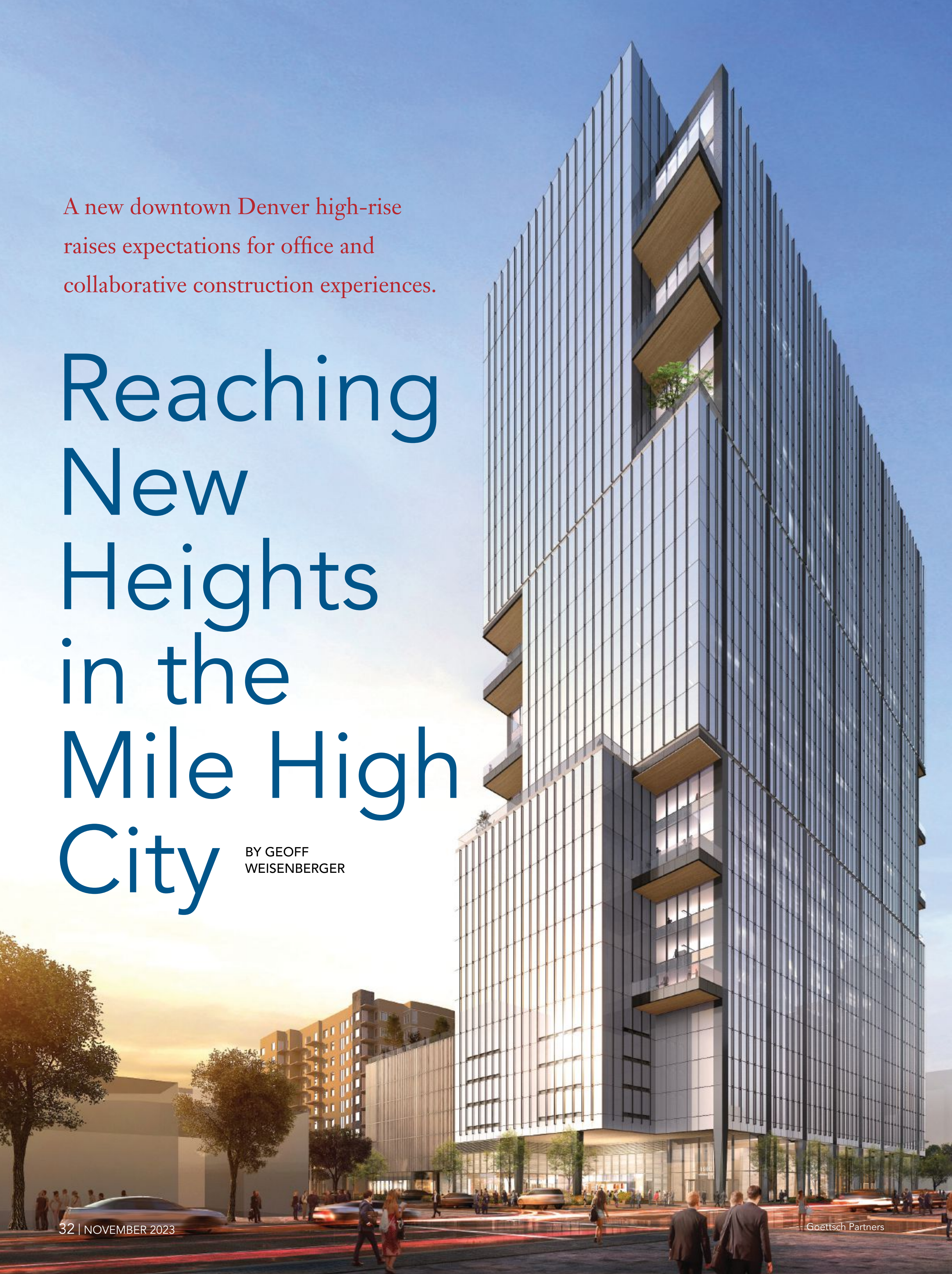
A new downtown Denver high-rise raises expectations for office and collaborative construction experiences.

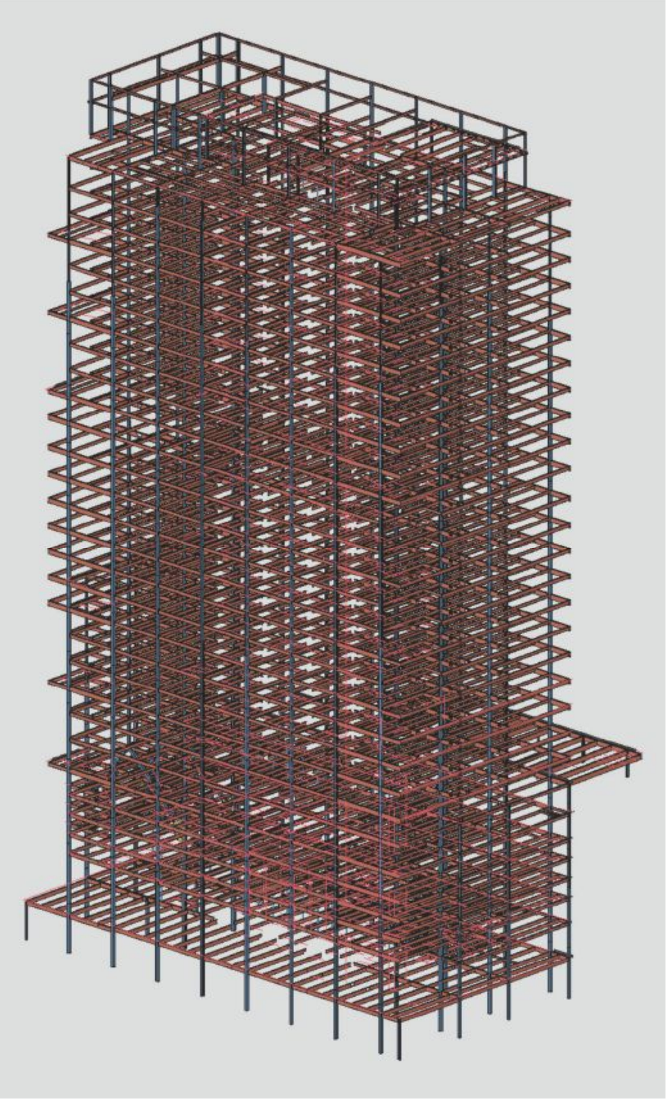
Reaching New Heights in the Mile High City

BY GEOFF WEISENBERGER

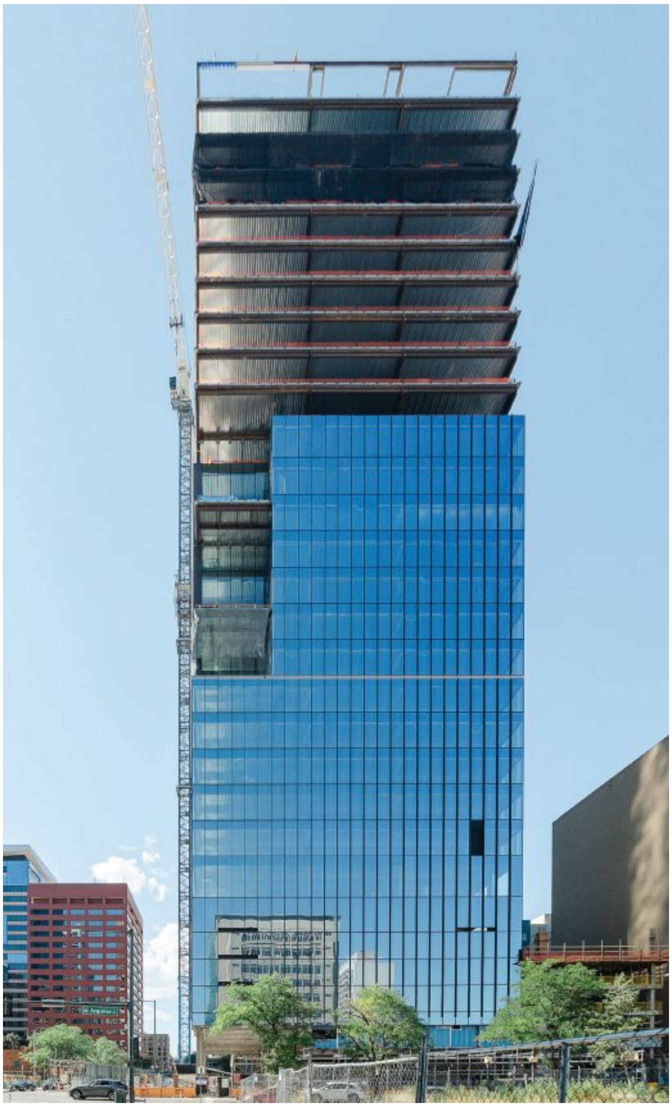


Goettsch Partners

A 3D model of the framing system, which uses 4,571 tons of steel.



The topped-out tower.



DENVER'S ELEVATION HAS ALWAYS BEEN a point of pride for its residents, and steady growth for over two decades—punctuated by one spike in the early 2000s and another in the 2020s, the latter resulting from the COVID-driven "Great Relocation—has resulted in another impressive number for the Mile High City. Between 1999 and 2023, the population has gone from under 500,000 to well over 700,000.

The growth is apparent throughout the city and the greater metropolitan area, but perhaps no more so than the area immediately north of the central business district, where multistory residential buildings have been and continue to be built at a rapid rate.

Many of these buildings are viewable from an under-construction office tower called 1900 Lawrence. And some of their residents will likely end up working there.

The 30-story building, which topped out in September, will reach 400 ft in height and add 720,000 sq. ft of office space (and 1.1 million gross sq. ft) to downtown Denver. And it's not typical office space. The exterior of the steel-framed building, which is clad in high-performance glass that facilitates abundant natural light, is punctuated by multiple terraces, an amenity that's more common in residential buildings than office towers. On the inside, a hospital-grade filtration system and a compartmentalized air supply approach (in which air isn't recirculated from other floors) facilitate the highest quality of indoor air.

Thanks to the steel framing system, the interior area is maximized, with 30-ft bay spacing, a 43-ft column-free stretch between the building core and exterior on all sides, and six corner opportunities on multiple floors due to "cut-outs" at two corners of the building.

The building's location also scores high in amenities and transit, boasting a walkability score of 96, a cycling score of 95, and a transit score of 98 (all out of 100). It's a short walk from Union Station, the River North Art District (RiNo), Coors Field, and the rest of downtown Denver and its surrounding areas.

But what about the structural steel framing system? Is it as impressive as the rest of the building? Members from Magnusson Klemencic Associates, Martin/Martin, and Puma Steel—the project's structural engineer, connection designer, and steel fabricator, respectively—shared how and why they think it is.

1900 Lawrence is adding more than 1 million gross sq. ft to Denver's growing downtown area.

Why was the project built?

Rob Chmielowski, MKA: The developer, Riverside Investment and Development, saw an opportunity for a new Class-A office building in the vibrant downtown Denver neighborhood LoDo (Lower Downtown).

What's the total steel tonnage?

Wade Lewis, Puma: We show 5,969 tons, including structural (4,571), deck (1,200), stairs (156), and miscellaneous (42).

The building has some retail space and a massive lobby space at the base. Was any long-span steel required?

Chmielowski: The expansive 27-ft-tall lobby exists on the south side of the building only. The balance of the tower footprint is dedicated to retail and plaza space. The western plaza's openness is achieved by transferring two full-height tower columns. Each column is transferred via a three-story transfer truss within the parking levels, providing a 66-ft by 121-ft column-free space at the ground level. The transfer of the tower columns also benefited circulation with the parking levels by keeping the columns out of the drive aisles.

There are a lot of balconies and cantilevers. Is that to provide more amenity space? What were some of the longest cantilevers?

Chmielowski: Cantilevers are commonly used in office buildings to provide highly desirable column-free corners. A typical office floor in this project contains six separate locations where cantilevering of the steel offers column-free corners. Cantilevered framing is also used to create the ten terraces that extend from the building façade at the southeast, southwest, and northwest corners. The terraces provide amenity space for the tenants and are generally 14 ft long.

How well do the glass façade attachments integrate with the steel framing?

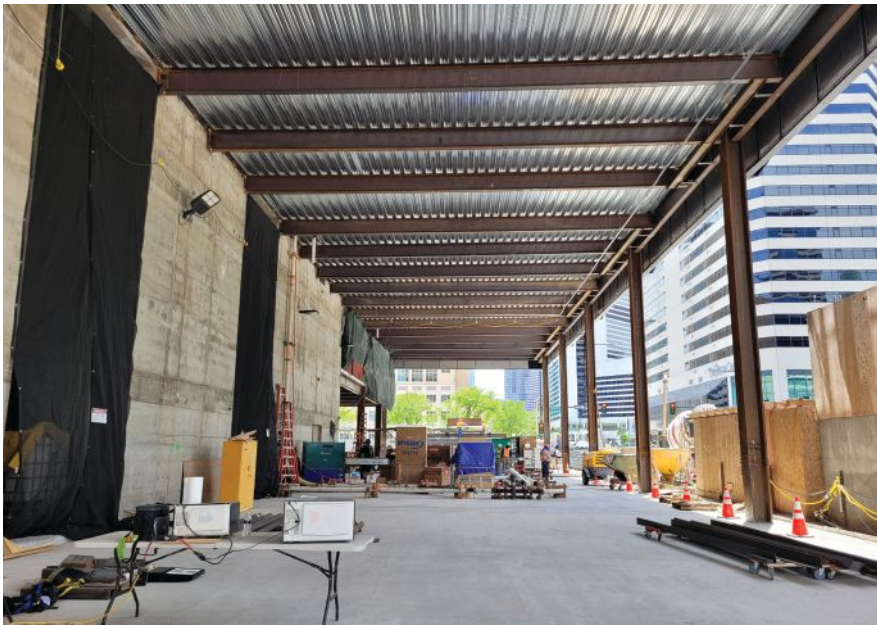
Chmielowski: Curtain wall attachments are achieved via a connection to the slab-on-metal-deck, which cantilevers beyond the perimeter spandrel beams. This is a standard installation method. MKA and the general contractor, Hensel Phelps (HP), worked together to develop an agreed-upon structural movement monitoring plan to assess the position of the structure at various stages of construction. The field survey results were compared to MKA's column shortening analysis that was based on the specific stage of construction at the time of survey and, if necessary, adjustments were made in the field. This collaborative process ensured that the structure behaved as anticipated and promoted level floor slabs once the building was topped out.

Goettsch Partners

A zoomed-out rendering of the entire building.

Goettsch Partners

A rendering of the lobby and street level.

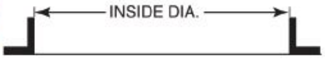


A portion of the lobby is two stories.

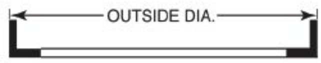
Standard Mill Shapes - Rolled To Your Specifications

Call 866-940-5739

We bend ALL sizes up to:

1 **Angle Leg Out**


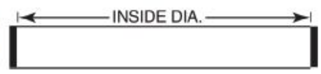
10" x 10" x 1" Angle

2 **Angle Leg In**


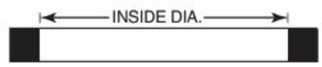
10" x 10" x 1" Angle

3 **Flat Bar The Hard Way**

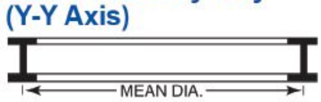

24" x 12" Flat

4 **Flat Bar The Easy Way**


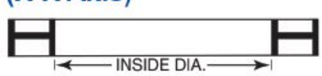
36" x 12" Flat

5 **Square Bar**


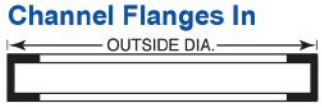
18" Square

6 **Beam The Easy Way (Y-Y Axis)**


44" x 335#, 36" x 925#

7 **Beam The Hard Way (X-X Axis)**


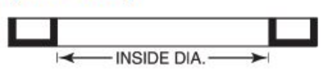
44" x 285#

8 **Channel Flanges In**


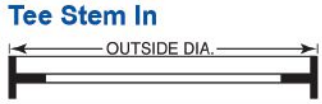
All Sizes

9 **Channel Flanges Out**


All Sizes

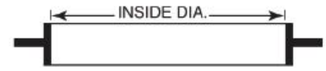
10 **Channel The Hard Way (X-X Axis)**


All Sizes

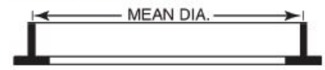
11 **Tee Stem In**


22" x 142 1/2# Tee

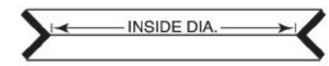
We bend ALL sizes up to:

12 **Tee Stem Out**


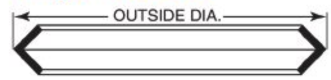
22" x 142 1/2# Tee

13 **Tee Stem Up**


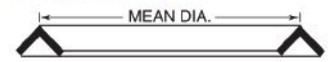
22" x 142 1/2# Tee

14 **Angle Heel In**


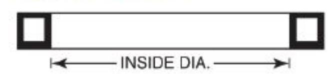
8" x 8" x 1" Angle

15 **Angle Heel Out**


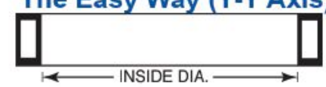
8" x 8" x 1" Angle

16 **Angle Heel Up**


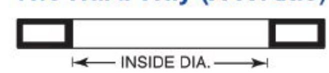
8" x 8"x1" Angle

17 **Square Tube**


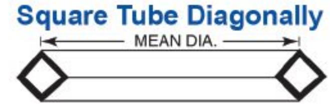
24" x 1/2" Tube

18 **Rectangular Tube The Easy Way (Y-Y Axis)**


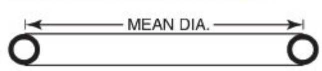
20" x 12" x 5/8" Tube

19 **Rectangular Tube The Hard Way (X-X Axis)**


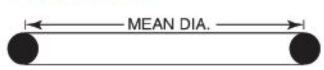
20" x 12" x 5/8" Tube

20 **Square Tube Diagonally**


12" x 5/8" Square Tube

21 **Round Tube & Pipe**


24" Sched. 80 Pipe

22 **Round Bar**


All Mill Produced Sizes

We also roll stair stringers, helical hand rails, off-axis bends, formed shapes and extrusions.

Visit cmrp.com for more information.

CHICAGO METAL ROLLED PRODUCTS COMPANY

CHICAGO • KANSAS CITY

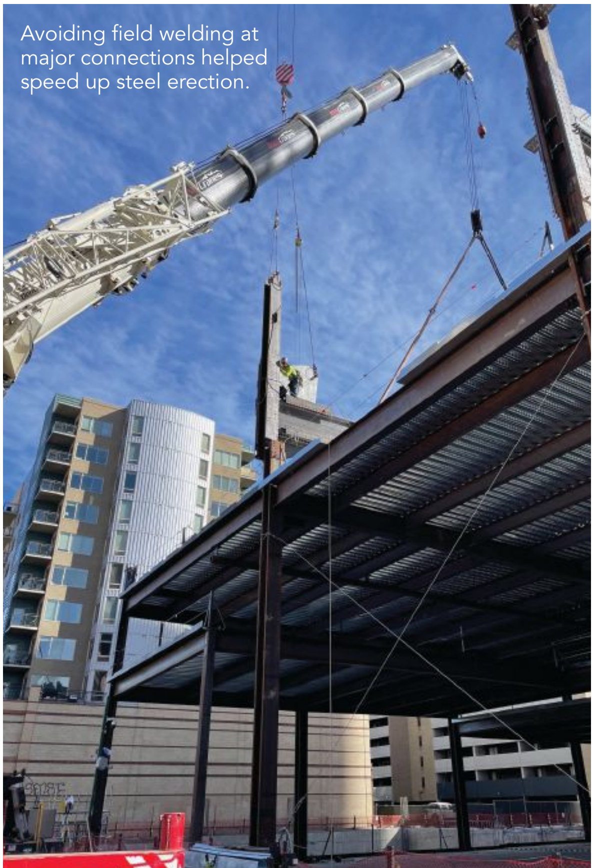
AISC ASSOCIATE

NOMMA

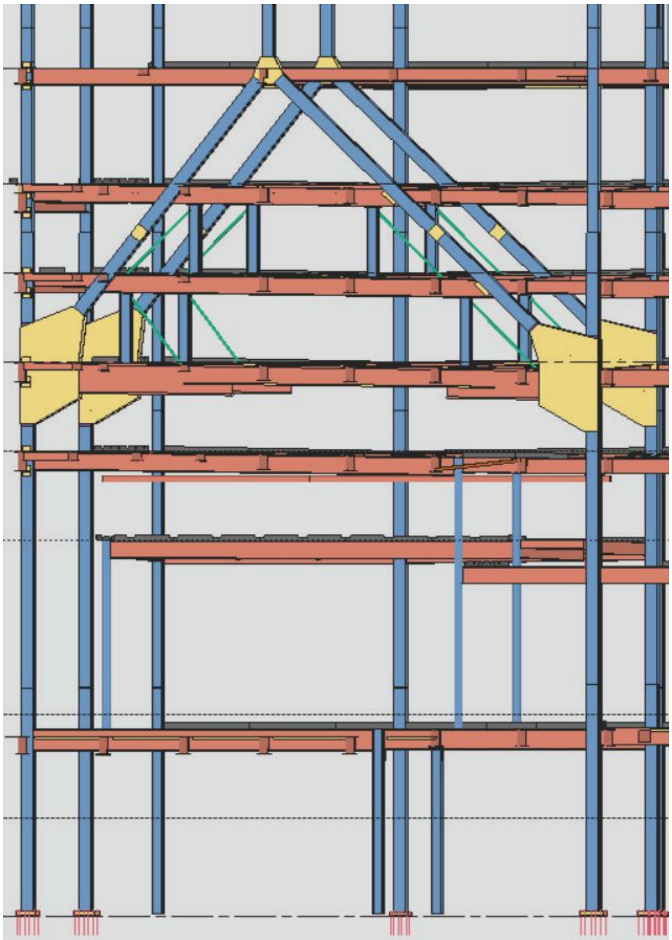
SMA

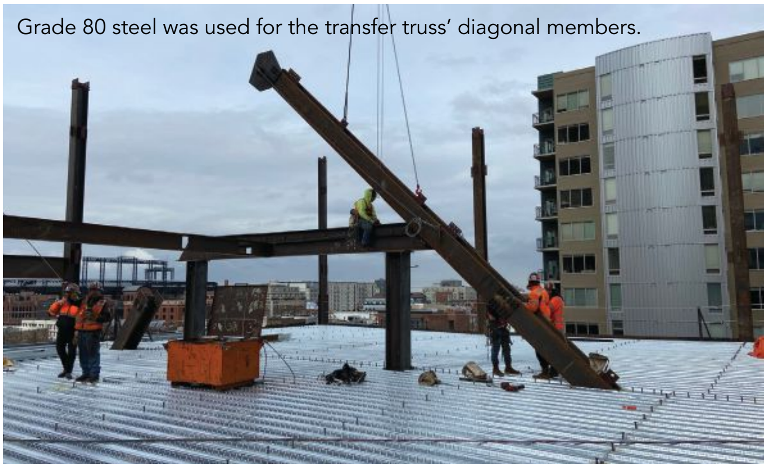
Lifting the bottom chord of the transfer truss.

A notched W40 girder was used to improve clearance in the parking garage.


Avoiding field welding at major connections helped speed up steel erection.


Cantilevered framing was used to create the ten terraces that extend from the building's façade at the southeast, southwest, and northwest corners.


A 3D model highlighting the three-story transfer truss that opens up column-free space at ground level.


Grade 80 steel was used for the transfer truss' diagonal members.


Steel framing supports the below-grade parking garage.

What grades of steel were used for the project? I understand that there was more than just 50-ksi. And was the higher-strength steel generally limited to the columns?

Chmielowski: MKA used higher-strength steel (greater than 50-ksi) for most columns to reduce project tonnage. Early collaboration with and feedback from Puma and their material suppliers determined which grade of steel was used for various sizes of columns since, due to material availability, not all sizes are produced in higher grades. In a first for Denver, A913 Grade 80 was used for columns W14×159 and larger. Columns ranging from W14×90 to W14×145 used A913 Grade 65, and columns smaller than W14×90 used conventional A992 Grade 50. Going with higher-strength steel required less fabrication and saved 275 tons of total steel for the columns.

Can you talk about the transfer truss details?

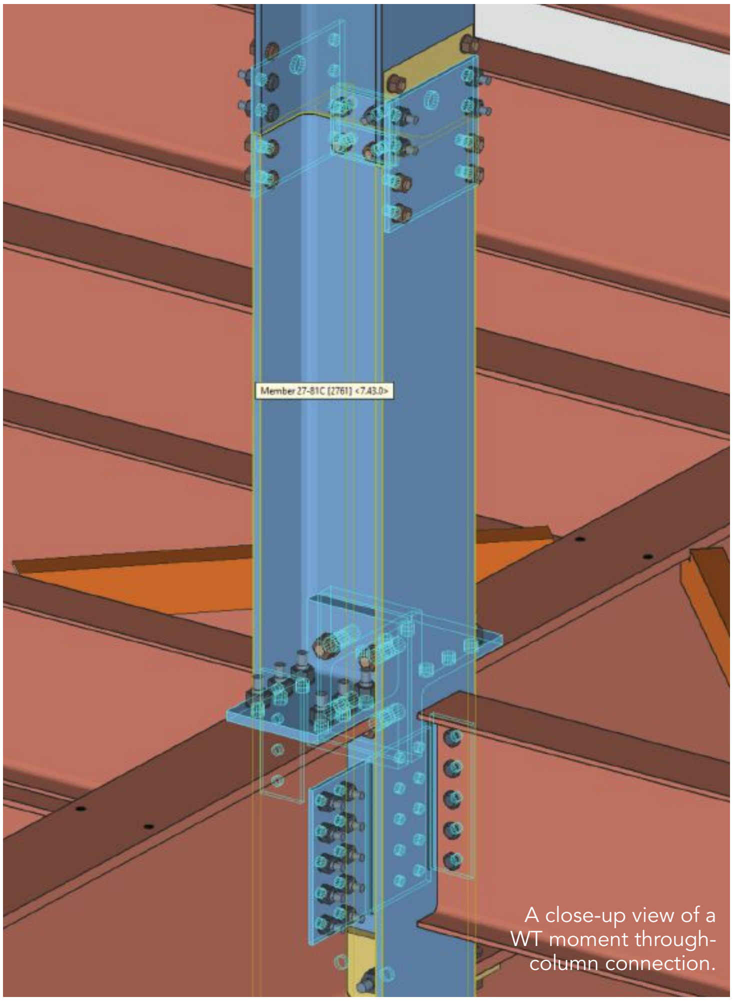
Chmielowski: The transfer trusses are three stories deep and span 66 ft. Each truss supports the force from the base of a tower column. Because the columns are located on the building face, controlling the deflection of the trusses became an important design consideration since excessive column displacement could impact the building façade above. The trusses used standard wide-flange sections (W40×392 for the bottom chords and W14×500 Grade 80 for the diagonals) oriented to simplify the connections.

The transfer trusses improved the openness of the plaza at the ground level and made circulation at the parking garage more efficient. The notched bottom chord alleviated a low head height condition without having to adjust floor-to-floor height at the level under the transfer truss.

What was the thought behind the concrete deck on the steel columns in the lower levels of the garage?

Chmielowski: This is an interesting component of the project. The owner wanted to construct the below-grade parking levels in concrete. A normal construction sequence would involve constructing the below-grade levels before proceeding with the steel framing for the above-grade tower. In other words, cast the concrete columns atop the foundations, then cast the elevated concrete slab, then cast the next lift of columns.

In this sequence, tower construction cannot begin until the below-grade levels are complete. Rather than incur the schedule impacts of this conventional sequence, the project team used an "up-up" construction sequence, which allowed the below-grade levels *and* the tower to be constructed simultaneously. Once the foundations were complete, two-story steel columns were erected to support steel framing at the ground level. Once the ground-level steel was erected, the steel tower could proceed normally. At the same time, the steel columns below grade were encased in concrete, which later would support the cast-in-place elevated parking slab. This sequence saved six weeks of construction time.



A close-up view of a WT moment through-column connection.


The building is located in the northwest portion of downtown, close to Union Station, Coors Field, and the River North Art District.

I noticed a lot of beam penetrations when touring the building. What went into that design choice?

Chmielowski: Beam web penetrations through the W30 girders keep the MEP systems within the beam pocket, which minimized the floor-to-floor height and reduced curtainwall costs.

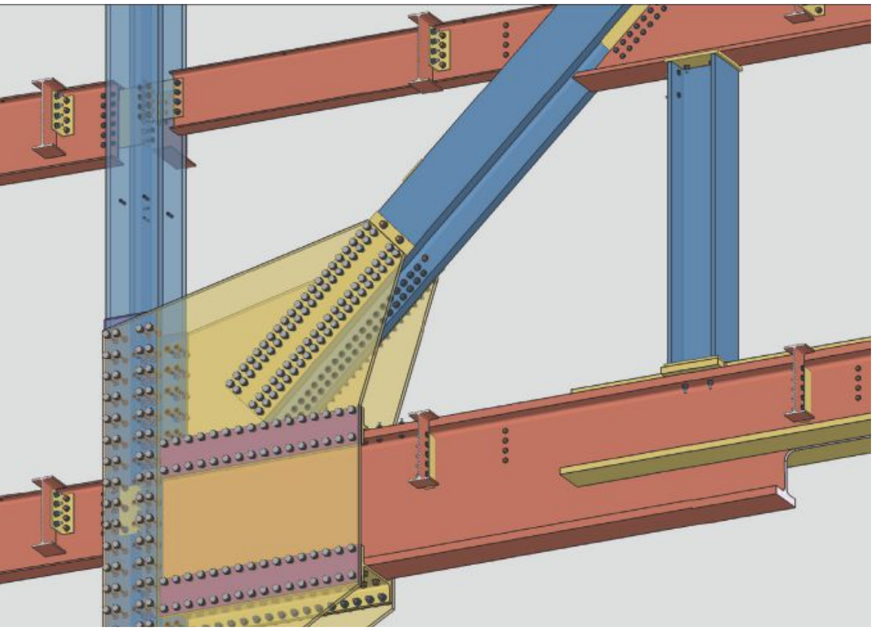
Patrick McManus, Martin/Martin: While MEP systems were generally located below the typical W18 filler beams, haunches in many beams were necessary to maintain the lower floor-to-floor height.

What was connection design like on a project like this, especially when it came to the jumbo sections?

McManus: Puma is a highly automated shop with a general preference toward shop bolting. However, connecting to jumbo sections warrants unique considerations over a simple decision of welding versus bolting. Once Puma became involved, Martin/Martin was immediately engaged because of their intimate knowledge of Puma's practices and preferences through a longstanding relationship. Martin/Martin and Puma worked to develop connection concepts for the most typical connections on the project and the most critical unique connections, such as for the transfer trusses and stepped moment connections. The key connection criteria included:

- Avoid field welding at major connections, which facilitated the speed of erection and allowed for reduced cost
- Avoid complete-joint-penetration (CJP) welds in the shop or field, which eliminated the need for ultrasonic testing (UT) and avoided the need for Charpy V-notch testing of the columns
- Keep welding relegated to the columns, which helped facilitate fit-up to the flanges of the jumbo columns (mitigates flange tilt as an issue) and created a desirable mix of work in the shop. The A913 steel used on this project did not require preheat for flanges greater than 2 in. thick and facilitated this approach to connection design at all levels throughout the structure

In an early predesign meeting, MKA and Martin/Martin came to the table fully prepared. We collaborated effectively to establish a complete understanding of connection criteria (including integrity requirements), agreed on connection concepts to achieve those criteria, and made framing adjustments to facilitate those concepts (such as rotating certain columns). MKA then took the initiative to bring those concepts to the architectural team soon after the collaborative meeting to verify geometries were acceptable, thereby avoiding coordination issues later in the project. One transfer truss connection in particular, which involved orthogonal bolted moment connections, really illustrated the effectiveness of this collaborative effort.

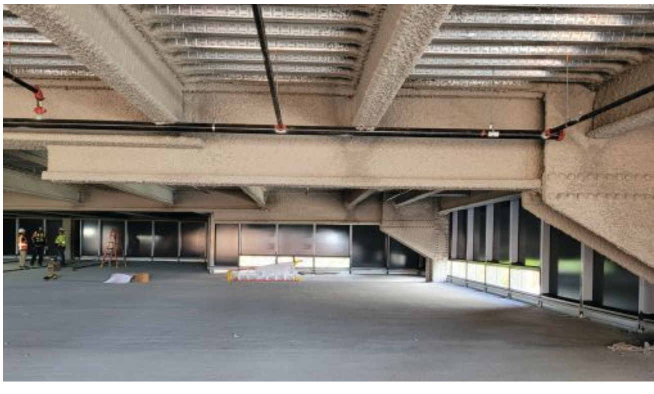


above: A model of the transfer truss connections.

below: The actual bolted connections.

below: The construction team took advantage of an emply street adjacent to the project for crane staging and material delivery and laydown.

above and below: Two views of the cut-out portion of the transfer truss, which was designed to alleviate a low head height condition without having to adjust the floor-to-floor height at the level under the transfer truss.



The space between two buildings to the north of 1900 Lawrence staged the crawler crane. Was it also used for material laydown? That seems like a great situation in a downtown area.

Chmielowski: Since the podium to the (plan) north was off the critical path for the project, its construction could lag compared to the tower. Thus, once the ground level was complete, it could be used for deliveries, laydown, and shakeout, which is highly valuable in tight downtown sites.

Were all connections shop-bolted (i.e., no field welding)?

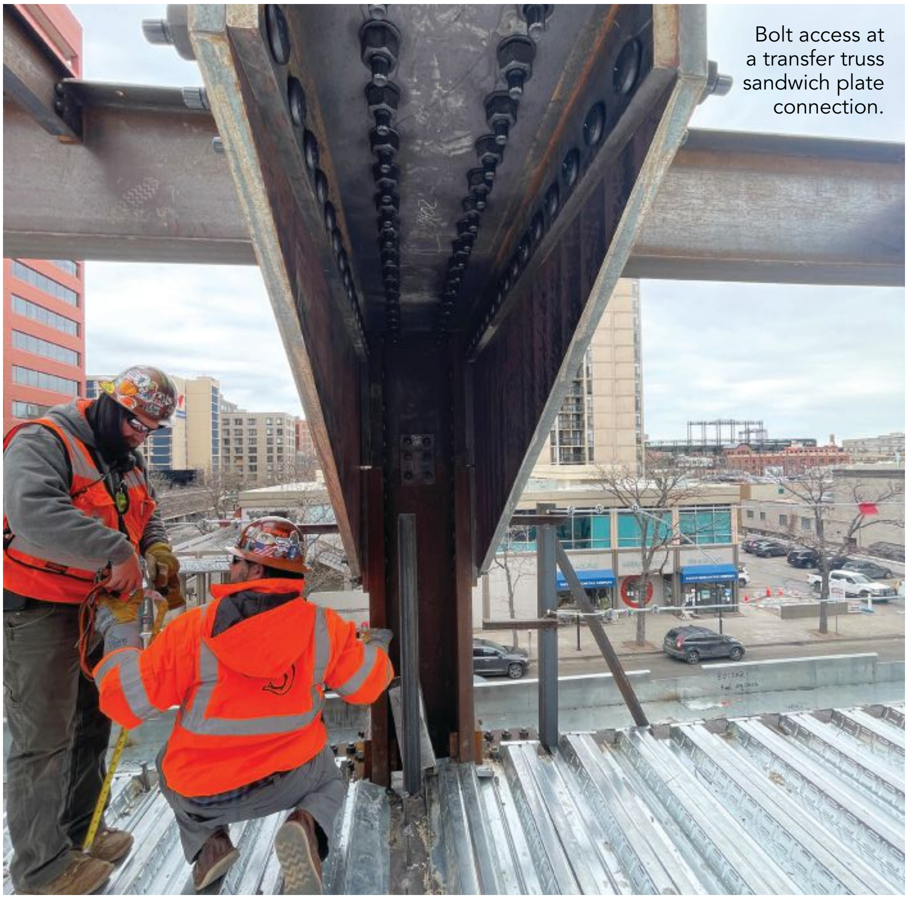
McManus: Shop-bolted extended bent plate connections were used for beam-to-girder connections, and shop-welded single-plate connections were used to connect beam webs to columns. Shop-bolted WTs were used at the beam flanges of most moment connections, except stepped connections where shop-welded flange plates were used at the top flange and shop-bolted WTs at the bottom flange.

At typical cantilevers through columns, the columns were rotated such that the connections could be made to the column web, thereby eliminating the need for continuity plates. In situations where connections were made to the column flanges, a bolted continuity plate was created by welding the stems of two WT sections. Transfer truss connections were shop-bolted, and using these connections avoided field welding at all steel-to-steel connections. The only field-welded connections were at the beam-to-concrete core connections, which was necessary to handle the axial loading and relatively high shear demands in shallow connections at several locations.

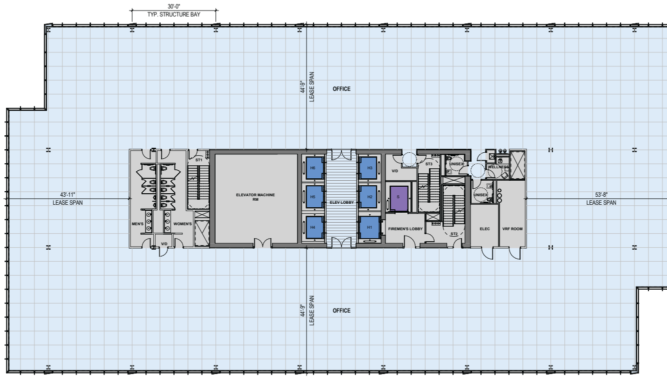
This project involved a lot of collaboration with the engineer and others. When was early collaboration particularly beneficial?

McManus: Much of what made 1900 Lawrence successful was that the experienced design and development team and the experienced steel construction and specialty design team came together with open minds and a true willingness to collaborate effectively.

Chmielowski: The up-up construction sequence required careful coordination between the design and construction teams. Because the below-grade steel columns were left unbraced for two stories until the elevated parking slab was constructed, the design team checked the column designs for a temporary condition with a two-story



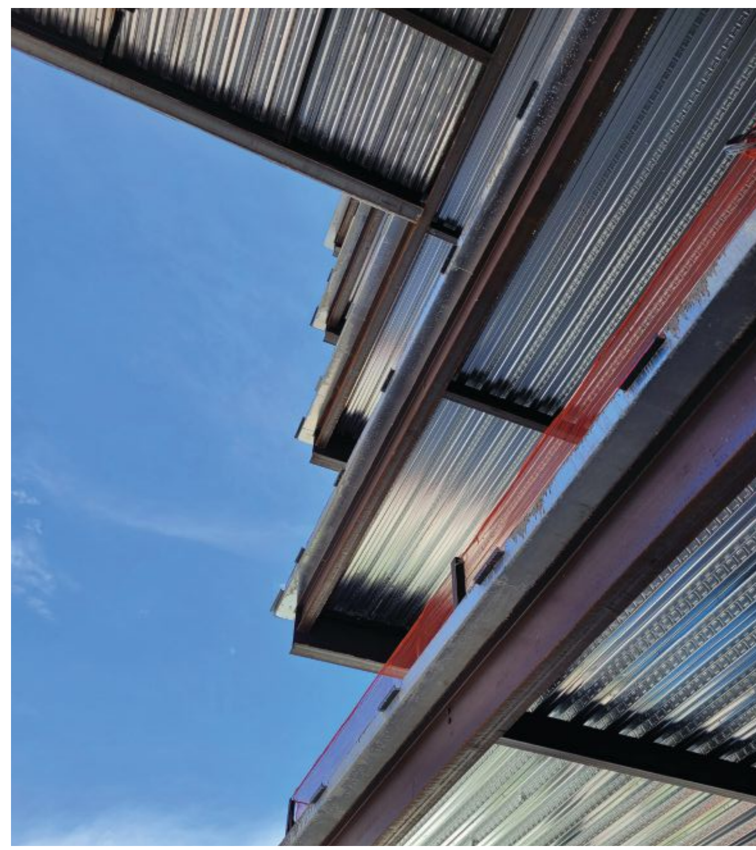
Bolt access at a transfer truss sandwich plate connection.



above: A floor plan of Level 21, a "six-corner" level.

left: Each office floor features 30-ft bay spacing and a 44-ft column-free stretch between the core and exterior on all sides.

below: The building has six corner opportunities on multiple floors due to "cut-outs" at two corners of the building.



below: Steel framing attaching to the concrete core.

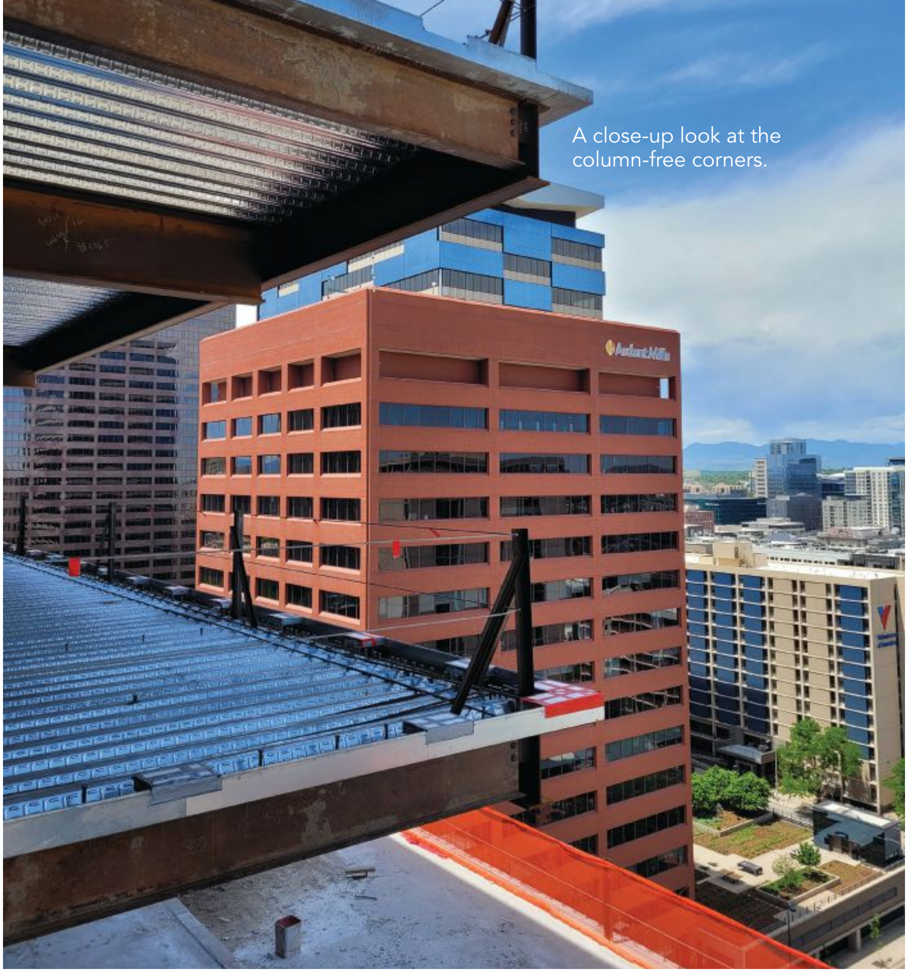
unbraced length but without the full design load, and the final condition with a single-story unbraced length with the full design load. Understanding HP's construction schedule was critical for this exercise.

The design of the columns for various material grades to provide an economical column design required coordination with and buy-in from Puma Steel.

Before construction, MKA and HP worked together to develop a structural movement monitoring plan that was implemented during construction. During construction, the top of column elevations were surveyed after each tier. MKA compared the survey to the expected elevations from our analysis based on the progress of construction and advised if any corrective action was needed prior to the placement of the next tier of columns. The team worked together to share data in real time, with MKA responding to the column surveys within hours.

Lewis: MKA's expected elevations analysis, along with fab and erection tolerance, were spot on. Zero columns had to be modified for any elevation issues.

Chmielowski: Soon after Puma was selected, MKA collaborated with them on several items that improved the fabrication and connection efficiencies. MKA reoriented tower columns to work more efficiently with Puma and steel erector Total Welding's preferred field moment connection detail. They strategically added two beams per floor to match the deck supplier's preferred decking layout and optimized the deck design. At



A close-up look at the column-free corners.

The building topped out in September.

the time, due to pandemic-related supply chain issues, decking costs and lead times increased dramatically. Adding two beams per floor to address decking supply-chain nuances netted cost savings to the project. ■

Owner
Riverside Investment and Development

General Contractor
Hensel Phelps

Architect
Goettsch Partners

Structural Engineer
Magnusson Klemencic Associates

Connection Engineer
Martin/Martin

Steel Team

Structural Fabricator and Detailer
Puma Steel (AISC Certified Fabricator), Cheyenne, Wyo.

Stair Fabricator
Pacific Stair Corporation (AISC Certified Fabricator), Salem, Ore.

Erector
Total Welding, Inc. (AISC Associate, AISC Certified Erector), Bennett, Colo.

Geoff Weisenberger (**weisenberger@aisc.org**) is editor and publisher of *Modern Steel Construction*.

Rob Chmielowski (**rchmielowski@mka.com**) is a Senior Principal with Magnusson Klemencic Associates. **Patrick McManus** (**pmcmanus@martinmartin.com**) is a Principal with Martin/Martin. **Wade Lewis** (**wade.lewis@pumasteel.com**) is a Vice President with Puma Steel.