A series of innovative T-shaped supports underscores the structural and architectural design of a 165,000 sq ft (15,000 m²) addition to the Nelson-Atkins Museum of Art, in Kansas City, Missouri, as well as of an adjoining underground parking garage that is topped by a skylight-pierced reflecting pool. Although the addition also is located mostly underground, it is distinguished by five translucent glazed structures that rise above grade to channel natural light into the lobby and key gallery spaces below.

By Robert Reid
The Nelson-Atkins competition judges selected the SHA design as “a magical response to the landscape and to the original building.”

of directors and his wife. Henry W. Bloch is a cofounder of the accounting firm H&K Block, which is based in Kansas City, Missouri. (The spelling of the family name was altered in the firm’s name for ease of pronunciation.)

Five other architects also were vying to design the addition, which was needed to house the museum’s collection of modern and African art. The competition brief specified that the best site for the new building would be on the north side of the Nelson-Atkins’s 22 acre (9 ha) campus behind the limestone facade of the original museum building. That six-story, 234,000 sq ft (21,700 m²) neoclassical structure—dubbed a temple of art—opened to the public in December 1933.

Most of the architecture and engineering teams in the competition presented designs that would be constructed in that northern space. They were large structures that would use the existing building as a backdrop and rise above a planned parking garage in the same area. But the winning competition brief specified that the museum’s collection of modern and African art. The addition with its “green” roof components and opens onto the museum’s Kansas City Sculpture Park. This large green space features more than 30 outdoor art objects, including one of the Nelson-Atkins’s signature acquisitions: a giant badminton shuttlecock designed by Claes Oldenburg and Coosje van Bruggen.

The SHA design also placed the new parking garage underground. Thus this two-story facility, to the north of the original building, creates an entrance plaza for buses and other vehicles accessing the addition. The plaza surrounds a large but shallow reflecting pool with a monumental installation by Walter De Maria that features a rectangular “sun” of gold leaf surrounded by 34 round “moon” skylights that channel natural light to the upper level of the garage.

Compared with the visually heavy bulk of the museum’s original building, the steel and glass addition gives the impression of a light structure, indeed, the design’s guiding metaphor invoked a feather versus a stone, notes Nordenson. Moreover, each lens is clad in a series of contrast to the strictly rectangular form of the museum’s original Beaux-Arts structure. But the design is very much in keeping with the surrounding landscape. Nordenson explains, and on its western side the addition with its “green” roof components and opens onto the museum’s Kansas City Sculpture Park. This large green space features more than 30 outdoor art objects, including one of the Nelson-Atkins’s signature acquisitions: a giant badminton shuttlecock designed by Claes Oldenburg and Coosje van Bruggen.

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Each lens is irregular in shape and follows a unique alignment. translucent glazed panels that softly illuminate the gallery spaces below during the daytime and are artificially illuminated from within at night to create something suggesting a Japanese lantern, adds Kelley Gipple, P.E., a principal of Structural Engineering Associates, Inc., of Kansas City, Missouri, the firm that served as the associate structural engineer on the project.

Located directly alongside the original museum, the Bloch Building is so close to its neighbor that the southernmost portion of the first lens, which serves as the Bloch’s entrance and lobby, is the largest of the aboveground structures, must angle away to avoid overlapping some of the neoclassical columns of the original facade. Below grade, the two structures are connected by new passages that access a large elevator. The passages and elevator were created to move both visitors and artwork between the two buildings. A large, angled skylight juts up from the green space that separates the new and old facades, bringing natural light into the lower lobby of the first lens.

The hillside on which the Bloch Building was constructed declines approximately 22 ft (6.7 m) in elevation from the first lens to the fifth and is restrained along its eastern edge by a series of tall retaining walls of reinforced concrete; the hillside is also retained by a preexisting line of shorter stone walls that separate the bottom of the slope from the adjoining Rockhill Road, notes Gipple. The new concrete retaining walls range in thickness from approximately 12 in. (305 mm) to 30 in. (762 mm) and feature a textured surface that complements the stone walls and imparts aesthetic appeal for the benefit of the largely residential neighborhood, southeast of downtown Kansas City, in which the museum campus is located. The berm of the hillside and the retaining walls also give the building a less imposing appearance; from end to end it is equivalent to a 67-story building lying on its side, notes Nordenson.

Each lens is irregular in shape and follows a unique alignment, but in general the first lens is sited in a north–south direction along the edge of the original museum while the other lenses are aligned in an east–west direction and cut across the underground portions of the addition, extending outward from the structure’s western side, which fronts the sculpture garden. The exact dimensions of each lens are difficult to measure, notes Gipple. For example, the first lens rises approximately 40 ft (12.2 m) above grade and stretches approximately 235 ft (72 m) in length but just 34 to 60 ft (10.4 to 18.3 m) in width, while the third lens measures approximately 90 ft (27.4 m) in the east–west direction, approximately 32 ft (9.7 m) in the north–south direction, and approximately 9 ft (2.7 m) above grade.

The first lens features a double-height lobby and an upper level that houses a library and office space; a long ramp leads visitors down to the lower lobby level and ends just beneath the angled skylight.

In addition to the structural Ts, the interiors of the lens gallery spaces feature a series of smaller steel-frame, plaster-enclosed structures called fluttering Ts that help to define the varying curves and shapes of the gallery ceilings, says Gipple. The ceilings at certain locations can appear to be “almost like a wing fluttering over your head . . . which creates a whole play of shadows” from the light that is diffused into the space by the lens, explains Nordenson.

The basic framing of the Bloch Building can be compared to a sophisticated lean-to, notes Nordenson, because the eastern side of the building rests against the hillside and the retaining walls while the western side is largely supported on steel I-beam columns, steel framing and concrete slabs on metal decks forming the interstitial structure. The steel framing for the lenses and the underground portions of the structure typically consists of W 18 to W 24 members weighing less than 80 lb/ft (119 kg/m), although there are also some heavier elements, including W 27 × 353 beams that support a transparent glazed opening between the third and fourth lenses. There is even a W 36 × 359 girder with cover plates that spans a 64 ft (19.5 m) long transparent glazed wall between the fourth and fifth lenses and creates the entrance for a gallery known as the Noguchi Court, a space that houses sculptures created by Isamu Noguchi, notes Gipple.

The lens portions of the Bloch Building also required additional innovative framing to accommodate the special requirements of these structures. The second, third, and fourth lenses, for instance, feature a system of nominally T-shaped supports that fulfill both structural and architectural purposes. Although called Ts, some of the supports actually resemble a Y or other shapes.

The structural Ts consist of a series of vertical trusses that begin in the service level basement in the second, third, and fourth lenses and extend up to support the lens roofs. Measuring more than 30 ft (15.2 m) tall, depending on location, the structural Ts are arranged in rows in the east–west direction of the lenses and are spaced at approximately 10 to 15 ft (3 to 4.6 m) intervals “like a marching plane of structures,” explains Nordenson. At the basement level, the structural Ts are open, but in the gallery spaces and in the above-
The first lens includes neither breathing nor flutering T supports, but its two-story lobby does feature a “fairly dama-
matic” staircase that spans a distance of approximately 60 ft (18.3 m) to access an upper-level office and library space, notes
Nordenson. The stairs are at the western side of the building at the transparent glass wall that forms the entrance to the first
level. They are supported on just one side—the side farthest from the glass—by a fabricated steel box beam that also serves
as a railing; the beam measures approximately 8 in. (203 mm) wide by approximately 3.5 ft (1.1 m) tall in cross section. The
steps cantilever approximately 6 ft (1.8 m) from this beam.

Although there is a second railing on the glass-wall side that is attached to the vertical aluminum mullions, “you feel you’re
in the open,” notes Gipple, because “structurally, there is a small gap between the edge of the step and the glass wall.”

The roof of the first lens is supported by a steel truss that is approximately 131 ft (40 m) long and 15 ft (4.6 m) deep and
is aligned diagonally across the top of the structure to act as a central spine, notes Gipple. This massive spine truss is sup-
sported in the center of the lobby by a vertical truss pier; both the pier and the spine trusses are covered in white plaster to
complement the surrounding palette, Nordenson adds. The top and bottom chords of the spine truss feature W 24 × 250 and
W 24 × 192 steel members with W 14 × 90 diagonals in most cases and W 14 × 195 elements in key locations.

Steel beams ranging in size from W 21 × 166 to W 14 × 34 cantilever 6 to 20 ft (1.8 to 7.9 m) from the spine truss,
depending on their location. The cantilevering beams con-
nect to steel pipe sections 4 in. (102 mm) in diameter that
are supported by one or more concrete columns in
the lower sections of glazed panels.

At the entrance to the first lens, the potential weight of the
glass panels and catwalk that would be suspended from the
cantilevered roof structure created a considerable challenge during construction. To solve this problem, the contractor and
the design team placed large concrete traffic barriers on the roof portion beside the open lens to represent the weight of the soil. The contractor could then install the glazing in the lens with the roof already deflected. As the soil was added, an equivalent weight of concrete barrier could be removed “and the glazing support elevation would remain unchanged,” Gipple says.

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either extend to the ground or, on the western side of the first
level, act as hangers to support the frosted glazed panels that are suspended above the wide-span transparent entrance to
the first lens.

The 70,000 sq ft (6,500 m²) of frosted glazing through-
out the various lenses includes an exterior double layer of in-
terlocking structural glass planks, each approximately 16 in.
(406 mm) wide and 10 to 18 ft (3 to 5.5 m) tall. To form the
double layer, the planks are separated by a translucent insu-
lation. There is also an interior single layer of glazed panels of a translucent, laminated glass of low iron content with an acid-
etched finish. Although the design had originally envisioned
vertical spans of as much as 22 ft (6.7) for the glazed panels,
the height of the glass had to be reduced by 4 ft (1.2 m) when
deflection calculations indicated the potential for excessive
movement in certain locations, notes Gipple.

In addition to the cantilevered roof system in the first lens, the glazed walls in the lenses are supported via foundation
walls, elevated floor framing, elevated catwalk framing, and other methods.

The catwalk system, in particular, serves a dual purpose.
Measuring approximately 2.5 ft (0.8 m) wide, the catwalks act as horizontal trusses to support the glazing both lateral-
ally and vertically. A track along the outer edges supports the bottom of one set of glazed panels while a header mullion
grips the tops of another set of panels, explains Gipple. The catwalks also provide access for cleaning and maintaining the
panels from within a pressurized air cavity that is climate
controlled to prevent condensation from forming on the in-
terior walls. Moisture, notes Gipple, could damage the mu-
seum’s artwork.

The catwalks in each lens are visible on the white glazed facades as slender horizontal lines that separate upper and
lower sections of glazed panels.

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Because the vegetated roof portions are designed to accommodate visitors—there are even pathways and works of art on the green space between some of the lenses—the roof structures in those sections were designed to support approx-
imately 200 psf (977 kg/m²) of superimposed load, twice the design loads for other portions of the roof, notes Gipple.

The underground portions of the Bloch Building cascade down the campus hillside in three main stepped sections: the
The two-story lobby of Lens 1 features a staircase that spans a distance of approximately 60 ft (18.3 m) to access an upper-level office and library space. The cantilevered stairs are supported on just one side by a fabricated steel box beam that also serves as a railing. The roof of the first lens is supported by a steel truss, below, approximately 131 ft (40 m) long and 15 ft (4.6 m) deep and is aligned diagonally across the top of the structure to act as a central spine.

first, or topmost, section includes the upper and lower lobby spaces, as well as a café; the second includes the second lens and gallery spaces for contemporary art; and the third includes nor just the third, fourth, and fifth lenses but also galleries for African art, photography, and special exhibits, as well as the Noguchi Court. Sloping ramps and stairs enable visitors to move between the various levels of galleries.

A basement art service level also connects key portions of each stepped section, and an elevator in the fifth lens facilitates the movement of art objects from the basement loading dock to the gallery spaces.

The sites for the first lens and the parking garage were excavated through an overburden of clay to a depth of approximately 35 ft (10.7 m) from the existing grade. The structures bear on either shale or limestone, says Gipple. The cuts for the rest of the Bloch Building extended down approximately 25 to 30 ft (7.7 to 9.1 m), depending on the elevation of the stepped sections, and also bear on shale or limestone, notes Gipple.

The foundations of the Bloch Building include continuous footings under the perimeter walls, a range of spread footings in the interior portions, and piers in one key location, Gipple says. The basement perimeter walls are nominally 1 ft (0.3 m) thick and are centered on continuous concrete footings approximately 3 ft (0.9 m) wide. Most of the interior footings measure 4 to 5 ft (1.2 to 1.5 m) square, although some are as large as 6 ft (1.8 m) square and even 1.2 by 6 ft (3.7 by 1.8 m), he notes.

Near the fifth lens, the Noguchi Court features several heavy stone art objects that are located above an area of newly compacted fill rather than a basement. Thus, that space is founded on a series of concrete piers that for the most part are 3 ft (0.9 m) in diameter and range in depth from 15 ft (4.6 m) to 20 ft (6.1 m).

Because the museum staff was concerned about possible damage to the artwork in the original building during the excavations for the Bloch foundations—work that in some places was conducted quite close to the foundations of the original building—Terracon, a consulting engineering firm based in Olathe, Kansas, carefully monitored the vibrations. Some gallery spaces in the original building were temporarily closed during the construction of the Bloch Building, Gipple notes, especially the spaces directly above a new tunnel, an elevator, and a visitor passage that were constructed to link the Bloch Building to the original museum structure.

The new entrance that connects the two buildings “provided an engineering challenge equal to any other on the project,” says Gipple. The service tunnel and the large elevator, which is more than 19 by 16 ft (5.8 by 4.9 m), were constructed nearly 40 ft (12.2 m) beneath the lowest floor of the original building and nearly 25 ft (7.6 m) below that structure’s concrete foundation piers. During the excavation of the elevator pit, these piers had to be supported on temporary steel beams via hydraulic jacks to take the 300,000 lb (136,000 kg) load of the original building’s limestone and brick wall. Concrete columns were cast beneath the existing piers to extend their depth, and then, in what was the most critical moment in the operation, the (Continued on Page 72)
Designed to a T

(Continued from Page 48) piers were cut free from the steel beams.

“As the time you cut the pier loose it would either try to spring up or sag,” Gipple explains. “If you calculate it perfectly to estimate the loads, it won’t do either, but it’s a challenge. You can’t just jack in extra load, because then the building would move up and crack the stone. Or if you underestimated the load it would sag and crack the stone.”

As it turned out, “our measurement of movement was minuscule and we didn’t encounter any cracks in the stone wall,” Gipple adds. “I was in the hole with the contractor when they saw-cut the piers and transferred the loads to the steel beams. It was re-assuring to see the solution come off without an issue.”

A passage for museum visitors was also constructed atop the service tunnel to link the new building to a pre-existing entrance on the eastern side of the original structure.

Because the new underground parking garage was intended to have an aesthetic as well as a utilitarian purpose—Holl envisioned it as the first part of a visitor’s museum experience—the design team incorporated a large ramp that leads directly from the upper level of the garage straight into the museum lobby. “You get the feeling that you just park the car and walk toward the museum, and you’re walking right into it, not walking into a basement lobby and then having to climb stairs to reach the actual museum,” says Nordenson. Then, he adds, “the people who are entering at the ground level [at the entrance of the first lens] will enter, in effect, the same space as they are entering from the underground garage.”

The team also did not want to use a traditional support system for the garage roof and floors. Instead, they developed a new form of prestressed concrete support called a wave T, a prefabricated beam of prestressed concrete that features a wavelike curve on the bottom. Each such wave T is 12 ft (3.7 m) wide and spans 60 ft (18.3 m). In plan, the garage is 240 by 328 ft (73 by 100 m). In contrast to a more traditional double T beam, which relies on two vertical legs, the wave T is supported at only one narrow point by a single column; these columns are spaced at 12 ft (3.7 m) intervals, notes Gipple. Stainless steel bent plates embedded in the flanges of the wave T at 8 ft (2.4 m) intervals are welded together to connect adjacent supports.

The upper level of the structure features a series of porthole skylights, each approximately 5 ft (0.9 m) in diameter, that help create the reflecting pool sculpture that sits atop a portion of the garage roof. Some of the openings for these skylights were cast directly in the concrete of the wave T, Gipple notes.

Together, the wavy beams, the column, and the glazed portholes “create this kind of corrugated ceiling pattern...so there’s light coming down through the water and through those skylights in between the wave Ts,” explains Nordenson.

The new garage features two sizes of wave Ts. The upper-level version is heavier to accommodate the greater loads it must bear. The floor-to-floor height of the upper level is approximately 19 ft (5.8 m), versus 11 ft (3.5 m) for the lower level. The upper-level wave Ts, which support the driving plaza, the reflecting pool, and a large portion of the vegetated roof, weigh approximately 92,000 lb (41,700 kg), compared with 86,000 lb (39,000 kg) for the lower-level supports. To reduce the weight as much as possible, both versions were constructed with lightweight concrete and feature center voids. The lower-level wave Ts have a single void roughly 27 in. (656 mm) in diameter, while the upper-level supports have twin voids, each nearly 17 in. (432 mm) in diameter, notes Gipple.

The reflecting pool atop the garage measures 1,114 by 161 ft (41 by 49 m) and holds 120,000 gal (454,200 L) of water. An elastomeric membrane layer provides waterproofing, and the garage roof is tilted for drainage, says Nordenson.

Drainage and waterproofing were also critical concerns within the Bloch Building itself, especially for the $28,000 sq ft (5,300 m²) of vegetated and irrigated roof. The roof is designed to manage the building’s storm water while also providing a high insulation value and sufficient thermal mass to significantly reduce the structure’s energy consumption.

At press time, the Nelson-Arkansas' Bloch Building was approaching its second anniversary. Thinking back to the design process that created this critically acclaimed structure, Nordenson muses on the concept of poché, the black lines on architectural plans denoting the solid walls that create the interior spaces in traditional Beaux-Arts structures, including the original Nelson-Arkansas building. SHA and Nordenson also thought in terms of poché for the Bloch Building, but with a twist. They used the walls of the structural and flanking Ts to enclose the building’s mechanical systems as well as to form the interior spaces. Then they pulled these massive structures into the middle of galleries and lenses to “free the [glazed] perimeter to be as crystalline as they are,” Nordenson says.

Likewise, the creation of the wave T supports in the parking garage represented a departure from the ordinary, something that Gipple sees as an essential goal for today’s structural engineers.

“Get the feeling that when you cut the pier loose it would either try to spring up or sag,” Gipple says. “It is easy enough to provide the traditional solution,” he stresses, but the Bloch Building demonstrates what can be achieved when “engineers embrace the non-traditional.”