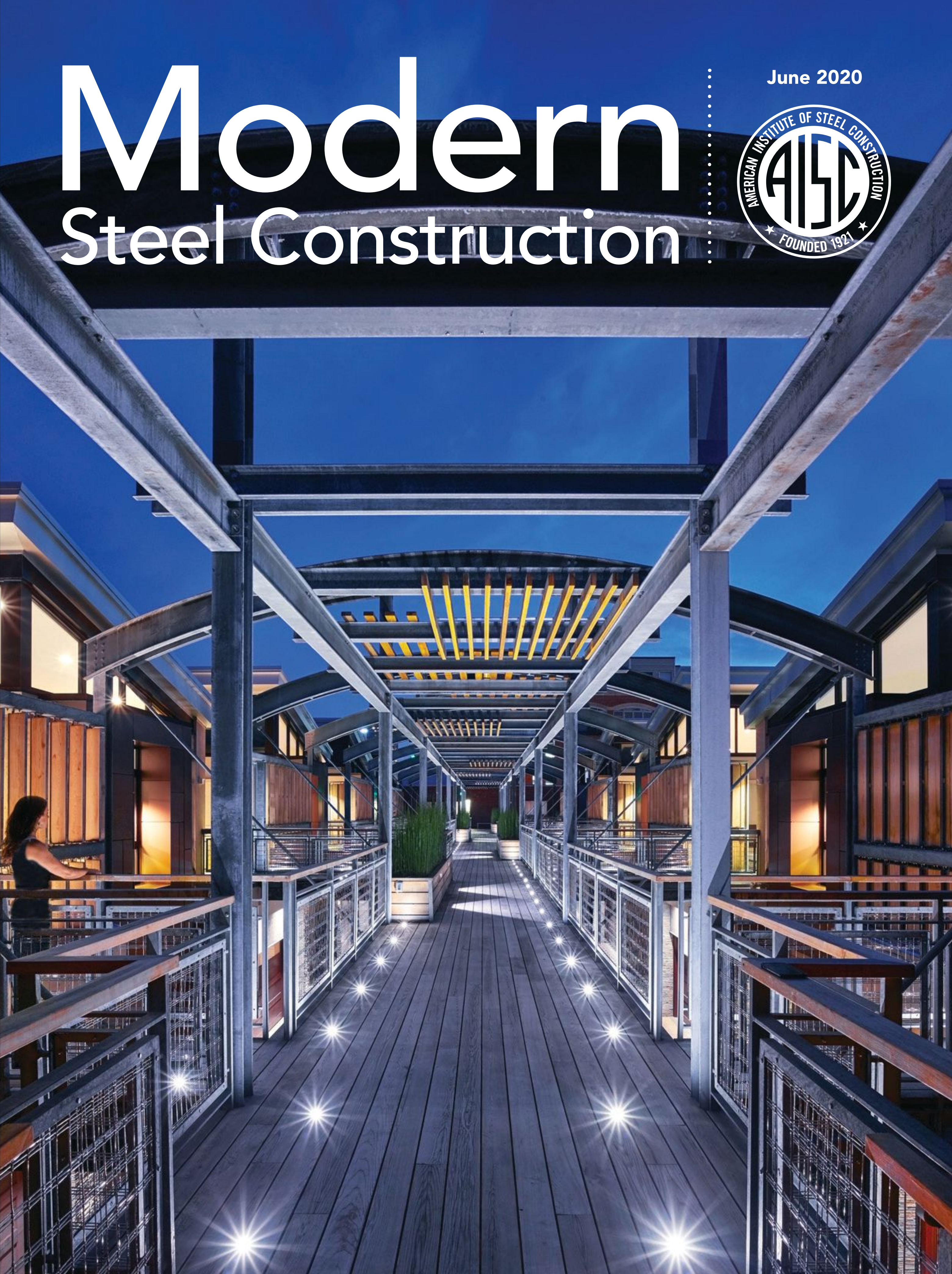
Modern Steel Construction

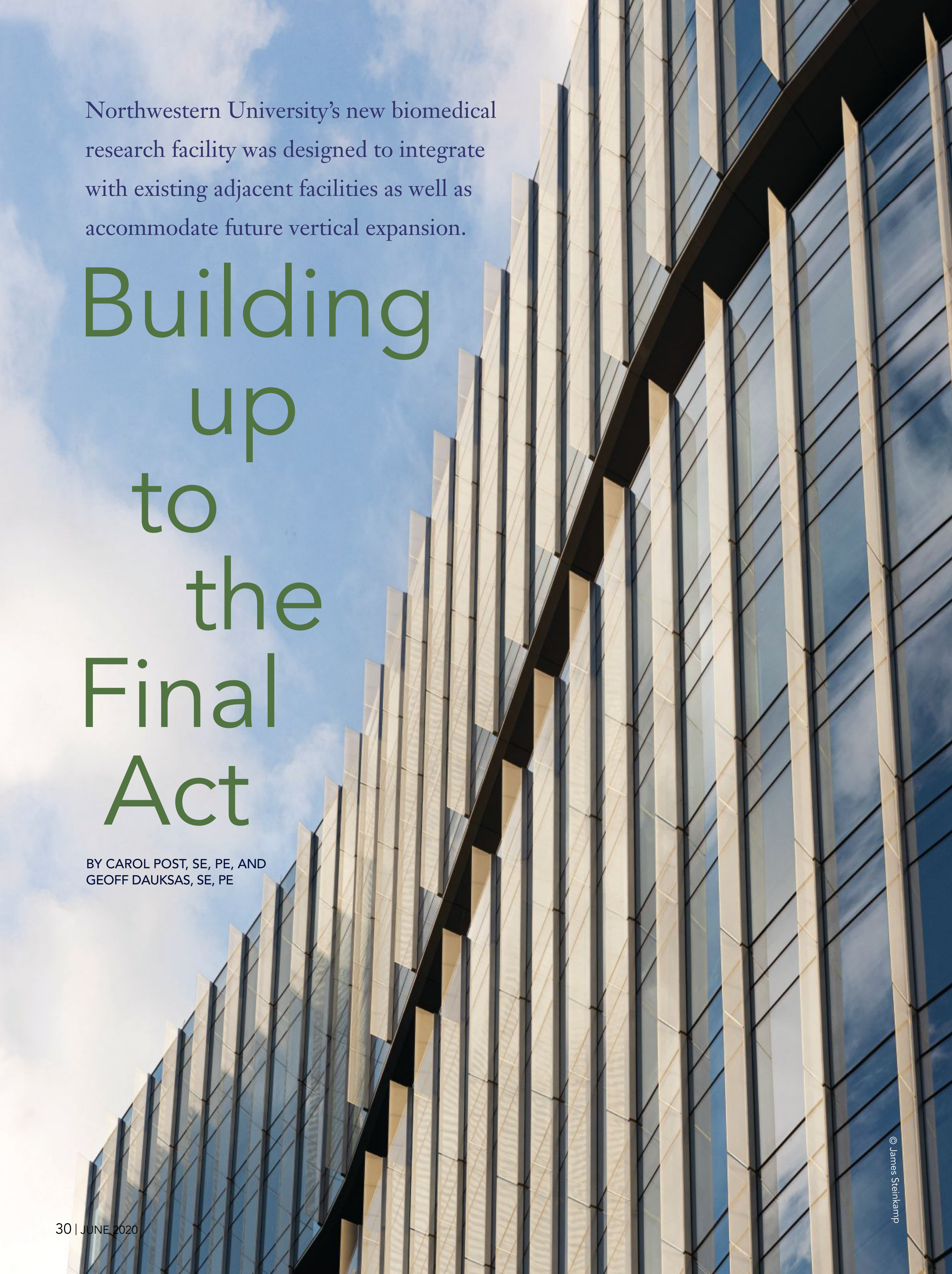
June 2020



Northwestern University's new biomedical research facility was designed to integrate with existing adjacent facilities as well as accommodate future vertical expansion.

Building up to the Final Act

BY CAROL POST, SE, PE, AND GEOFF DAUKSAS, SE, PE



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opposite page and below: From the beginning, the Louis A. Simpson and Kimberly K. Querrey Biomedical Research Center (SQBRC) was designed with expansion in mind. Phase 2 (which currently has no set time frame) will eventually take the 320-ft-tall tower to 600 ft.

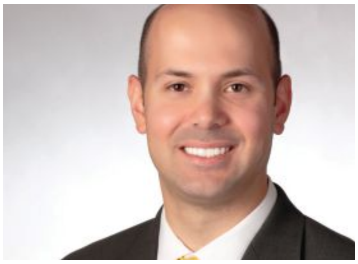
NORTHWESTERN UNIVERSITY is boosting its research profile higher than ever.

Its new 14-story, 320-ft-tall Louis A. Simpson and Kimberly K. Querrey Biomedical Research Center (SQBRC) was designed to serve as a hub for the university's downtown Chicago medical-academic district and is sculpted to fit seamlessly within the existing research campus.

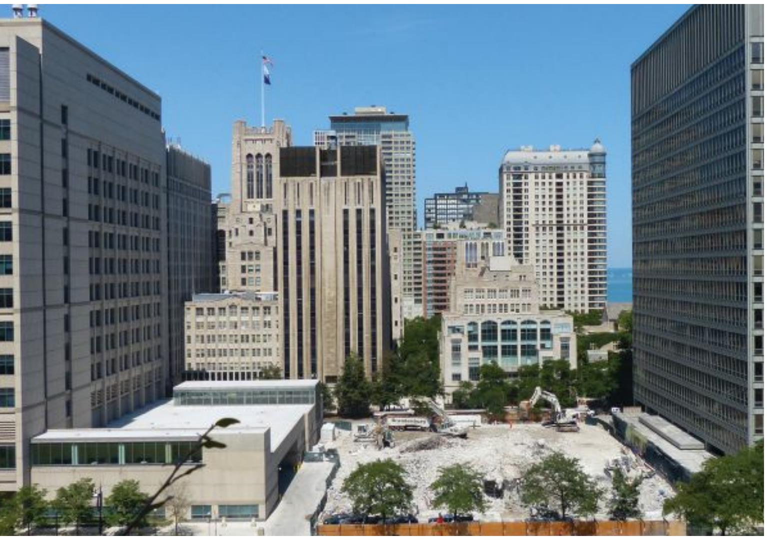
From the beginning, it was planned with future expansion in mind. The 14-story building, consisting of 624,000 sq. ft of space, is phase one, which opened last year. Phase two will eventually take the building 280 ft higher to 600 ft tall, adding 600,000 sq. ft and making it one of the tallest laboratory buildings in the world. And it was obvious that only steel could accomplish this future flexibility.

The new building is located on a site previously occupied by a large hospital and partially above the adjacent Ann and Robert H. Lurie Biomedical Research Building (Lurie), an existing lab building. The original design of Lurie included a planned vertical expansion above the level 2 podium, and SQBRC takes advantage of the structural capacity that was built into Lurie. However, the portion of SQBRC built above Lurie, comprising 100,000 sq. ft, is significantly different from the planned design. The new research center has a different architectural module, column grid, and a curved northern profile to avoid blocking light into the existing Lurie labs. As a result of these modifications, the new column locations did not align with the existing columns or deep foundations. These offsets drove the need for column transfers to allow for the new lab above with the existing column locations.

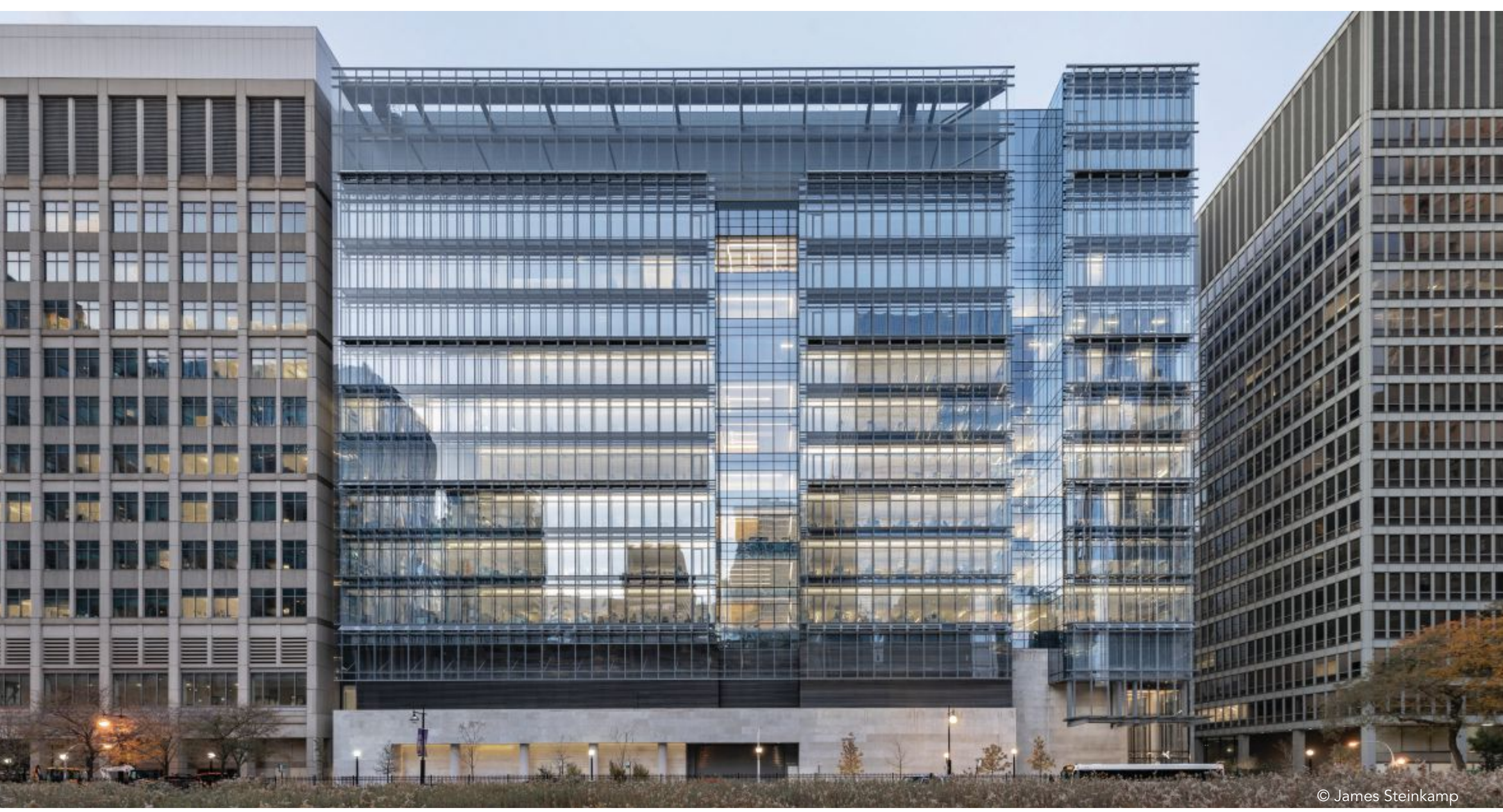
Structural engineer Thornton Tomasetti designed a series of steel plate girders and transfer trusses, weighing approximately 365 tons, to accommodate the desired laboratory layouts. Several of the transfers occur at the newly constructed third level. However, due to the existing column and braced frame layout, not all of the transfers could take place above the existing building, so areas of the second level had to be



Carol Post (**cpost@thorntontomasetti.com**) is chief quality assurance officer and **Geoff Dauksas** (**gdauksas@thorntontomasetti.com**) is a senior associate, both with Thornton Tomasetti in Chicago.

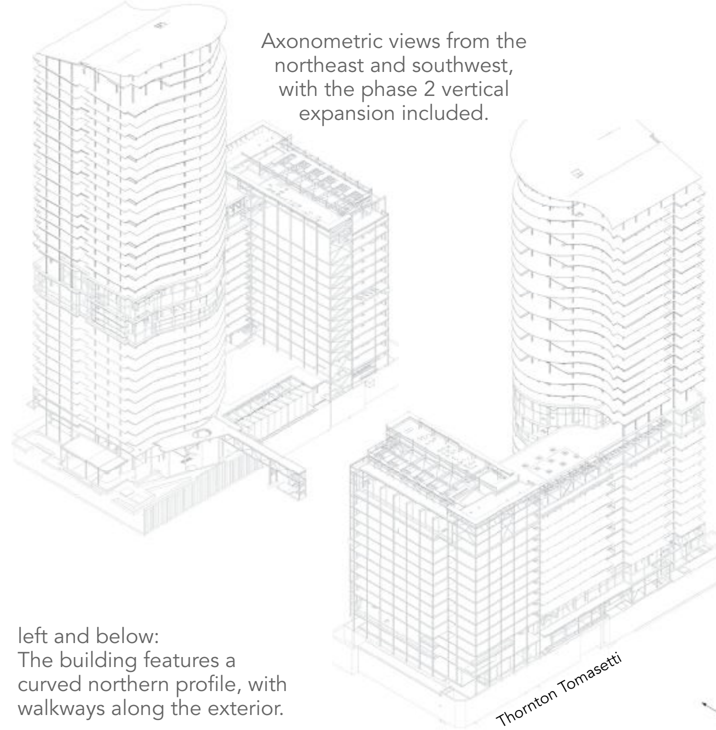


Construction progress from start of construction to near completion of the steel framing to the completed and open tower. The new building is located on a site previously occupied by a large hospital and partially above the adjacent Ann and Robert H. Lurie Biomedical Research Building, an existing lab facility.



removed to allow for the new transfers at level 2. Extensive coordination between Thornton Tomasetti, general contractor Power Construction, steel fabricator Zalk Josephs Fabricators, and erector Chicago Steel was necessary to accommodate the existing conditions at the roof of the existing building. Surveys of the existing Lurie columns were performed to accurately locate them so that the transfer girders and columns splices could account for any as-built variations from the previous construction documents.

Approximately 500,000 sq. ft of SQBRC phase 1 is located adjacent to Lurie on a site that was previously occupied by a large hospital. The hospital was demolished above grade, but the basement and deep foundations remained. As a result of this existing condition, new deep foundation elements had to be strategically located to avoid the existing belled caissons. This forced new caisson locations that did not align with the column grid, making it necessary to use deep grade beams to transfer the vertical load to new caissons. The new building has a two-story, 38-ft-deep basement with levels that are purposely aligned with the existing floor levels of the Lurie building, so that eight doorways could be cut through the existing foundation wall to combine the two basements into one unified space.



Axonometric views from the northeast and southwest, with the phase 2 vertical expansion included.

Thornton Tomasetti

left and below:
The building features a curved northern profile, with walkways along the exterior.

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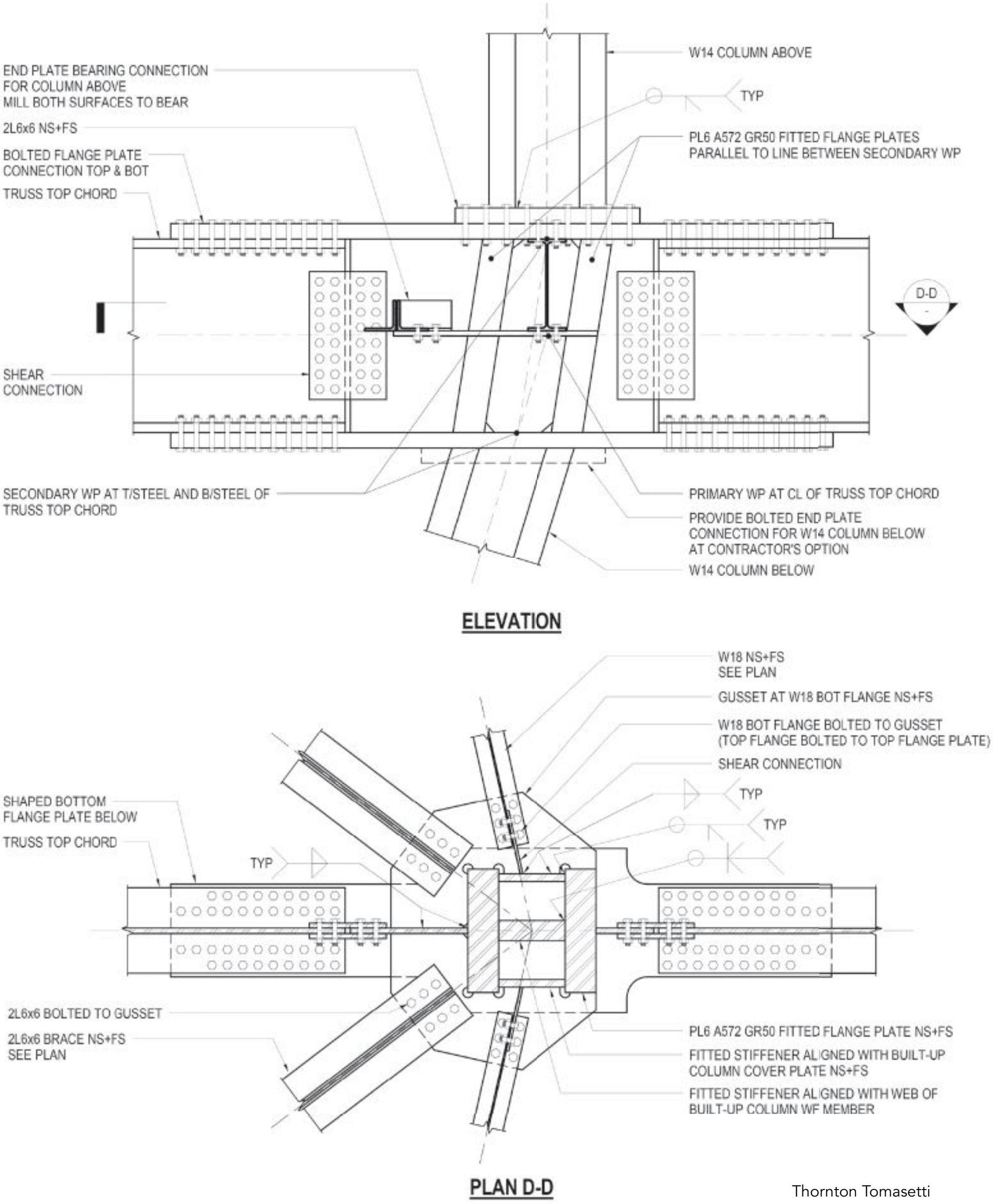
The tower consists of 14 stories of steel framing. Steel columns range from cover-plated W14×873 at the base to W14×68 for columns that do not extend into phase 2. Cantilevers are typically W30 or W36 for the larger conditions, internal girders are typically W24 or W27, and beams range in size depending on the vibration criteria. Like the basement levels, these new levels also align with the levels of the existing Lurie building to allow for a connection at each floor. Two concrete cores provide the lateral stiffness for the new tower, and high-strength, 65-ksi steel columns were implemented to minimize the column dimensions and reduce the need for cover plating. Between the ground level and the first labs at level 3, three one-story deep steel trusses (made up of shapes ranging from W14×159 to W14×426) were needed to transfer the columns from their locations at the lab levels to locations required by the lobby and loading dock functions. In anticipation of the second phase, multiple "future-use" details were designed—particularly at the top of the columns and shear walls just above the first phase roof—for future crane foundations and anticipated crane tie-in locations to minimize interruptions of the occupants when the second phase is constructed.

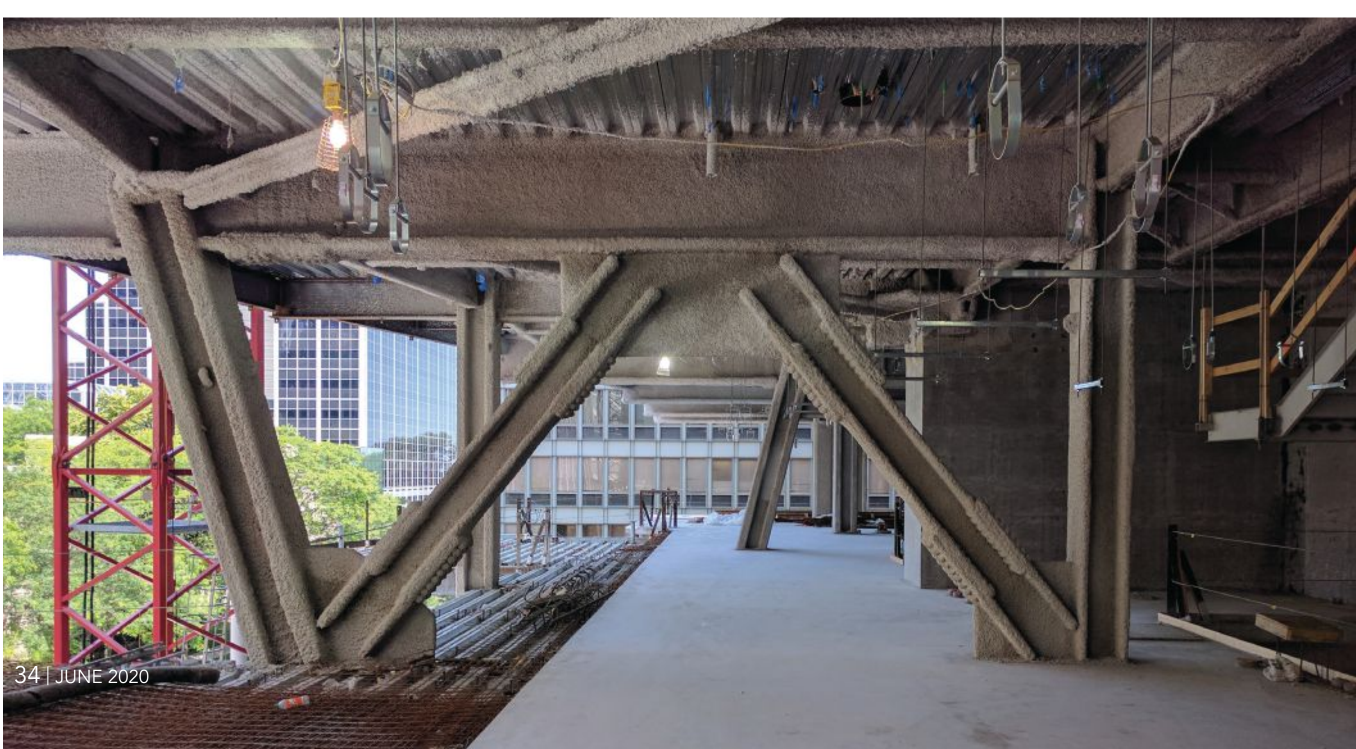


Thornton Tomasetti

above and below: Thornton Tomasetti designed a series of steel plate girders and transfer trusses, weighing approximately 365 tons, to accommodate the desired laboratory layouts.

The architectural vision for the south elevation consisted of a column-free space with a double-skin glass façade to let in natural light and provide a glimpse of the research that is going on inside. The typical framing along the south façade consisted of 14-ft cantilevers to the south to support the façade, while the northern façade incorporates cantilevers ranging from 10 ft to 21 ft. To help with field erection of these large cantilevers, Zalk Josephs proposed interrupting the steel columns and running the beams through the beam-column joint at each level, which also helped to reduce the number of field moment connections. The exterior wall weight, anticipated vertical movement, and slab connection detailing were coordinated and documented prior to bid to allow for efficient framing sizes, and the impacts on the ceiling heights and structural profile at the slab edge were also minimized thanks to the team detailing the cantilevered framing with coped ends.

In addition to the planned vertical expansion, considerations for the expansion joints between SQBRC and Lurie also needed to be addressed. Thornton Tomasetti collaborated with wind tunnel consultant RWDI to minimize the expansion joint size by carefully reviewing wind tunnel



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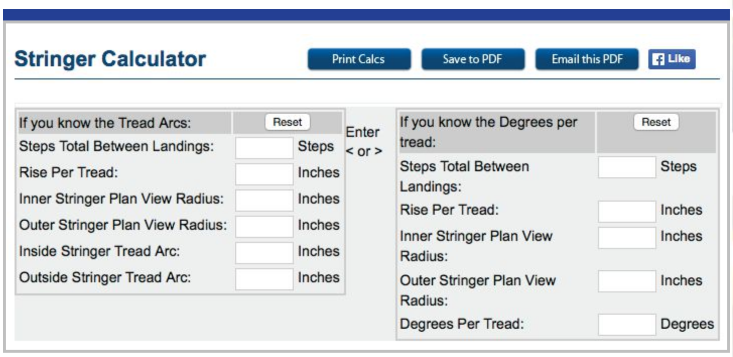

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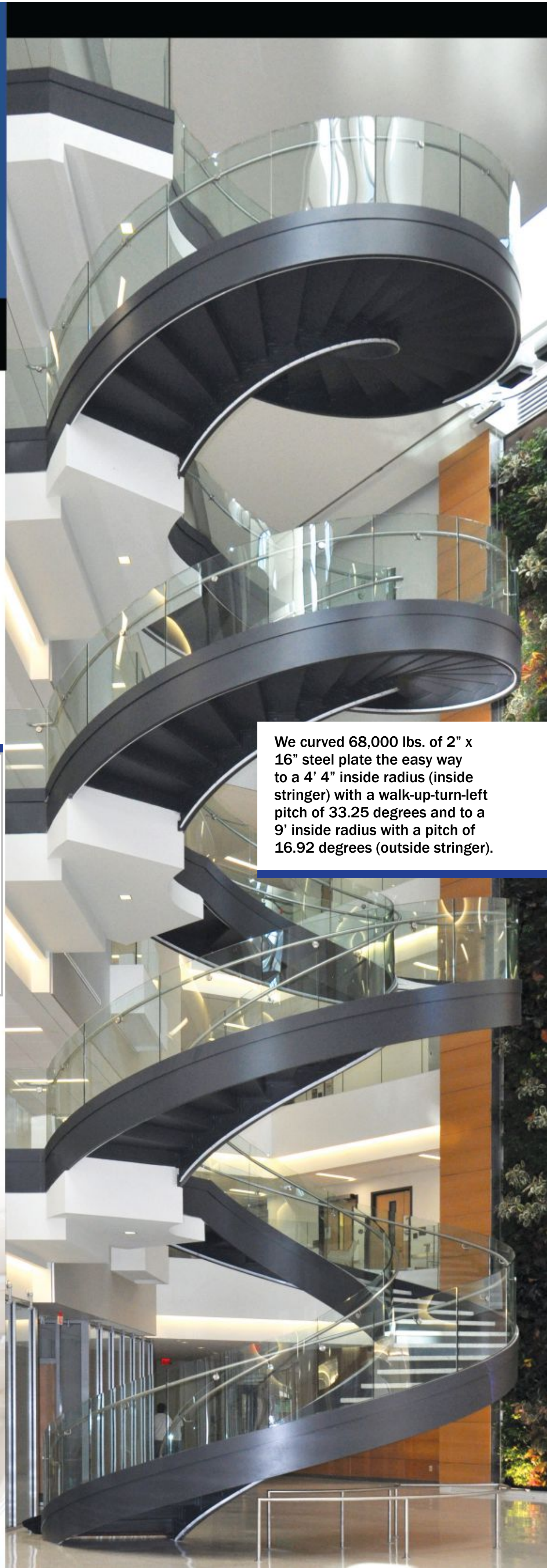

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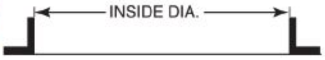
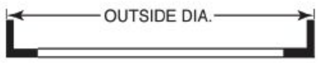


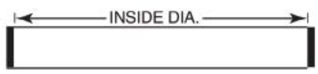
10" x 10" x 1" Angle

2 Angle Leg In


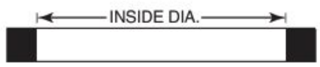
10" x 10" x 1" Angle

3 Flat Bar The Hard Way

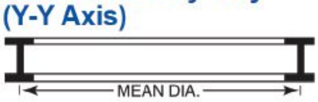

24" x 12" Flat

4 Flat Bar The Easy Way


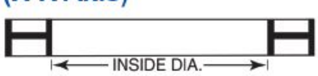
36" x 12" Flat

5 Square Bar


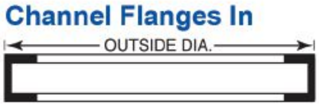
18" Square

6 Beam The Easy Way (Y-Y Axis)


44" x 335#, 36" x 925#

7 Beam The Hard Way (X-X Axis)


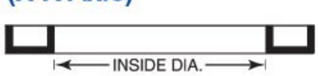
44" x 285#

8 Channel Flanges In


All Sizes

9 Channel Flanges Out


All Sizes

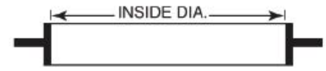
10 Channel The Hard Way (X-X Axis)


All Sizes

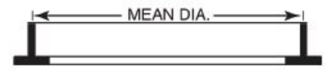
11 Tee Stem In


22" x 142 $^1/_2$# Tee

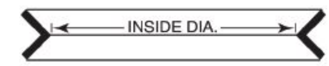
We bend ALL sizes up to:

12 Tee Stem Out


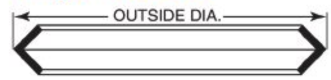
22" x 142 $^1/_2$# Tee

13 Tee Stem Up


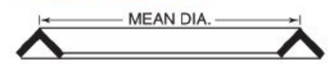
22" x 142 $^1/_2$# Tee

14 Angle Heel In


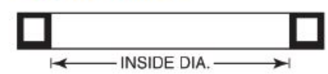
8" x 8" x 1" Angle

15 Angle Heel Out


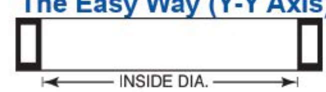
8" x 8" x 1" Angle

16 Angle Heel Up


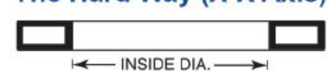
8" x 8"x1" Angle

17 Square Tube


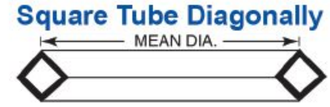
24" x $^1/_2$" Tube

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


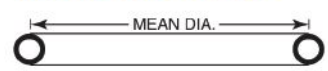
20" x 12" x $^5/_8$" Tube

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


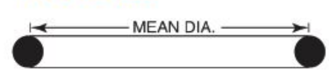
20" x 12" x $^5/_8$" Tube

20 Square Tube Diagonally


12" x $^5/_8$" Square Tube

21 Round Tube & Pipe


24" Sched. 80 Pipe

22 Round Bar


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recommendations and comparing them with the results from the analytical models. Equally important was the collaboration between Thornton Tomasetti and architect Perkins+Will, which resulted in revising an expansion joint location so as to minimize its impact on the building's architecture.

As with most higher education research facilities, vibration considerations needed to be addressed, particularly in the laboratory spaces. Steel framing was analyzed using methods from AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (available at **aisc.org/dg**) as well as finite element models, with RWDI performing vibration analysis and Thornton Tomasetti verifying and fine-tuning the results.

While steel provided the best solution for both phase 1 and the anticipated phase 2, it also added artistic value. Prominent exposed steel spaces, designated as architecturally exposed structural steel (AESS), include a pedestrian bridge, multiple monumental staircases, and a glass "fly-by" parapet. The long-span pedestrian bridge is formed by two steel trusses extending north from SQBRC over Superior Avenue to provide a direct connection to the existing Searle Medical Research Building. To avoid affecting the Searle Building's foundations, the bridge incorporates a 53-ft cantilever at its northern tip. In

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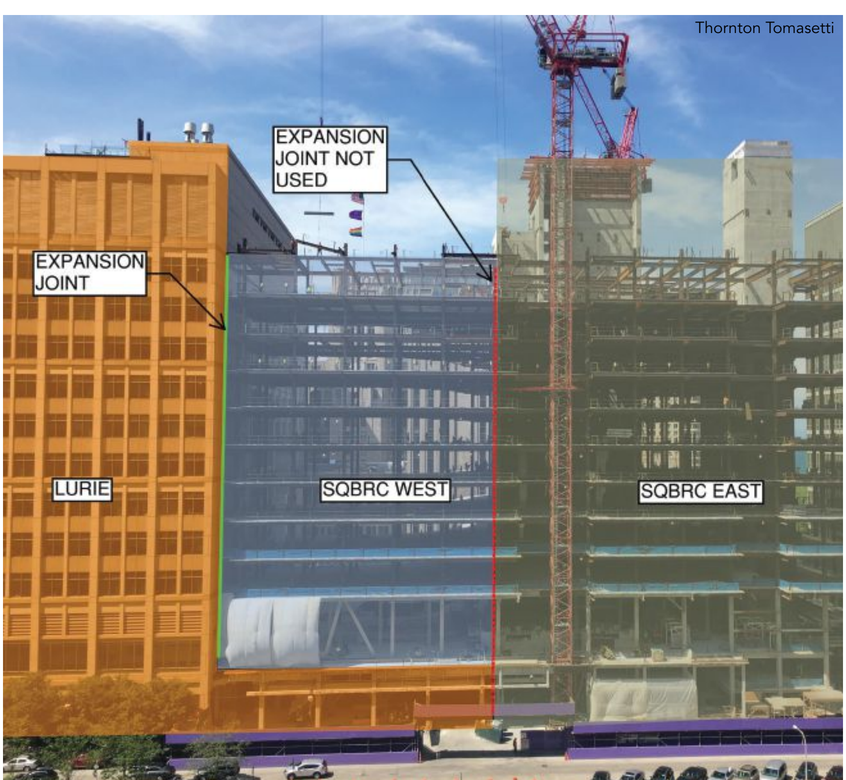
above: The project used approximately 7,500 tons of structural steel.

below: Assembling kinked columns at Zalk Josephs' fabrication shop.

Zalk Josephs



Thornton Tomasetti

Expanded Possibility

Perkins+Will's vision for SQBRC was to seamlessly connect the 12-story vertical expansion (SQBRC West) above the existing level 2 podium of Lurie to a new neighboring 14-story building (SQBRC East). Traditionally, engineers would advocate for an expansion joint separating the two buildings to allow for differential movements. In this case, it was a nonstarter since it would add a joint through the exterior façade and require braced frames within the open lab plan. Thornton Tomasetti went beyond the obvious solution and proposed one that would give P+W and Northwestern the façade and lab plan that they wanted. A hard connection ties the SQBRC East lateral system to the existing Lurie building at and below level 2. Above level 2, concrete cores within SQBRC East laterally support SQBRC West. An expansion joint at the preferred architectural location is much less noticeable due to a change in the façade type and allowed the new double-skin curtain wall façade to be joint-free. This also reduced the wind load on the existing Lurie building, as the wind load on SQBRC West is redirected to SQBRC East.