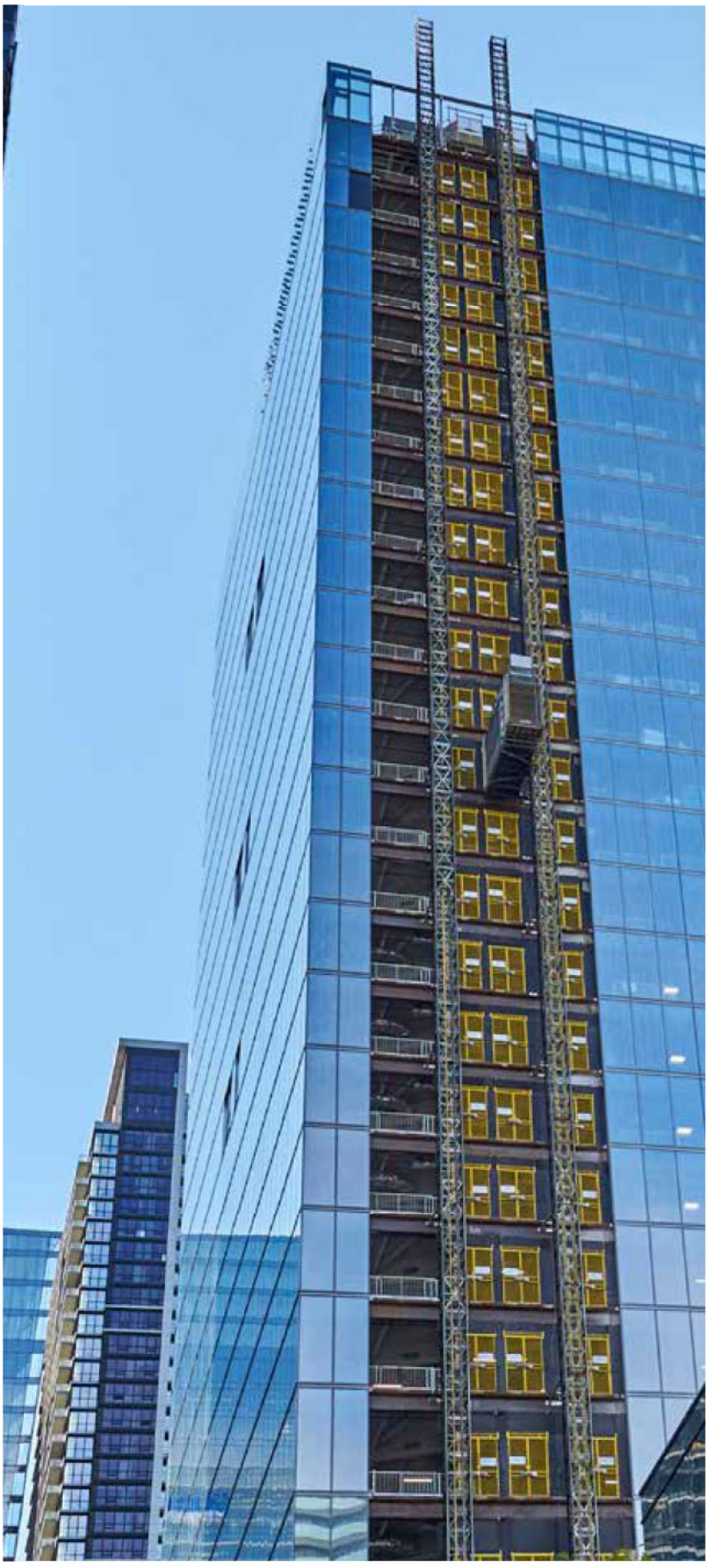
TRIO OF TOWERS RISE HIGH IN TORONTO

Collaborative innovation pushes long-awaited project to the finish line

BY :: JULIA PRESTON AND DON NORMAN

On Bay Street in Toronto, a long-planned high-rise complex is finally complete. The Bay Adelaide Centre, composed of three towers, adds 127 floors of office space to Toronto's financial district.



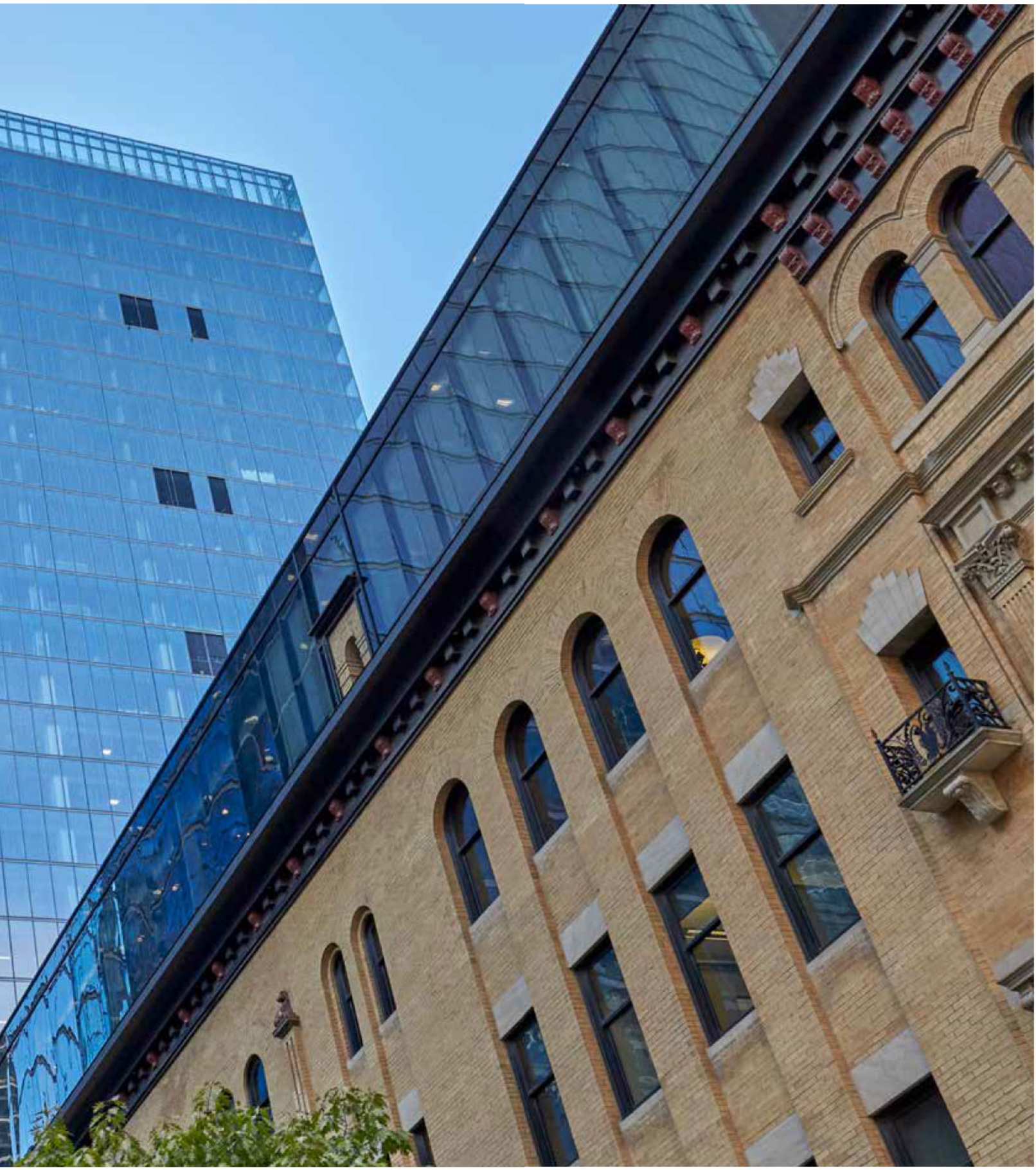
The Bay Adelaide Centre was initially conceived in the 1980s. Construction on a first tower began in 1990 but soon stopped due the recession. Eventually, Brookfield Properties took over the site and in 2005 filed plans to construct three high-rises.

The first tower, Bay Adelaide Centre West, was completed in 2009. This 52-storey tower was the first steel-framed high-rise building to be constructed in Toronto in more than 10 years.

"Going way back to 1987, the original south tower had been a post-tensioned concrete building. There was concern that they wouldn't make the delivery date, so we switched to steel because steel was faster," explains engineer Barry Charnish of Entuitive.

The 44-storey Bay Adelaide East was built in 2016. The final tower, Bay Adelaide North, will be completed this year with 32 floors. All three structures use high-strength sections from ArcelorMittal.

In redesigning the west tower from concrete to steel, Charnish had specified 50 grade steel. However, during the bidding process, the possibility of using TradeARBED HISTAR 65 ksi steel arose.



Look up!
The Bay Adelaide Centre was fabricator Walters Inc.'s first foray into high-rise construction.

"I actually went to Luxembourg to look at the plant. I had a lot of questions about the 65 grade," says Charnish. "We did a lot of study, and it proved to be acceptable to us the way the steel came out. This wasn't done casually."

Bay Adelaide Centre West was the first tower in Canada to use 65 ksi steel.

"65 ksi steel was a huge breakthrough for our industry," says Tim Verhey, Executive Vice President, Engineering & Operations at Walters Inc., the company responsible for the detailing, fabrication and erection of the structural steel framing on all three towers. "That gives you 30 per cent more strength for the same cross-sectional area (compared to 50 ksi steel). Or conversely, you could do the same job with 30 per cent less steel if you look at a vertical tower column, which was a significant advancement that TradeARBED (now ArcelorMittal) brought to the market."

As the Bay Adelaide project progressed, the steel used for each tower continued to blaze the trail in terms of steel quality. Bay Adelaide East was originally designed with A992/350W, and the columns were converted to A913-70. On Bay Adelaide North, which was tendered with A913-65, the columns and transfer struts were converted to A913-80, which was just becoming available.

Ed Lacroix, Vice President of Projects for Walters, explains, "We were working directly with the general contractor to come up with solutions to make the [north] tower buildable… [and] discussing steel options."

At the same time, Walters had been working on a separate project with ArcelorMittal to develop welding procedures for higher-grade materials.

"We went fairly in-depth in terms of developing the procedures, doing the third-party testing, doing an extensive range of testing to make sure that the grade 80 columns were weldable," says Lacroix. "I don't think anyone in the industry had those welding procedures in place, [but] once complete, we knew we could actually perform. Going to the grade 80 material definitely helped to save some cost to the client and gave us a competitive advantage."

Verhey drills down a little further on the importance of the work they did with ArcelorMittal. "For welding, we are required under [CSA Standard] W47.1 to have certified welding procedure specifications, which define the background for our welding processes. Normally, for regular steel fabrication with normal steels, fabricators will have a healthy library of welding procedure data sheets that instruct their welders [on] how to weld different materials together," he explains. "With the higher-strength steels, because they're not widely used, we were developing those welding procedures alongside ArcelorMittal to establish appropriate heat inputs, pre-heat requirements, post-heat, wire-feed speeds, travel speeds, etc., to ensure we could

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complete sound welds predictably that would fall within the W47.1 Quality Management System."

Grade 80 is a high-strength, low-alloy, quenched and self-tempered (QST) steel for structural shapes. The steel is produced from 100-per-cent recycled scrap using an electric arc furnace and a thermo-mechanical rolling process. The rolling and QST process results in a very fine grain material with superior toughness when compared to other structural steels. Grade 80 improves structural efficiency, simplifies fabrication and reduces costs.

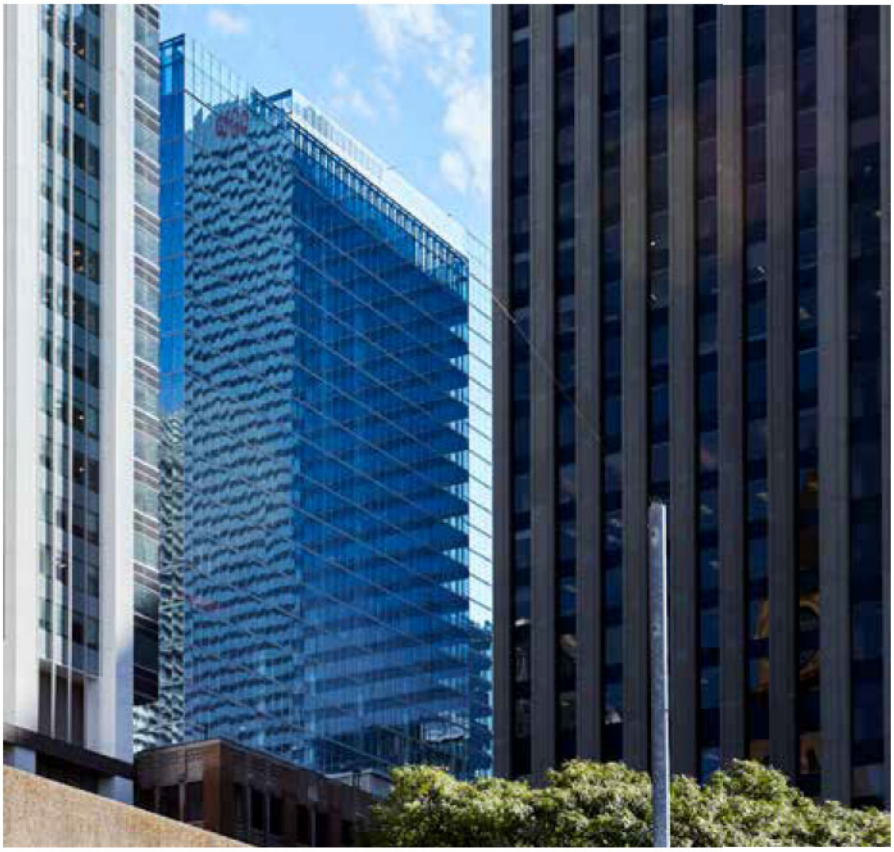
As grade 80 was just coming to market during construction of the north tower, a lower range of section sizes were available. Charnish had to adjust the design to use what was available.

"We wanted to have at least one column with the 80 ksi because we were pushing the technology," he explains. "As soon as we confirmed what we had, we had to design to suit it. If they didn't have the heavier sections and there were only the lighter sections, we pushed it up higher in the tower."

Because higher grades were not available in the full range of column sizes, a small number of columns in all three buildings used lower grades (50 ksi for east and west or 70 ksi for the north). However, the majority were converted to higher-strength steel.

The changing grades required reanalysing the structure to adjust the super elevation. Super elevation describes how concrete and steel settle or compress differently. Usually, the variation is only a couple of millimetres per floor, but the difference is significant when added up over 30 or 50 storeys. On Bay Adelaide, the steel columns were three to six inches taller so, when under the force of thousands of tonnes of structural material, the steel and concrete would eventually compress to the same level at the top of the building. Mixing the grades of steel added another layer of complexity to this calculation.

Interestingly, the Bay Adelaide project was Walters' first foray into high-rise construction. "Sometimes what you don't know can't hurt you," says Verhey. "We weren't saddled with poor practices or legacy history – we had to



come in with open minds to understand how to build high-rise towers with all of their inherent complexity." That's not to say they didn't come in with a plan; these are smart people, and they do their homework. "While we brought a lot of creativity to bear with our teams, we also have partners in New York City that really helped us figure out how to execute these projects efficiently," explains Verhey. "Understanding the optimal erection cycle time; determining the best strategy to efficiently hoist steel from the street to the working floor (and then from there, installing it); which cranes should be used and how to remove those cranes once the tower was completed, and so many other challenges. High-rise steel towers look quite straightforward; however, a significant amount of innovation was needed to construct these towers efficiently. That new knowledge has continued to improve through building the more than a dozen high-rise towers we've constructed since that first tower back in 2007."

Safety is always an important consideration, but in high-rise construction, it becomes ever more critical. "Steel construction is a high-risk industry and requires very safe work practices," says Verhey. "Back in the 1990s, steel erection moved to 100 per cent tie-off so ironworkers were at all times secured with a certified fall arrest system. This focus on safety must therefore always be top of mind. Every piece of structural steel is hoisted with rigging that's going to be connected by an ironworker, and that worker needs to access that rigging safely," he explains. "Ironworkers have to be able to safely walk the steel. Everything we plan on these projects is driven by safety, and high-rise construction, put that it into a whole new perspective for us."

Walters puts a similar premium on quality assurance. And once again, the importance of quality is amplified in high-rise construction where there is significant repetition. "If you have a poor detail or a difficult situation that makes it difficult to weld, you risk weld defects. On high-rise towers, the sheer number of conditions can quickly amplify, so now you have hundreds of difficult conditions to deal with," explains Verhey.

While much of the focus for Bay Adelaide was above ground, there were challenges underneath as well. "Below the entire structure is a parking garage, retail space and the PATH system (an underground walkway) that is directly under where we needed to place the cranes," explains Lacroix.

The tight downtown city site also presented challenges. "They had to have a

BAY ADELAIDE CENTRE WEST

Owner: Brookfield Office Properties
Architect: WZMH Architects
Structural Engineer: Halcrow Yolles
Construction Manager: EllisDon Construction
Structural Steel:
Structural wide flange shapes (W) to conform to CAN/CSA-G40.20/G40/21 grade 350W or ASTM A992/A992M grade 50 (ksi)
**Originally designed/tendered with A992/350W, and the columns were converted to A913-65.*

BAY ADELAIDE CENTRE EAST

General Contractor: Brookfield Multiplex Construction Canada
Owner: Brookfield Office Properties
Architect: Adamson Associates Architects
Structural Engineer: Entuitive
Construction Manager: Brookfield Multiplex Construction Canada
Structural Steel:
Structural wide flange shapes (W) to conform to CAN/CSA-G40.20/G40/21 grade 350W, ASTM A992/A992M grade 50 (ksi)
**Originally designed/tendered with A992/350W, and the columns were converted to A913-70.*

BAY ADELAIDE CENTRE NORTH

Owner: Brookfield Office Properties
Architect: Adamson Associates Architects
Structural Engineer: Entuitive
Construction Manager: Brookfield Multiplex Construction Canada
Structural Steel:
Structural wide flange shapes (W) to conform to CAN/CSA-G40.20/G40.21 grade 350W, ASTM A992/A992M grade 50 (ksi)
Structural wide flange shapes (W) for use as columns and transfer struts shall conform to ASTM A913 grade 65 (449 MPA)
**Originally designed/tendered with A913-65 for the columns and transfer struts, many of which were converted to A913-80.*

lot of capacity, and they were also restricted as to where they could swing on site," says Greg Kern, Walters' Director of Sales.

Walters supplied the tower cranes

On the first tower, Walters' solution was to put the crane inside the building core. The company developed a crane climbing system specifically designed for the site logistics.

The third tower required two cranes, along with smaller mobile cranes. Walters sourced large diesel cranes that had a high capacity and also fit within the budget. One crane was cantilevered off the building using a girder system from the concrete core to the structure's exterior. The second crane was supported on a large steel frame that was built over existing concrete columns that went down through the underground retail and PATH areas. Temporary steel beams were installed over top of the PATH system to support the outriggers.

"By the time we got to the third tower, we knew the underground quite well, so we were able to navigate the various constraints a little quicker and more efficiently," says Lacroix.

Walters also developed a sequencing of the erection plan that tied into the schedule and broke the structure into work zones. "That was the key, to be able to build the structure in a staged and time-sequenced manner so that by the time you come back around the core… to where you initially started, you can progress. You're not stopped. It's a perfect choreograph of many different activities to make sure it works," says Lacroix.

Erection on the west tower started in late 2007 and was completed in a tight, 11-month timeframe. To meet the aggressive schedule, Walters worked closely with the concrete contractor to coordinate the pouring of concrete core ahead of steel erection so that teams could work simultaneously.

The west tower was constructed on the site of the former National Building, a designated heritage building. The 11-storey façade of the historic structure was carefully removed and reconstructed as part of the new tower. Cantilevered construction created eight corner offices on each floor.

For Walters, the relationship with ArcelorMittal is key to their success. "We've been front runners in the industry in terms of adopting a new grade," says Lacroix. "We're trying to be innovative and work with the industry to keep ahead of the curve."

That relationship is a testament to the important role collaboration plays in the steel construction industry. "Like in any industry, relationships are what it's all about," says Verhey. "We rely on the mills and key vendors to give us attractive pricing. We like to be aware of the innovations they're bringing to market so we can take advantage of that. So having a strong relationship with your key stakeholders is fundamental." But when a collaboration breeds success, companies will return to the source of that success, and Verhey says Walters' collaboration with ArcelorMittal has been very fruitful. "We've been a trailblazer alongside ArcelorMittal as they developed these new products. We've known them for decades, we've purchased many tens of thousands of tonnes of their steel, and it's located in buildings across Canada and in the U.S. in our projects. They're a fantastic partner."

The Bay Adelaide Centre represents a new standard for AAA-class office buildings due to the innovative design and technology incorporated into construction and day-to-day operations and its integration with the heritage and community of the financial core.

Kern concludes, "We've proved that these composite or all-steel towers are a cost-effective way to go, [and that they're] very predictable and go up quickly." AS