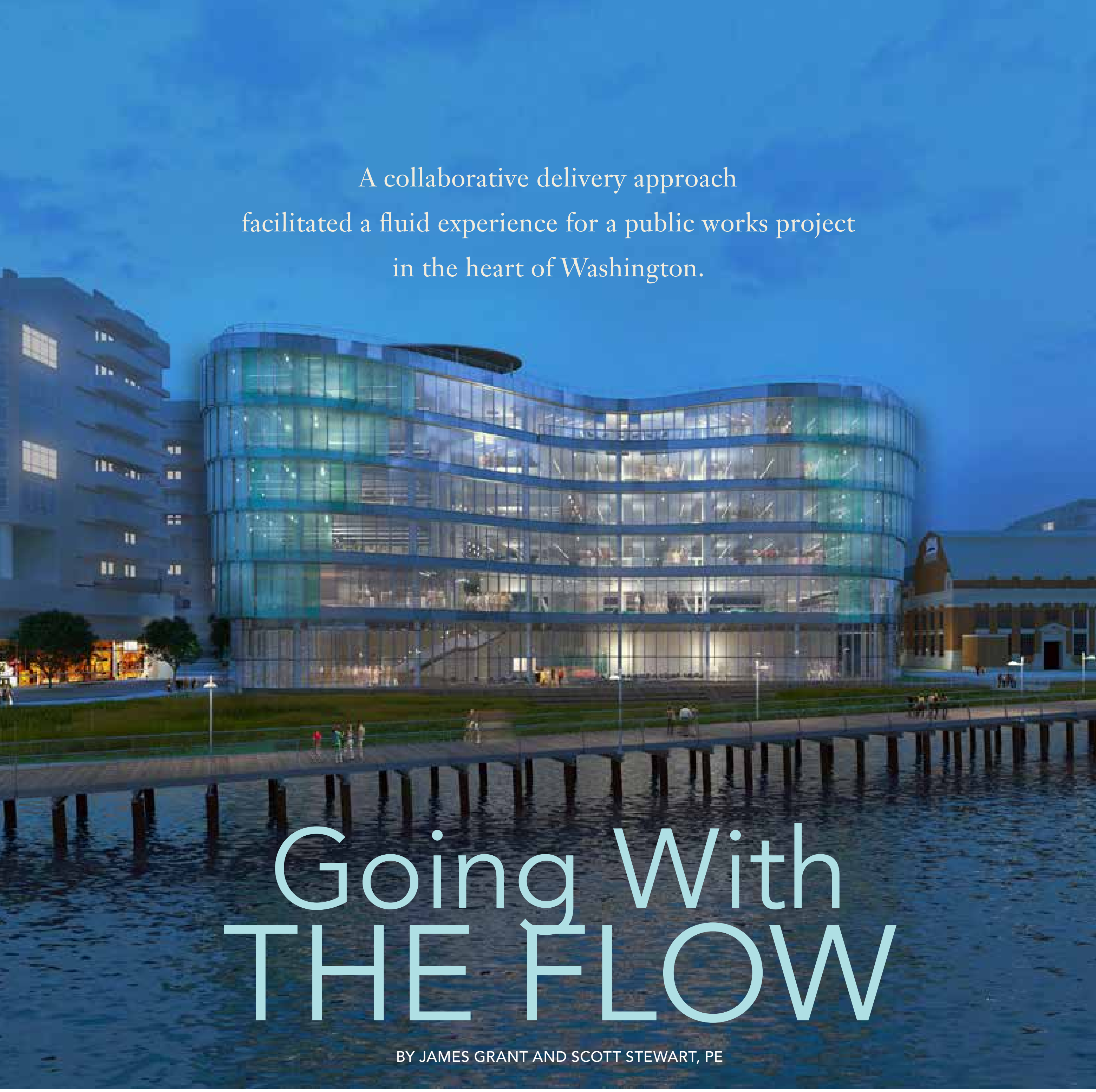

A collaborative delivery approach facilitated a fluid experience for a public works project in the heart of Washington.

Going With THE FLOW

BY JAMES GRANT AND SCOTT STEWART, PE

AT THE EDGE OF THE ANACOSTIA RIVER, just upstream from Nationals Park, sits a utilitarian, two-story brick-clad structure known as the O Street Pump Station.

Owned by the DC Water and Sewer Authority, the building is located adjacent to the rapidly developing Capital Riverfront and The Yards neighborhoods of southeast Washington, D.C. The O Street facility and the nearby Historic Main Pumping Station form a critical part of the city's infrastructure, continuously pumping approximately 70% of the city's storm water and sewage to the Blue Plains Wastewater Treatment Plant a few miles to the south on the Potomac River.

In 2013, DC Water approved a Revised Facilities Master Plan to optimize the use of its existing land and facilities. The plan included the construction of a new headquarters building on the site of the existing O Street station, with a goal of consolidating administrative offices, reducing leased space, locating staff in a more centralized, convenient location and freeing up space at the Blue Plains facility.

The resulting facility, scheduled to open this year, is a six-story, 150,000-sq.-ft steel-framed structure embraced by a fluid architectural form. The building's curving footprint was carefully shaped to develop a unique, site-specific solar response that reduces heat gain while maximizing daylighting potential and panoramic views of the Anacostia River. The façade is enveloped by full-height curtain walls on the south, east and west sides to take advantage of the scenic views, and gradually shifts

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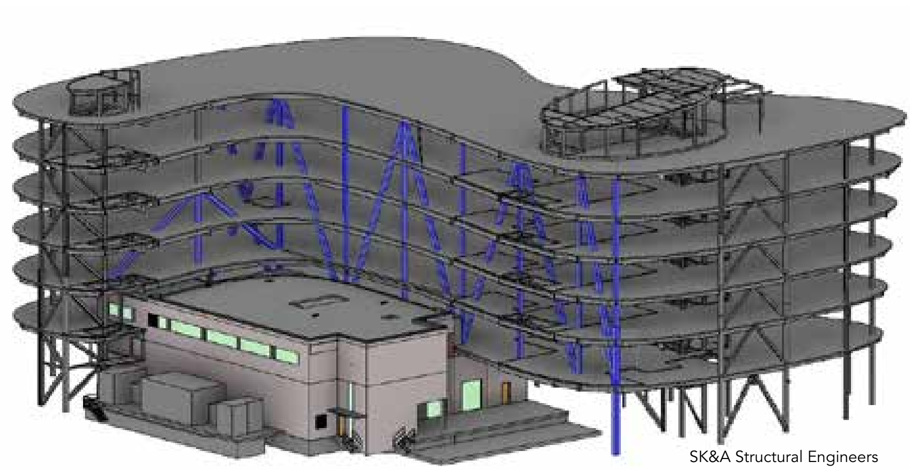

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▲ A Revit model of building structure, with integral trusses highlighted.

◄ A view of the new building from the Anacostia River.

▼ The landscaped rooftop amenity space.

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to punched windows on the north side of the building. The structure consists of five office levels and an accessible roof terrace. The lobby will include areas where visitors can see portions of the pump station in operation and learn about the building site's many sustainable features. The second floor includes a large column-free boardroom and pre-function space at the southwest, with flexible open office space comprising the rest of the floor, while the roof level features an undulating landscaped green roof and hardscaping.

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W14×730 and W14×665 top chord sections at the fabrication shop.

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The façade is supported with cantilevers and an assembly of angles.

T-1 truss spanning over the existing pump station.

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The building partially encapsulates the existing pump station.

Site Constraints

Developing the project site proved challenging thanks to a number of constraints existing in almost every direction. For starters, the O Street Pump Station needed to remain accessible and operational throughout construction. The project also had to tackle multiple utilities below the site, including concrete vaults, box culverts, electrical duct banks and very large clay brick sewer lines dating back more than 100 years—and also had to deal with the fact that poor subsurface conditions were widespread throughout the site. In addition, the structure was to be set back from Anacostia River, and views to the river down Canal Street on the east side needed to be preserved.

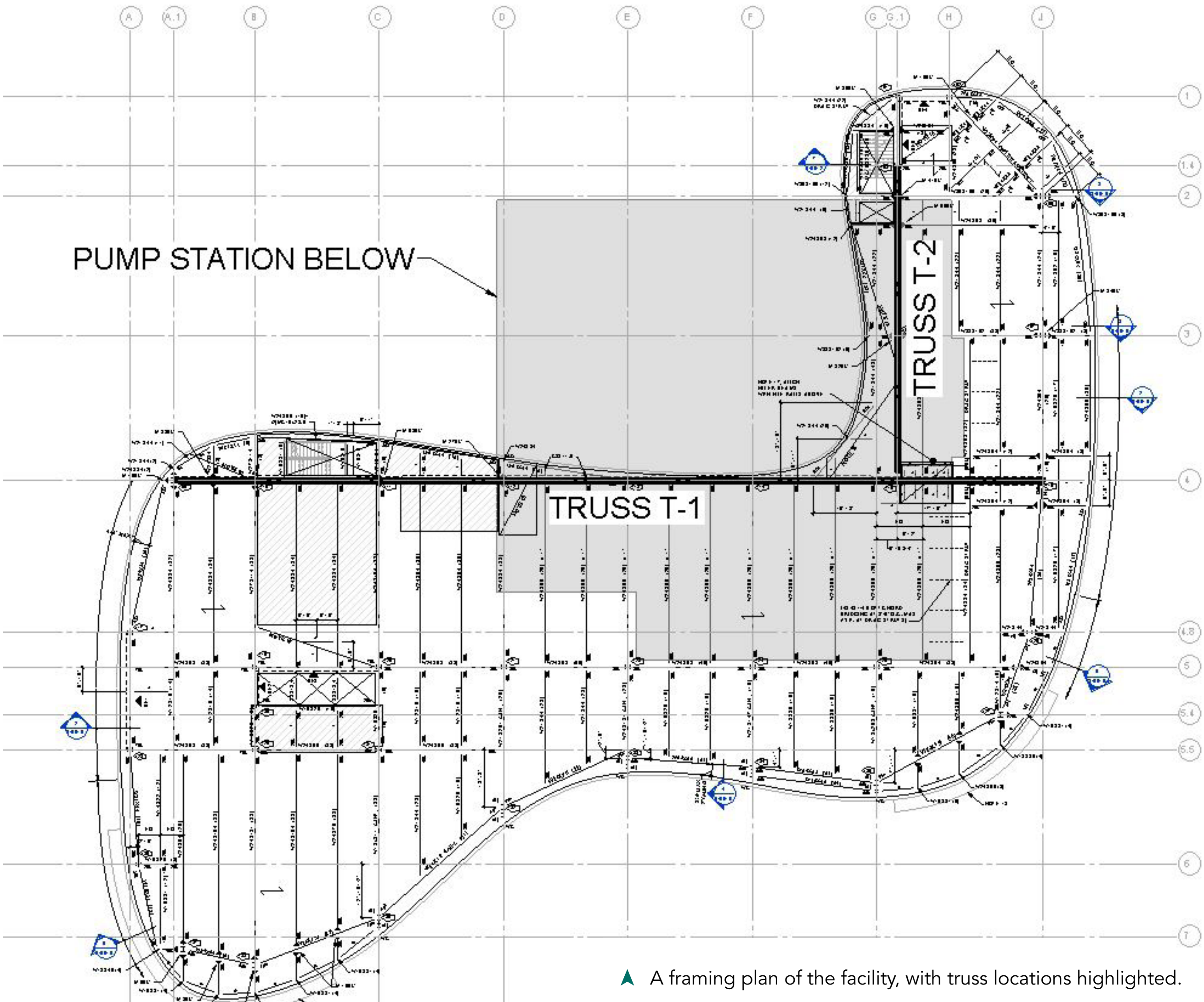
The required setback and view requirements greatly reduced the portion of the site that could be used for new construction. As a result, the program required the new building to be constructed partially over and encapsulate the existing pumping station. As the architectural design evolved from an initial parallelogram to the final curving shape, the structural challenges became evident. The building configuration required the structure to span over the pump station in two directions, provide large cantilevers, use "walking" columns to support the projecting south façade and locate foundations strategically to avoid the existing below-grade utilities. While cast-in-place concrete is common for new construction in Washington, the design team recognized that structural steel's inherent capabilities would be important to the success of the project—particularly for the integral long spans. Nearly 1,800 tons of structural steel was used in all.

Trusses

Since the existing pumping station was not capable of structurally supporting the new headquarters building, the new building needed to be self-supporting and span over the station. After studying various framing configurations and coordinating possible column locations, the team decided on two perpendicular multi-story trusses.

The primary truss (T-1) is an integral five-story (second floor to roof), 210-ft-long, 517-ton truss spanning the length of the building from east to west. While the pump station is much shorter than this—approximately 110 ft long—the need to bridge existing infrastructure and a loading dock necessitated the longer span. Perpendicular to the T-1 truss, a 75-ft-long, two-story truss (T-2) spans north-south over the shorter dimension of the pump station as the headquarters building turns the corner. This truss is column-supported at the north end and frames to the T-1 truss at the south end. To accommodate a high-bay portion of the pump station, the T-2 truss is located between the third and fifth levels, with a portion of the second floor below supported by hangers.

With deflection as a key consideration in the truss design, the need to limit axial deformation, as opposed to strength limit states, controlled the design of the primary truss members. The truss members are W14 sections, up



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A framing plan of the facility, with truss locations highlighted.

to 665 lb per ft in the T-1 truss, and W14×730 columns support factored loads in excess of 5,000 kips. Live load reduction was considered when designing the trusses to aid in economizing member selection. The final design configuration of the truss weighed 517 tons.

In addition to the gravity load transfer, the trusses also served as an integral part of the lateral load resisting system. Driven by site constraints and the architectural program, the braced frames could not be ideally located to provide the needed lateral stiffness for the structure, but integration of the T-1 truss provided the additional stiffness needed to stabilize the building. Forces were transferred out of the truss to the braced frames through the second-floor diaphragm, requiring extra attention to detailing and load paths.

Collaboration

The project's successful design was the result of significant collaboration between the design-build team members, who worked integrally through design solutions and constructability and erection challenges. As the design evolved, general contractor Skanska engaged Berlin Steel, the fabricator and erector for the project, in a design-assist role. Berlin provided valuable input related to material availability, crane access requirements and locations, staging and temporary erection support solutions. As it was critical to the overall project schedule—and considering the rolling schedules for the larger sections used in the trusses—the team prepared an early steel package so that Berlin Steel could expedite material procurement.

Given the member sizes, truss spans and crane limitations, assembling the trusses prior to erection was not feasible. While the final trusses are not exposed to view, gusset plates at the truss connections were not desirable, and the team realized that they might impede circulation and views. As such, the truss construction consisted of shop-welded "node" assemblies and straight "sticks" to be field bolted.

Using temporary supports located on the pump station columns, temporary shoring adjacent to the building and a system of hydraulic jacks, Berlin Steel stick-built the trusses integral with the building as it progressed vertically. Truss deflections were monitored as work progressed and jacked as needed to maintain alignment and allow fit-up of subsequent levels. The process allowed for the jacking to be done on the top of the bottom chord due to the existing structure being only 20 in. from the bottom of the bottom chord. The T-1 truss remained shored until it was topped out, connections were completed and inspected and sufficient adjacent framing and decking were in place to brace the truss. Truss deflections were checked after the shoring was released and the slab was placed, with observed deflections consistent with those calculated during design.

Cantilevers and Walking Columns

To reach beyond the underground utilities and to facilitate

The building's curved edge is attained with a system of continuous bent plates and angles.

Truss diagonals were field bolted to truss nodes.

A temporary shoring tower and jack supporting the T-1 truss.

Shop-welded, field-bolted truss node assembly (T-1 truss).

the fluid slab edge, the structure required large cantilevers in several locations. Cantilevers up to approximately 12 ft were employed along the east façade, and portions of the southwest and north façades used similar cantilevers to address the curving design while controlling interior spans and maintaining the alignment of the T-1 truss. In each instance, a study of deflections and resulting compounding deflections was performed and coordinated with the curtain wall and façade assemblies.

Another interesting aspect of the new headquarters building is the use of "walking" columns along the south façade of the building. To provide a level of shading at each floor below, the building slab edge and façade progressively step out up to 2 ft at each floor moving up the building. Architecturally, sloping columns or progressively increasing cantilevers were not desirable, so these walking columns were placed equidistant from the façade at each level. At these locations, the

➤ Truss nodes were directly welded to eliminate large gusset plates and also to avoid impeding circulation.

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floor beam below cantilevers at each level to support the column of the floor above it. This required evaluating the load accumulations, addressing the potential for compounding deflections and coordinating with the curtain wall system, as well as respecting beam depth limitations established by a raised soffit along the façade.

In addition to overcoming the site challenges, the project team and owner have embraced sustainability as an integral part of the project design and its success. The facility will take advantage of the wastewater outflow volume with an innovative heat recovery/rejection system that uses heat from the pumping station to condition the new building. In addition, the stepped and layered façade provides self-shading, an accessible green roof tops the building and a 30,000-gallon cistern collects rainwater for on-site toilet flushing and irrigation—a fitting example of an environmentally minded building geared toward water management. It is expected to achieve LEED Platinum certification.

The long-span capabilities of structural steel and the collaborative project approach made this building feasible on a complex site, resulting in a fluid design that appropriately reflects the building's function as a water management facility as well as its location along the river. And its attractive, efficient façade will make it a welcome new neighbor in this up-and-coming area and a worthy addition to a city of thoughtfully designed, high-profile buildings. ■

Owner
DC Water and Sewer Authority, Washington, D.C.

General Contractor
Skanska USA, Rockville, Md.

Architect
SmithGroupJJR, Washington, D.C.

Structural Engineers
SK&A Structural Engineers, PLLC, Washington, D.C.
(Superstructure and EOR)
Leuterio-Thomas Architects and Engineers, National Harbor, Md.
(Foundations and Associate EOR)

Steel Fabricator, Erector and Detailer
Berlin Steel Construction, Glen Burnie, Md.

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▲ A rendering of the view from the Anacostia Riverwalk Trail.

▼ Walking columns are supported by short cantilevers.

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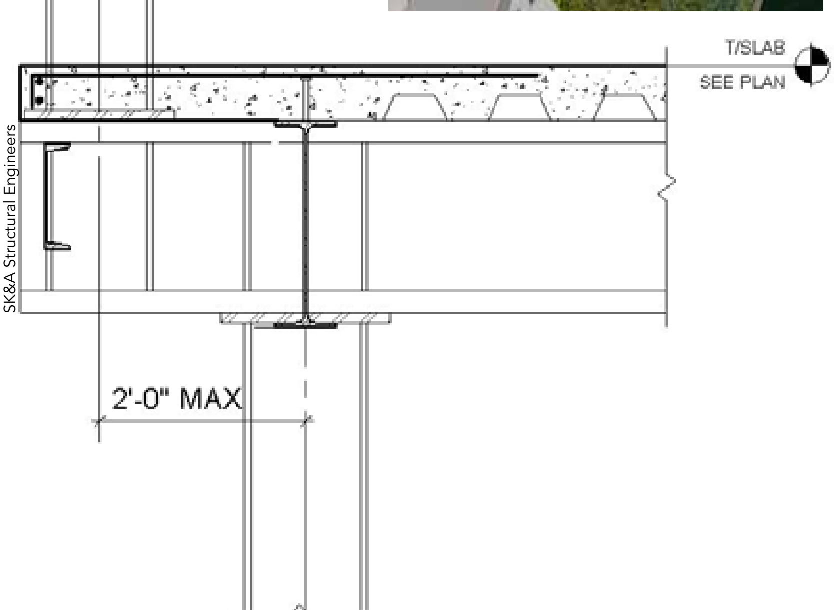
➤ Darker green panels are used to shade the building during the brightest times of the day.



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