutants and suspended solids before being released onto the site. Bathrooms are equipped with waterless urinals, sensor-activated faucets, energy-efficient hand dryers, and low-flush toilets, which consume 20% less water than standard units. All these measures add up to an estimated annual water savings of 90%.

Energy System and Building Envelope

The pavilion's energy system, designed and modeled by P.A. Collins, P.E., is powered by two geothermal heat pumps that use well water from 1,500 feet below the surface to provide cooling and heating. Because of the relatively stable year-round temperatures in well water, geothermal heat pumps have much higher efficiencies than standard HVAC systems and are cleaner and less costly to operate than fossil-fuel-burning heating plants. A reclaimed vegetable oil electric generator uses the 50 gallons of waste vegetable oil produced by the adjacent concessions building every week to produce approximately 28,500 kWh/year of electrical energy, accounting for approximately 8% of the pavilion's total energy supply. Further demonstrating his commitment to the building's sustainability, Hill purchased wind renewable energy certificates – energy commodities that assure that one megawatt-hour (MWh) of electricity will be generated from an eligible renewable energy resource – for 100% of the pavilion's remaining electrical demand.

Retail Pavilion Interior.

Retail Pavilion Interior.

Reducing the heating/cooling loads on the pavilion's HVAC system is an energy-efficient envelope. The glazing units wrapping the façade consist of insulated low-emittance glass, which improves the building's capacity to keep heat indoors during the winter months and reject the sun's infrared radiation during the summer months. Because the pile foundations and frames are composed entirely of steel, a thermal break was introduced to interrupt the conductivity between the foundations and superstructure by placing a ¼-inch-thick neoprene bearing pad between the bottom of the column baseplates and the top bearing surface of the steel pile caps. To completely seal off the elevated floor structure from the weather, Acheson Doyle specified that sheathing be hung from the light-gauge metal floor studs and that the cavity between the plywood floor and sheathing be filled with spray-foam insulation, providing an R value of 19 for the assembly. Overall, with the help of a tight envelope, the building's HVAC system consumes 35% less energy than the ASHRAE energy code baseline building.

Summary

An experienced structural engineer has much to offer in supporting LEED certification and the overall sustainability of a project. Because structural engineers have a thorough understanding of the way various construction materials are produced and manufactured, their regional availability, and the sequences of building erection, renovation, and eventual deconstruction, they can design a structure that uses fewer natural resources throughout its lifecycle.

Historically, the focus of green rating systems such as LEED and, in turn, the construction industry, has been on the improvement of HVAC systems and building envelopes in an effort to reduce a building's operational energy over its lifetime and, more generally, to reduce the consumption of fossil fuels and other natural resources. However, structural engineers can take it upon themselves to lead the team in reducing the total embodied energy of a building through an integrated, environmentally conscious design.

Ultimately, the success of this project must be attributed to the experienced design team, an owner truly committed to sustainability and willing to support creative solutions, and an unconventional sustainability effort led by the structural engineer to integrate sustainability into every aspect of the design process.▪

*Panagiotis Koklanos, P.E., LEED AP is a senior structural engineer with Weidlinger Associates, Inc., New York, and spearheads the firm's sustainability consulting efforts. He may be reached via email at **koklanos@wai.com**.*

Photos courtesy of Acheson Doyle Partners Architects, PC.