conference preview

THE BOW TOWER

BY NEB ERAKOVIC, P.ENG.,
AND TIM VERHEY, P.ENG.

Calgary's newest skyscraper stands out, thanks to its height and eye-catching external bracing system.

THE BOW TOWER is a striking presence on the Calgary skyline. And it needs to be, what with the city's stunning mountain backdrop competing for attention.

Opening this year, the building will become the new headquarters for natural gas producer Encana. Its site occupies two city blocks in downtown Calgary and, at 238 m (780 ft), it will be the tallest building in western Canada and the country's tallest commercial office building outside of Toronto.

The gross constructed area of Bow Tower above grade is 195,000 sq. m (2.1 million sq. ft) and 97,000 sq. m (1 million sq. ft) at six levels below grade, including 1,375 parking spaces along with the loading dock and service areas.

With its iconic crescent-shaped, inversely curved form, the 59-story tower features several atria, stacked vertically, with the façade integrating an architecturally exposed diagonal grid structure (a "diagrid") in six-story segments. The perimeter diagrid frame acts as one of the building's structural systems making up the hybrid lateral force resisting system (LFRS).

Oriented Toward Green

The design of the tower enthusiastically pursued green design goals, and orientation was a key consideration. The building was positioned to maximize daylighting for the office space and internal gathering locations. And the building's shape itself led to a greener building; as a result of the curving bow shape, wind loads were reduced, resulting in a more efficient framing system. The bow shape also gave rise to the locations of the atrium along the southwest elevation. This atrium, or plenum-type buffer zone, is designed to absorb the heat from daily sunlight and use it to partially warm the building in the winter and buffer the solar gain in the summer, further minimizing the structure's environmental impact. This orientation has the added benefit of maximizing unobstructed views to the majestic Rocky Mountains.

Structural steel was a natural choice, given the overall design objectives and building requirements, the developed geometry and the importance of achieving sustainability goals. The curvilinear geometry of the floor plate, cladding design, exterior and interior aesthetics, space planning, access to natural light and economics of the steel framing scheme were primary decision-making factors for the building's primary lateral system.

In addition, the high strength of structural steel generally offers advantages over other construction materials in that its use results in smaller vertical load carrying members. This provides more usable open spaces and enables the use of lightweight long-span floor framing, resulting in larger column-free areas and greater flexibility in adapting to future occupancies. Because it is relatively light, structural steel also allows for more economical foundations.

A Hybrid System

After considering various structural solutions for the LFRS, a dominant perimeter "diagrid" frame combined with more

Matthews / H&R REIT

▲ The Bow Tower is the tallest building in western Canada.

Foster + Partners

▲ The "sky garden" and mountain view from the Bow.

standard structural systems was selected to create a hybrid LFRS. This hybrid system involved three primary braced frames on the curved south elevation and the two northerly facing elevations, coupled together with steel moment resisting and braced frames. In addition—and to augment the lateral stiffness of the tower between the six-story-spaced "nodal" floors—secondary bracing systems consisting of conventional steel braced frames were also provided at two remote finger core stairs and around the main central elevator core. As a result, the overall lateral system consists of four principal components:

- At the northwest and northeast sections of the perimeter, six-story high diagonal grids are facetted along the building perimeter.
- The diagrid elements are interconnected through the core with a series of braced frames between the elevators and the north stair shafts.
- Along the south atrium screen wall face, a similar six-story modular diagrid spans outside of the atrium and is connected to the bulk of the building by horizontal axial-force members (also known as drag struts) at the ends of the atrium.
- The two dominant diagrid elements are interconnected at the ends of the building with a series of rigid frames.

The gravity load carrying system of the building was affected by the need to minimize the building's height. As the location of the building is just south of the Bow River in Calgary, the urban guidelines prepared by the municipality require that the building be low enough to avoid shadowing the river during the September equinox period. As a result, a network of interior columns was added in a layout to keep the depth of the floor beams below 485 mm (19 in.), underneath a composite floor slab construction.

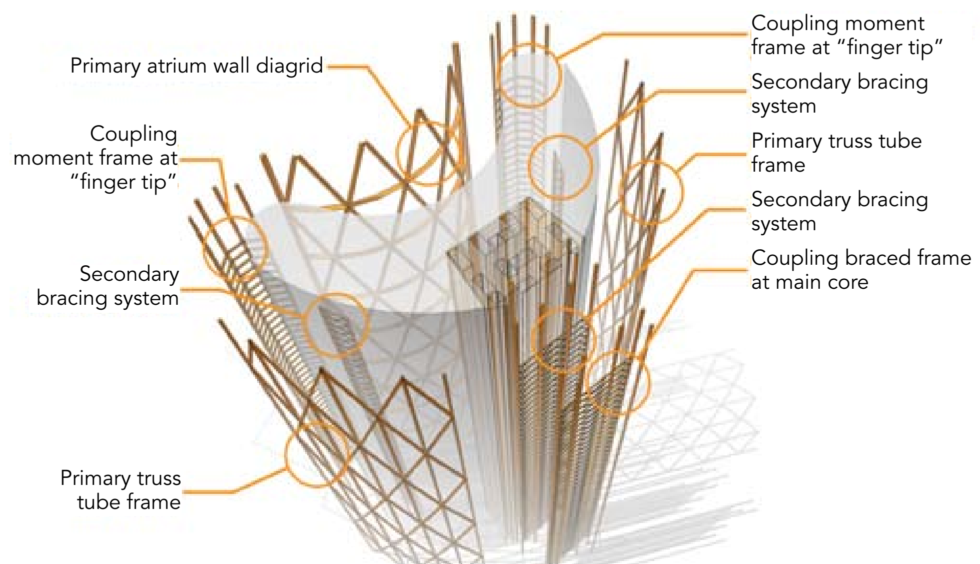

Illustration by Yolles

▲ Exploded view of components of the Bow's hybrid system.

Neb Erakovic, P.Eng., is a principal with Toronto-based Yolles, a CH2M HILL company, and is involved in all major building sectors, with a focus on complex structures and collaboration with signature architects. **Tim Verhey**, P.Eng., is vice president of engineering and operations for the Walters Group, a steel constructor located in Ontario.

Erakovic

Verhey

▲ Erection of the diagrid in its early stages.

▼ Diagrid construction nearing completion on the Bow Tower's inner curve.

The Diagrid

Again, the atrium screen wall is a defining characteristic of the building's design. The wall is also an important structural component, as the diagrid is involved in completing or closing the perimeter lateral load resisting system. Complicating the structural aspects of the screen wall are the large unsupported length of the compression elements and the tendency of the screen wall to attract gravity load from adjacent floor plates.

Various cross sections for the diagrid were studied to determine the impact on aesthetics, intrusion into the atrium, ease of connections, support of secondary building services, support of the perimeter curtain wall, fireproofing system and constructability of the structural system. On a pure cost-of-materials basis, round HSS with flange plate connections offered the best solution. But factoring in all of these other aspects—particularly aesthetics—the triangular shaped elements proved a much better overall solution. The concepts of connections initially were developed by the structural design team through a series of hand-drawn sketches, and details were then further refined and fully engineered by the steel contractor. The final result was a series of nodes with dimensions of approximately 2.8 m (9.2 ft) in width and standing 4.2 m (13.8 ft) tall.

The designers established a plan tolerance of +/-25 mm (+/-1 in.) of the theoretical position over the full height of the tower for all slab edges and the atrium diagrid structure; this is more stringent than the traditional +50/-75 mm (+2/-3 in.) AISC-specified tolerance for high-rise buildings, and thus required highly accurate shop fabrication and special measures in the field. To ensure the atrium was constructed to this tolerance, each of the AESS members that connected the atrium to the tower was custom trimmed prior to erection, and the entire height of atrium was ultimately installed within 15 mm (0.6 in.) of the theoretical plan location. MSC

Owner

H&R REIT, Downsview, Ontario, Canada

Architects

Foster+Partners, London, United Kingdom; and Zeidler Partnership, Calgary, Alberta, Canada

Structural Engineer

Yolles, A CH2M HILL Company, Toronto, Canada

This article provides a preview of what the authors will present in Session N6 at NASCC: The Steel Conference, April 18-20 in Dallas. Learn more about The Steel Conference at www.aisc.org/nascc.