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UPSIDE-DOWN GLASS BUILDING—
RESTON STATION OB1

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Introduction

Buildings need strong foundations, which is why they typically are the largest at the base. Reston Station OB1 breaks this rule by growing wider with each ascending floor (Fig. 1). Also known as 1900 Reston Metro Plaza, the mixed-use building is located adjacent to the Wiehle-Reston East Metro station in Reston, VA. To achieve the structure's "upside-down" design, a concrete post-tensioning slab system was required. In addition to the unique detailing required for the post-tensioning to meet the architectural design intent, the building features a diagonalized, exposed concrete exoskeleton on both the east and west sides as well as an open-air plaza on its north end. While the exposed concrete exoskeleton and overall geometry of the building posed many challenges, the Reston Station design and construction teams were up to the task and worked together to create this iconic landmark along the Dulles Toll Road.

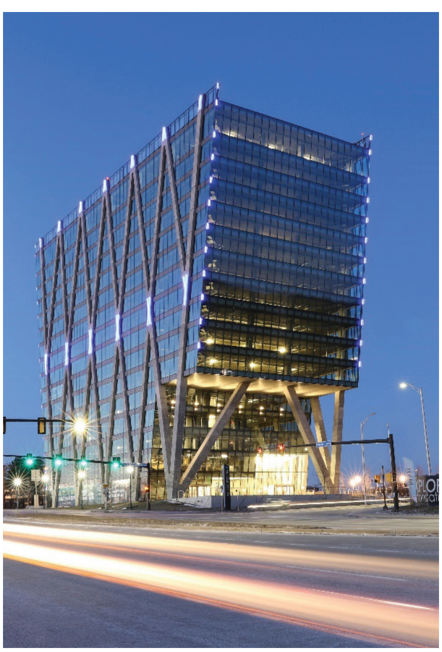

Fig. 1—Overall building. Image Credit: Thornton Tomasetti

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Project overview

Reston Station OB1 consists of a 16-story, 371,000 ft^2 (34,500 m^2) office tower as well as eight levels of below-grade parking for the building's occupants and Metrorail riders. It is one of several office and residential buildings making up the Reston Station complex along the Silver Line Metrorail, which extends from Washington, DC, and is being expanded farther to Dulles International Airport.

Tower Structure

Gravity floor system

Key to the tower's gravity load-resisting system are its floor slabs, which are 10 in. (250 mm) thick, two-way post-tensioned (PT) slabs, with 6 in. (150 mm) drop panels (Fig. 2). Slab spans are typically around 40 ft (12 m), with edge spans varying slightly at every floor due to the building's geometry, and with 15 ft (4.6 m) cantilever slabs (9 in. [230 mm] thick) at the north and south ends. The cantilevered end spans are from Levels 2 to 17. Spandrel beams, designed as tension ties, are provided along the east and west edges of each slab to accommodate the variable slab edge spans up to 40 ft (12 m), resulting from the sloping support columns (Fig. 3). Continuous drop panels are provided between end columns, spanning in the east-west direction at the north and south ends of the building. The continuous shallow drop beams provide support for the cantilever slabs. In addition to the typical spandrel beams, Level 17 has several PT beams and girders to transfer the penthouse roof loads (Fig. 4).

Banded PT tendons are mainly provided in the north-south direction along the shear walls located in the core of the building. Some of the banded tendons were kept at a straight profile along the core walls to act as tension ties to resist the force from the interior sloping columns. Banded tendons are also provided along the continuous drops located between the end columns. Distributed PT tendons are provided in the east-west direction and additional distributed tendons are provided in the north-south direction in the last two spans to help with proper load transfer from the cantilevered slab and to control slab deflections at the cantilever ends.

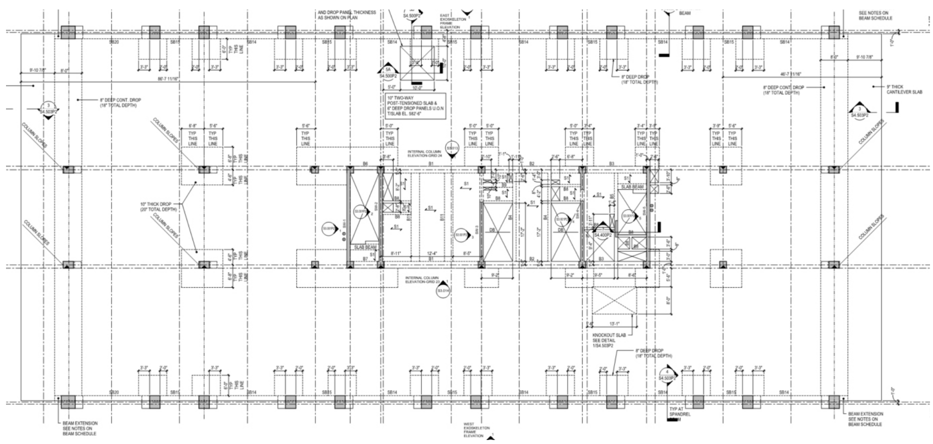

Fig. 2—Typical floor plan. Image Credit: Thornton Tomasetti

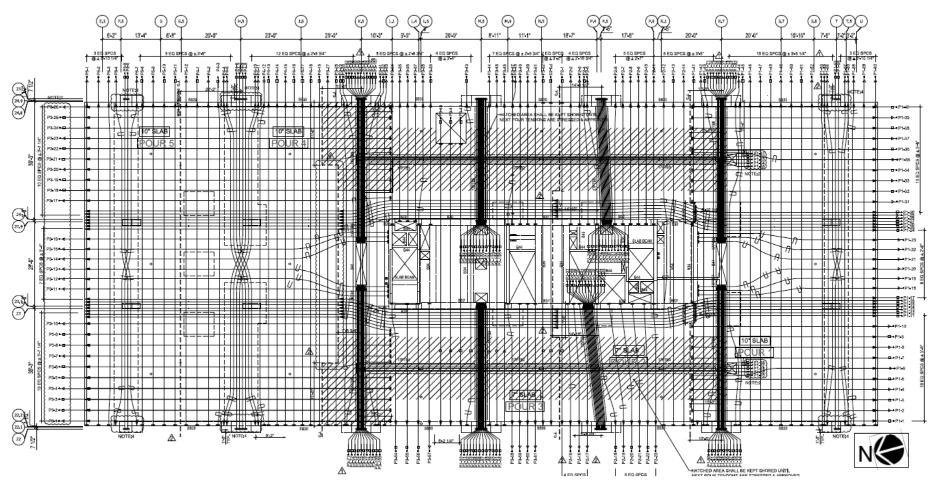

Fig. 3—Typical PT layout for Levels 2 to 16. Image Credit: CCL USA, Inc.

Concrete exoskeleton and building slope

Reston Station OB1 has only 10 interior columns. The slabs outside of the core span from the shear walls or core columns to the concrete exoskeleton columns, which are typically 36 x 45 in. (915 x 1140 mm) high-strength concrete and slope at 11 degrees from vertical, matching the slope of the building's north and south faces. These columns not only support the gravity loads from each floor level but also act as the lateral force-resisting system for the building in the north-south direction. The concrete exoskeleton (Fig. 5) predominantly acts as a braced frame due to triangulation of the columns resulting from column intersections at the top, bottom, and midheight of the structure; however, the exoskeleton columns also experience flexure due to the bending of the floor spandrel beam-column intersections between the stiff braced frame points. The lateral force-resisting system in the east-west direction is made up of six shear walls located in the core of the building along the elevator and stair shafts.

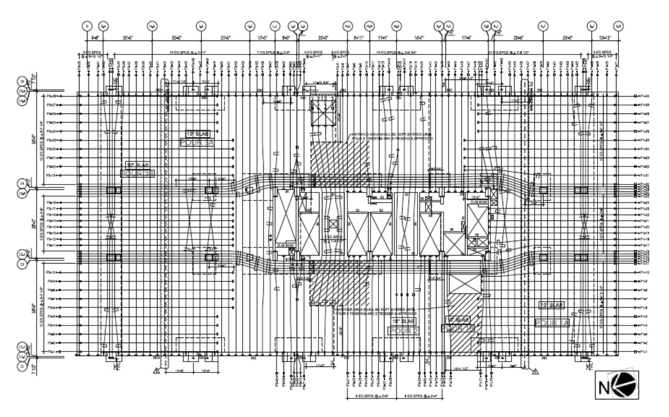

Fig. 4—PT layout for Level 17 showing PT beams and girders. Image Credit: CCL USA, Inc.

Using post-tensioning for the slabs enabled the design team to achieve the thinnest slab depth possible. This is particularly evident in the two end walls—the north and south façades—where the combination of thin slabs, glazing, and the overhanging design gives the impression of an unsupported glass space floating above the ground. The exoskeleton columns are exposed and, hence, no stressing pockets were allowed to be visible to give a clean architectural look to the building. Achieving this impression created a challenge that was resolved by crisscrossing the distributed PT tendons (Fig. 6) in the east-west direction at midspan to conceal dead-end anchors inside the exterior columns and allow the tendons to be stressed at the spandrel beams.

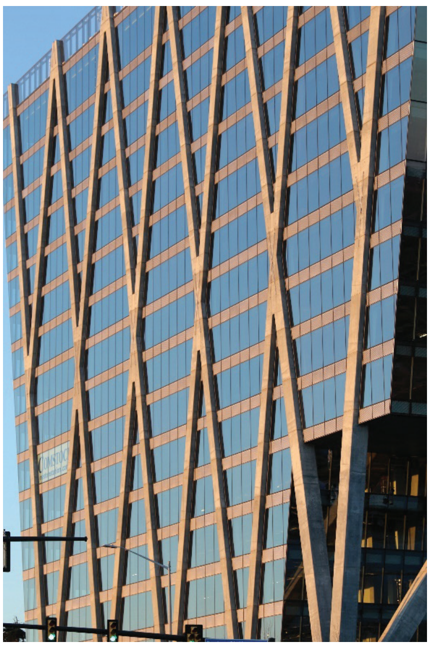

Fig. 5—Exoskeleton side view. Image Credit: Thornton Tomasetti

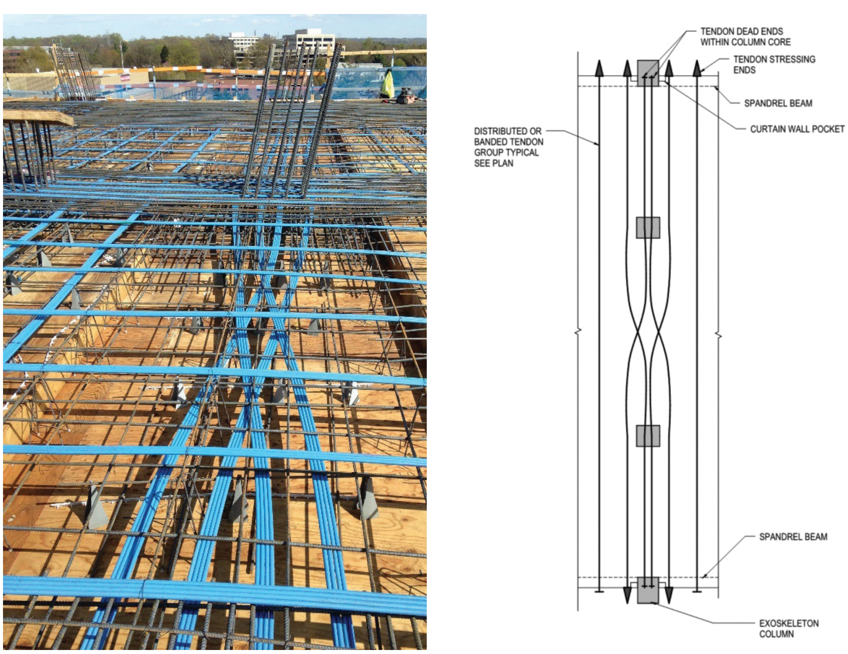

Fig. 6—PT distributed tendons crossed at midspan. Image Credit: DAVIS

This tendon crisscrossing layout maintained a clean, finished look on the face of the architecturally exposed exoskeleton columns, with the stressing ends at the spandrel beams concealed by the spandrel panels in the curtain wall. Level 17 had many PT beams with more than 40 tendons that could not be stressed from the exoskeleton columns. Hence, all of the beam tendons were stressed from the interior location at the core wall side through temporary stressing blockouts.

The exposed concrete exoskeleton not only posed challenges for coordinating the stressing and dead ends of the post-tensioning, but also created structural challenges. Like a folding drying rack, it has a tendency to spread under gravity loads. To overcome these spreading loads as the building grows taller and wider, the design team added spandrel beams. The spandrel beams are located all along the perimeter of the building on the east and west faces, and were designed and detailed as tension ties. Close coordination between Thornton Tomasetti, CCL, and the rest of the design team was required to accommodate the post-tensioning anchors along the spandrel beams as well as curtain wall anchor pockets. Coordination meetings were held well ahead of the start of construction to identify conflict locations between PT, reinforcing bar and curtain wall embeds. After identifying the conflict locations, detailed sections and end views showing necessary clearances and tolerances were provided in the shop drawings for ease of installation of post-tensioning anchors around the reinforcing bar and embeds (Fig. 7). Part of the solution included having the PT anchors spread out and installed in multiple layers, which kept the design center of gravity of steel (CGS) per the contract documents as well as avoided stressing from the exoskeleton columns. Coordination of the post-tensioning, reinforcing bar, and embeds ahead of time proved beneficial during construction by avoiding delays, adhering to the construction schedule, and preventing any last-minute surprises on the jobsite.

Open-air plaza tree columns

In addition to growing outward at 11 degrees from vertical, the building steps out drastically at the Level 6 floor over the open-air plaza on the north end. This large overhang is supported by two sets of "tree columns" which are five-story (approximately 72 ft [22 m] long) unbraced structural steel and concrete composite columns that start at one node at the ground floor and splay out like a tree to support the 11 stories above (Fig. 8). Each column contains a steel core constructed of two W30 flanges and a W24 web, forming a built-up H-shaped member. Two columns from each tree column set slope to match the exoskeleton columns, while one column from each set slopes in two directions at 34 degrees from vertical to support the interior sloping column at Level 6.

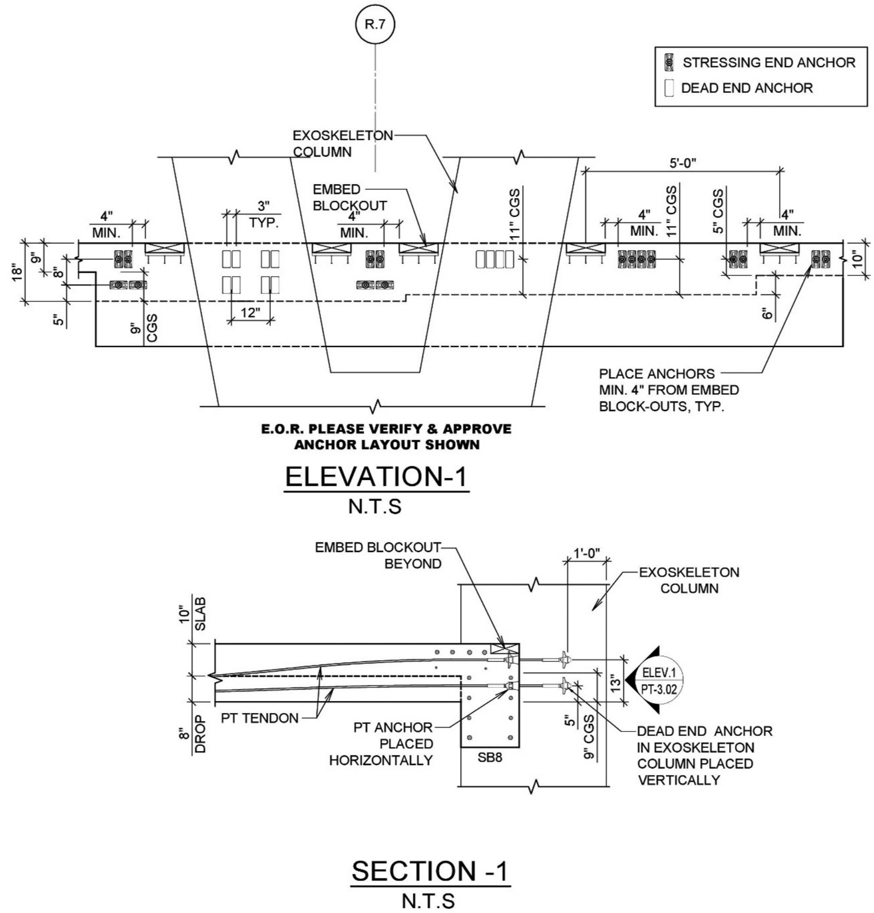

Fig. 7—PT shop drawing coordination view. Image Credit: CCL

PT beams and PT girders

The roof slab, or Level 17 slab, contains the most post-tensioning of all the floors. This is not only because it is the largest floor plate but it also includes post-tensioning beams that support posts around the mechanical penthouse. These PT beams span in the north-south direction at midspan of the typical floor slab and are supported off PT girders running in the east-west direction from the exoskeleton columns to the core. The PT beams and girders (with more than 40 tendons each) were stressed in a staged manner, meaning a portion were stressed when concrete reached the required strength for stressing after placing the concrete beams, and then the rest of the tendons were stressed after the penthouse concrete construction was completed (including the posts and penthouse roof slab). The PT girders spanning in the east-west direction to the exoskeleton frames required beam-stressing blockouts that were infilled with "drop-in beams" with no tendons to allow for stressing toward the interior of the building and dead-end anchors in the exposed concrete exoskeleton. These drop-in beams between the PT beams were attached to the PT beams via mechanical reinforcing bar threaded couplers.

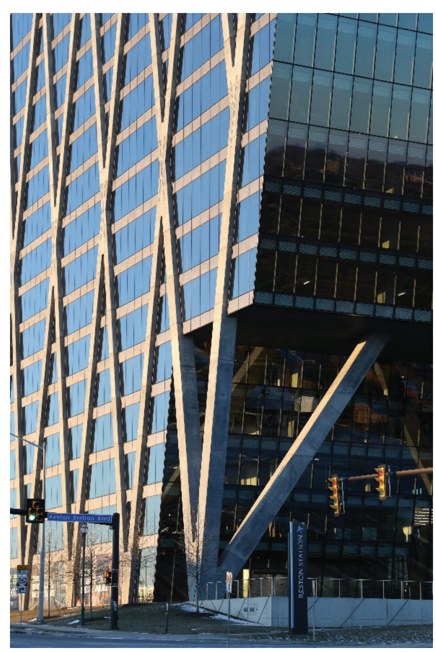

Fig. 8—Tree columns. Image Credit: Thornton Tomasetti

Conclusions

Post-tensioning was used to eloquently meet the architectural design intent for this unique inverted office tower, which has been nicknamed, "the upside-down glass building." Post-tensioning was required to meet the slab thickness limits for the long spans, support the large cantilevers at the building's north and south edges, provide horizontal tension resistance along the core to the spreading force of the building, support the posts up to the penthouse roof, and achieve the industrial feel of the architectural exposed concrete exoskeleton. A highly visible and soon-to-be-iconic structure, its many exposed structural elements, including a diagonalized concrete exoskeleton and unbraced tree columns, are truly unique.

Team

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Architect: JAHN
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Contractor: DAVIS
Concrete Subcontractor: Miller & Long
PT Supplier: CCL USA, Inc.
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