ADVANTAGE STEEL

NO. 66 WINTER 2020

GO FURTHER WITH STEEL

CAVENDISH FARMS PLANT

CAST STEEL REPLACEABLE LINKS

THE HUMANITI COMPLEX

NEW BERMUDA INTERNATIONAL AIRPORT TERMINAL

THE YUKON STRIKER

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CANADIAN INSTITUTE OF STEEL CONSTRUCTION

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ADVANTAGE STEEL

NO. 66 WINTER 2020

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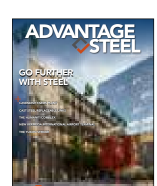
If you are working on a project that you think should be featured, send us an email at ciscmarketing@cisc-icca.ca.



On the Cover:
A rendering of the Humaniti complex in downtown Montréal

Ed Whalen, P.Eng.
President & CEO, CISC

Net-Zero, Circular Economy & Cradle to Grave – Say What?!

IF YOU HAVE BEEN living under a rock for the last year, you will be shocked to hear that the environment and, more specifically, greenhouse gas emissions is front and centre. For most governments and for the millennials and post-millennials, reducing carbon and other greenhouse gases is priority number one. For some industries and some governments, deflection and avoidance seems to be the course of action.

Here in Canada, and with respect to the construction industry, we have two major greenhouse gas initiatives from the Federal Government: carbon taxes (to drive behaviour) and changes to the National Building Code to include a "net-zero energy ready" model. The goal of the net-zero energy ready model is to construct a building that will consume only as much energy as it produces. Although this mainly affects the electrical and mechanical trades, there will also be code and government requirements to construct new buildings with materials creating the lowest global warming potential (GWP).

In other parts of the world, Net-Zero is old news and the "circular economy" is the new buzz phrase. Where recycling was king, reuse becomes the goal. Global ISO standards are now in development for construction material reuse with the knowledge that the more we reuse, the less new products we need to make, and thereby less impact on global warming - in theory anyways. I am starting to see this discussion take place in North America, albeit at lower frequency.

If you folks in the bridge side of things think you will escape the GWP bandwagon, think again. Just because you escaped the LEED program, you won't escape GWP. Transportation Ministries across Canada are beginning to think green and considering GWP impacts for future projects and within the scope of the code.

So how does steel as a material rank on GWP? As it turns out, pretty darn good! Although there are all sorts of claims from other materials, it turns out that steel is as good or better when looking through a "Cradle to Grave" lens. There are generally two types of ways the world has been looking at materials from a life cycle analysis (LCA) perspective: Cradle to Gate and Cradle to Grave. Cradle to Gate is an analysis from the extraction of materials to the factory gate; Cradle to Grave includes Cradle to Gate but also incorporates the construction and end use and/or end-of-life impacts. Since the true long-term GWP impact on the world is Cradle to Grave (and not just a portion), this is the reason why the rest of the world is pushing beyond Cradle to Gate and opting for reuse and the circular economy model. The circular economy model is the ideal state. It is an economy where we continuously reuse. This would reduce or eliminate the need to make new products. What's old is new again. The days of a fridge lasting 20-25 years, or longer, may be coming back... perhaps only if we stop making them in China and out of plastic - but you get the idea. Planned obsolescence will be gone and all industries will be pushed to have their products last longer and be reusable.

In a recent study, "Quantifying Environmental Impacts of Structural Material Choices Using Life Cycle Assessment: A Case Study by Magnusson Klemencic Associates" (see the CISC website for the study), they found that there was a surprise in the outcomes of their own analysis

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Advantage Steel and the French-language edition **Avantage Acier** are published by the Canadian Institute of Steel Construction (CISC) on behalf of its members and associates. CISC is not responsible for the opinions expressed in this publication by those contributing articles.

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If you have been living under a rock for the last year, you will be shocked to hear that the environment and, more specifically, greenhouse gas emissions is front and centre.

of the various structural framing materials with no clear carbon winner. When looking through a Cradle to Grave lens and using the appropriate design for each material, steel stacked up as good as or better than the rest of the materials, including better than wood. In their report, there are many missing factors in wood's current data and assumptions. They suggest further work needs to be done to more accurately include the impacts for all materials before any one material has the bragging rights on true Global Warming Potential. For now, we are very happy to report we have one of the best environmental materials for construction and look forward to the development of more accurate criteria and data that will drive the innovation of all materials for the betterment of the global environment. AS

Charles Albert, P.Eng.
Manager of Technical Publications & Services, CISC

CISC provides this column as part of its commitment to the education of those interested in the use of steel in construction. Neither CISC nor the author assumes responsibility for errors or oversights resulting from the use of the information contained herein. Suggested solutions may not necessarily apply to a particular structure or application and are not intended to replace the expertise of a licensed professional engineer or architect.

Question 1: What is the buckling resistance of a compression member when only one flange is laterally braced?

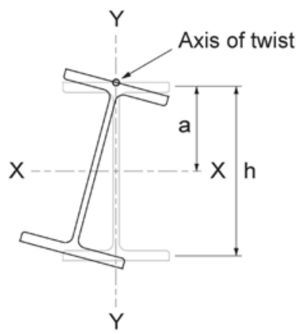

FIGURE 1
Torsional-Flexural Buckling About a Constrained Axis

Answer: Although this condition is not covered in CSA S16-14, it occurs mainly in two situations: (1) exterior columns in single-storey buildings, and (2) beams in braced frames supporting a steel deck. In case (1), the outside flange of the column is laterally braced by girts while the inside flange is unsupported. In case (2), the top flange of a roof beam, for example, is continuously braced by the deck while the bottom flange is unsupported. In both cases, torsional-flexural buckling under axial loading occurs about a constrained axis of twist located near the braced flange, as shown in Figure 1.

Ziemian (2010) provides a formula for the elastic buckling load:

$$P_{eyz} = \frac{P_{ey}\left(\frac{h^2}{4} + a^2\right) + GJ}{a^2 + r_x^2 + r_y^2}, \quad P_{ey} = \left(\frac{\pi}{L_y}\right)^2 EI_y$$

where:
a = Distance between the constrained axis and the shear centre of the member
G = Shear modulus
h = Distance between the flange centroids
I_y = Weak-axis moment of inertia
J = St. Venant torsional constant
L_y = Unsupported member length between points of zero twist
P_{ey} = Euler (flexural) buckling load about the weak axis
r_x , r_y = Principal radii of gyration

This buckling mode is also referred to as "constrained-axis torsional buckling" in ANSI/AISC (2016). Due to the finite stiffness of the lateral bracing, it is recommended to limit P_{eyz} to 90% of the calculated value.

In case (1), since the girts provide discrete rather than continuous bracing, flexural buckling of the column about the weak axis should also be checked separately using S16-14 Clause 13.3.1 with the unsupported length taken as the girt spacing.

References:

ANSI/AISC. 2016. Specification for Structural Steel Buildings. American Institute of Steel Construction, Chicago, Illinois.
Ziemian, R. D. 2010. Guide to Stability Design Criteria for Metal Structures, 6th Edition. John Wiley and Sons

Question 2: How is the formula for M_u in S16-14 Clause 13.6(e) applied to a WT-section in bending with the stem in compression? And what value of β_x should be used?

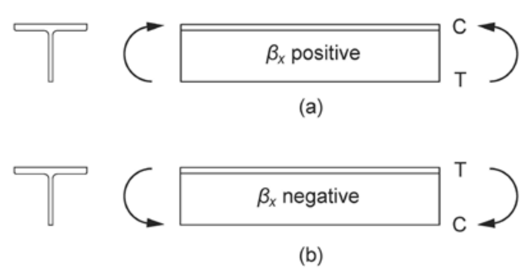

FIGURE 2
Laterally Unsupported WT-Section

Answer: The same formula for the elastic buckling moment, M_u, is used whether the WT stem is in compression or tension. The only difference is that the asymmetry parameter, β_x, is taken to be (a) positive when the flange is in flexural compression, and (b) negative otherwise (i.e. when the stem is in flexural compression), as shown in Figure 2. In case (b), the WT-section is less stable, and M_u will therefore be smaller than in case (a).

The values of βx listed in Part 6 of the Handbook of Steel Construction were calculated for WT-sections using the exact expression given in Part 2 (CISC Commentary on CSA S16-14). The formula for βx in Clause 13.6(e), on the other hand, is an approximation for singly-symmetric beams that is not valid for T-sections (according to the new CSA S16-19). AS

Questions on various aspects of design and construction of steel buildings and bridges are welcome. They may be submitted via email to info@cisc-icca.ca. CISC receives and attends to a large volume of inquiries; only a selected few are published in this column.

Bonnie Pankratz

Featured Expert

NDT METHODS

The most important question you need to ask when approaching inspection and testing, is what do you want to accomplish? How does the inspection and testing that is done affect my bottom line, and what information do you need for the application? This article is intended only as a basic introduction to guide and direct you to use the most efficient testing method for your project.

SURFACE METHODS

Visual Inspection, Magnetic Particle Testing and Liquid Penetrant Testing are considered surface testing methods; these methods assess the weld metal or parent material at a surface level. Visual Inspection is not just for welds; it is an important part of the quality overview for dimensioning and general workmanship. Magnetic Particle Testing (MT) has three types of test methods, which range in terms of sensitivity. How critical the area is and the surface type will determine the appropriate method. Dry powder, black on white (also called the wet method) and fluorescent give increasing levels of sensitivity. It is important to mention that MT can only be performed on material that is magnetic, typically carbon steel. Magnetic Particle Testing is not suitable for aluminum or stainless steel applications.

SUBSURFACE METHODS

Ultrasonic Testing (UT) and Radiographic Testing (RT) are key testing methods in structural steel. These methods are important tools in structural steel. CSA S6[1] will require weld splices to be ultrasonically or radiographically tested.

Ultrasonic testing is commonly used as there are significant advantages of UT over RT in terms of cost efficiency. UT can be done during regular shifts, and as soon as Code allowances permit.[2] The technician is able to work alongside fabrication and mark deficiencies while fabrication is progressing. Two significant things to note are that UT is only as good as the technician performing the work. The competency of the technician is an important factor in this method; secondly, there is no permanent record of the acceptable results.

Radiographic Testing is comprised of two methods: X-ray and Gamma Ray. X-ray is limited as to the thickness of the material that it can test, so typically Gamma Ray is the method used in structural steel. Gamma Ray, though, provides a permanent record and is less subject in terms of the competency of the technician, and the cost efficiency of the method is less attractive. Gamma Ray testing requires that the fabrication area and often the building be clear of non-RT personnel. Radiographic Testing is often performed during night shifts, which requires a cost premium to be paid, as well as preventing the option of a night shift for fabrication.

Phased Array Ultrasound (PAUT) is becoming more widely accepted. This advanced NDT method combines that accessibility of UT with the ability to provide a permanent printed record. CSA W59[3] has been recently revised to allow for the use of PAUT in structural steel applications. This method has some of the concerns of conventional UT, in that the competency of the technician is integral to the results. The qualifications and training are different

1. CSA S6 A10.1.8.2
2. CSA S16 annex 19
3. CSA W59 7.4.3.1

than that of a conventional UT technician, which is an important factor when considering this NDT method for a project.

MATERIAL ANALYSIS

X-ray Fluorescence (XRF): this equipment is portable and analyzes the chemical composition of a material. This method is key in ensuring that the material being used matches the properties of MTR (mill test report) as to what has been specified, as well as providing information when origin of material is unknown.

This is just a quick snapshot of NDT and not comprehensive or detailed. The primary purpose is to provide a launching place for the structural steel industry to have the knowledge to ask questions at the start of the project. AS

Michael Holleran, P.Eng.
Chairman of CISC's Education & Research Council

Structural steel has been built on education and research

THOUGH IRON HAS been around for centuries, its usage of structural steel in construction is relatively modern. As the production methods improved around the industrial revolution, new materials and shapes were developed, and the presence of structural steel was founded. The fathers of modern steel making (1856 Bessemer and 1879 Thomas) mastered a method to remove impurities from the steel manufacturing process, which increased its quality and its possibilities. With such new developments, the use of steel in construction grew rapidly and in turn became more cost effective. World War I was another major milestone in the history of steel production with more than 50 million tons of steel being produced in North America entering into 1920. Fast forward only 100 years to 2020 – structural steel is used today for every building application imaginable. The advancement of structural steel has been built on education and research.

The CISC's Education and Research Council (ERC) has been fundamental in the progression and development of structural steel through promotion of academic research and technical education. No other construction material has advanced so quickly, in such a short amount of time. We at the CISC embrace and foster these changes. Through the support of their contributors, CISC's ERC has been able to improve design codes, innovate new structural steel products and educate the Canadian design community.

The ERC has undergone a remarkable evolution in the past five years (evolving from Steel Structures Education Foundation – SSEF, to now the ERC) as we have pursued our vision to advance the education and research in steel construction. What is more evident than ever before, though, is that we cannot achieve success if we choose to pursue these goals independently. Rather, success requires that we consistently work to achieve our goals through integrated initiatives that place priority on moving the steel construction industry forward simultaneously on multiple fronts.

After four years as the Chair of the ERC, my tenure has ended, and I have decided to pass the torch to our next successor. I would like to express how sincerely grateful I am for the honour and privilege of working with the ERC; their wisdom and guidance is immeasurable in the direction and progression of steel construction to the present and future generations.

Once again, please consider supporting the CISC's ERC to ensure steel research continues and the growth of the structural steel industry remains strong for the next generation. Your funding is needed in order to sustain steel education and research. A full list of recent research and education projects can be viewed on the CISC website. Please contact the CISC for more information on how your funding can directly support education and research in the steel industry. AS

"Success requires that we consistently work to achieve our goals through integrated initiatives that place priority on moving the steel construction industry forward simultaneously on multiple fronts."

SUCCESS STORY: Mike's Metal Works

Meets Challenging Deadline with PythonX STRUCTURAL

CHALLENGES

1. Missed opportunities
Because they strictly focused on miscellaneous, they were missing out on a lot of structural opportunities that their competitors were bidding on.

2. Unable to meet deadlines with outdated technology
Unable to meet a customer's deadline with their current outdated technology, they knew they had to upgrade their equipment.

SOLUTION

RESEARCH
An industry expert recommended the PythonX STRUCTURAL, and they had watched PythonX STRUCTURAL videos online and were amazed at the speed that the PythonX STRUCTURAL processed structural steel. So they decided to take a closer look at FABTECH and bought it on the spot. The primary reason they chose PythonX STRUCTURAL is that Lincoln Electric makes it, and they were impressed with the quality, workmanship, and support that are superior to competitive systems.

THE PRODUCT
PythonX STRUCTURAL, a versatile and complete solution that requires only 1 operator and no programming. All processing operations are automated, resulting in increased productivity, unmatched cut quality, predictable, and consistent throughput.

RESULTS

INCREASED EFFICIENCY OPENS UP NEW OPPORTUNITIES
When they implemented the PythonX into their production process, they didn't anticipate its effectiveness and the new opportunities that the PythonX STRUCTURAL would open up with other customers with their new manufacturing potential. Growth was imminent.

PythonX paid for itself with its first job processing 500 pieces of steel

Decrease Time
To complete infill beam production from a minimum of 90 minutes to 6-8 minutes

124% INCREASE IN REVENUE **OVER 3 YEARS**

Since starting the business from a single person operation in the family's garage, they have expanded to a 50,000 sq. ft. facility with 37 employees based in San Diego, CA.

MIKE & JACKIE HANCOCK
President and CEO,
Mike's Metal Works

For more information on this revolutionary technology: Call +1 833 PYTHONX
Watch our Customer Success Videos: www.pythonx.com/customer-success

G.L. Kulak Award Recipient

ABOLFAZL ASHRAFI IS A third-year PhD student at the Civil and Environmental Engineering Department of the University of Alberta. He received his M.Sc. in Structural Engineering from Sharif University of Technology, Iran, in 2015. Before starting his PhD, he worked as a Structural Engineer in Tehran, Iran for two years. His PhD research focuses on the seismic response and design of steel multi-tiered eccentrically braced frames and is being conducted under the supervision of Dr. Ali Imanpour at the University of Alberta CISC Centre for Steel Structures Education and Research (the Steel Centre).

Steel multi-tiered braced frames (MT-BFs) are commonly used as the lateral load resisting system of tall single-storey buildings such as convention centres, sports facilities, warehouses, chemical plants or industrial applications. In multi-tiered configurations, the frame height between the ground and roof levels is divided into multiple bracing panels, because often the application of a single braced panel with long and large braces is neither practical nor economical (Fig. 1). Although multi-tiered concentrically braced frames (MT-CBFs) are often preferred in practice, multi-tier eccentrically braced frames (MT-EBFs) could represent a cost-effective solution in seismic design as eccentrically braced frames (EBFs) offer a highly ductile and stable response in earthquake.

FIGURE 1
A four-tiered concentrically braced frame in an industrial building.

As of today, there is no research into the seismic behaviour of MT-EBFs. No distinction is made by the current Canadian steel design standard (CSA S16-14) between these frames and EBFs as part of multi-storey structures. This research aims to study the seismic response of such frames with emphasis on the column and link beam stability response. In addition to the response evaluation using advanced numerical simulations and full-scale experimental testing, seismic analysis and design requirements will be proposed in the framework of the CSA S16. The findings of this study will help structural engineers to achieve a safe and efficient design as well as code developers to improve the current seismic design provisions for steel MT-EBFs. AS

Canadian National Steel Bridge Competition (CNSBC)

MAY 14TH - 18TH 2020

Western University, London, Ontario

THIS COMPETITION AIMS to recognize the talent and perseverance of our young students in civil engineering who have invested a lot of energy in the field of the study of steel bridges. Let's not forget that they are the next generation of our industry. It is therefore essential to give our support and show our respect for the engineers that they will be tomorrow.

ASSIST IN LARGE NUMBERS IN THE COMPETITION WHICH:

- Encourages innovation;
- Allows students to deepen their knowledge with a practical project;
- This human experience develops their interpersonal skills and professional skills;
- Creates relationships between students and industry.

WE WILL KEEP YOU POSTED ON HOW YOU CAN ENCOURAGE AND SUPPORT THE TEAMS AS

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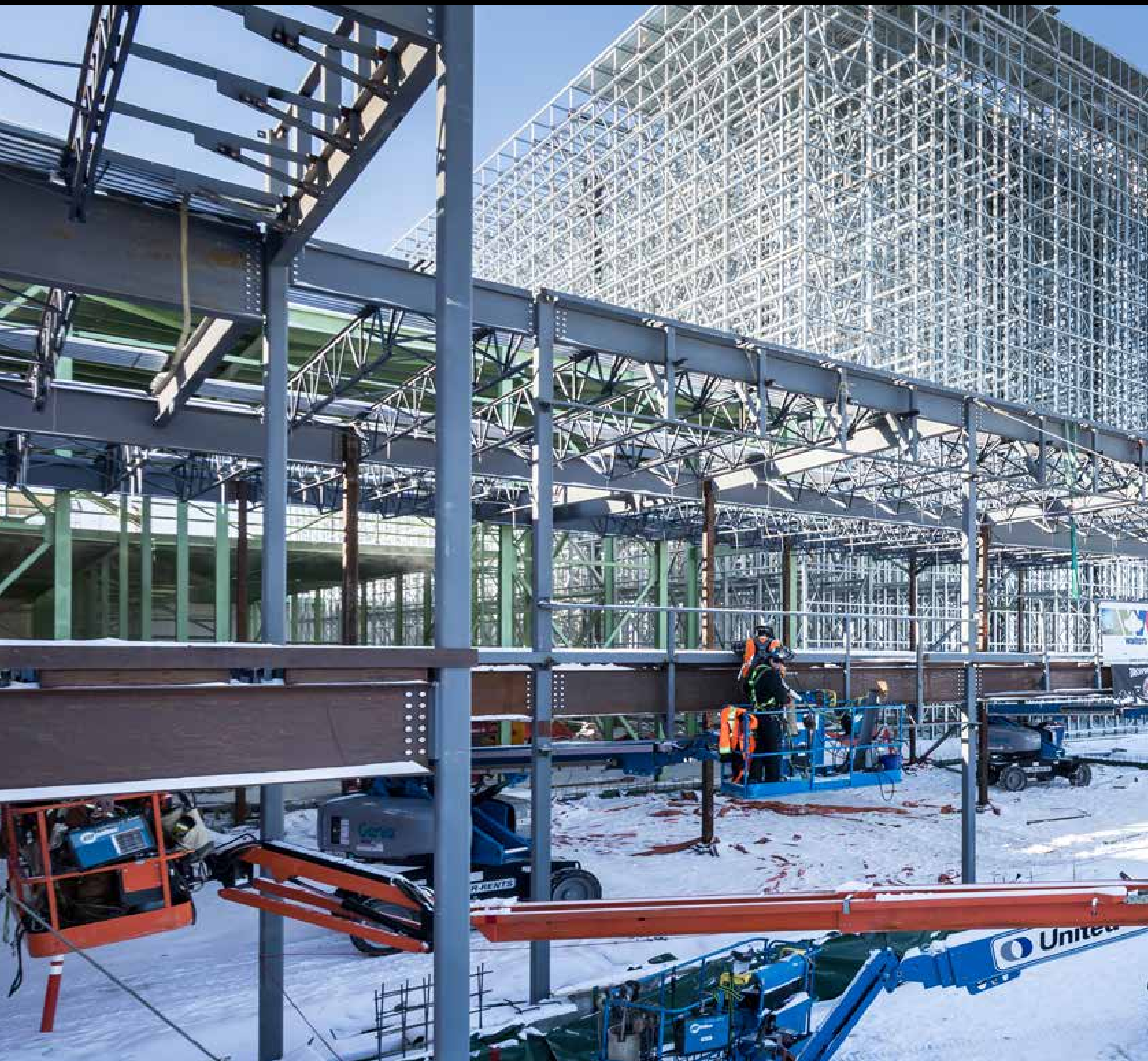
WALTERS GROUP DELIV

New Cavendish Farms Plant in just 10 months

By Mark Koppelaar, Executive Vice-President, Projects & Production, Walters Group



ERS

CAVENDISH FARMS' new $360 million potato processing plant is a huge feat, not just in stature, but in its expected impact on the residents of Lethbridge, AB.

In an official press release from the family-owned food company, President Robert K. Irving said, "This significant investment in this community reinforces our commitment to the region and our employees, growers and customers." The sentiment was echoed by former Premier Rachel Notley, who said, "Together with the City of Lethbridge, the federal government and the good folks at Cavendish, we are creating more opportunities for our agricultural workers, more jobs for people in the area, and even more reasons to be proud of an industry central to who we are as Albertans."

It's clear that the plant, which was completed in fall 2019, will be a boon to Cavendish Farms' production capacity and Lethbridge's economic outlook. But the new facility is also a major achievement for Walters Group.

A MASSIVE PLANT ON A FAST TRACK SCHEDULE

Founded in 1956, the family-owned steel construction company has designed, fabricated and constructed a variety of commercial and industrial projects throughout North America. Those projects include the Canadian Museum for Human Rights in Winnipeg, the Burgoyne Bridge in St. Catharines, and the Ferrero Processing Plant in Brantford. Despite having worked on a diverse array of structures in the past, including processing plants, the Cavendish Farms project represented a new challenge. Aside

from its sheer size, there was a very limited amount of time to finish the entire process.

"The challenge was a fast track schedule, so it had to happen really quick," said Tim Verhey, Jr., Walters' Senior Project Manager. The steel scope was completed within 10 months, and Walters had a substantial design-assist role in bringing the structural design to completion.

Finishing any building project in 10 months is an accomplishment, but once you consider the massive efforts and the magnitude of the processing plant, it's all the more impressive.

Over the course of the entire project, an estimated 900 construction workers were on-site. 5,600 tons of structural steel, trusses, beams and columns were required, all with shop-applied high-performance coatings, and three cranes erected the structural steel simultaneously.

The processing plant played to Walters' strengths and relied heavily on the company's vast experience. About the company's typical role in construction projects, Verhey said, "We're responsible for the connection design, from member to member. We fabricate all the structural steel members, ship them to site, and then construct them."

He added, "There's a lot of coordination with the connection design and the detailing, so we work closely with the design engineer. Then it's a lot of additional coordination with other trades, like mechanical and electrical."

These skills were especially crucial with the Cavendish Farms project, as Walters provided end-to-end services, including the 3D modelling, 4D scheduling, fabrication and painting, plus erecting of the structural steel and installation of the 360,000-sq.-ft. metal roof deck. The project also required collaboration with multiple partners, such as Stantec Consulting Ltd. and EllisDon Construction Services Inc.

A PLANT WITH UNIQUE CHALLENGES

Walters' expertise truly came in handy when the original design of the processing plant was altered.

"There were a lot of design changes, so we had to constantly react to changes," Verhey said. "It's a real challenge, especially on a fast track job." The project timeline was already tight and, despite the updated designs, the team still needed to meet the original deadline. This required Walters to bring in additional crews to maintain the pace, which created an even more complex job site for Walters and all its project partners.

Walters Site Superintendent Glen Dobbs had to manage both a large number of workers and many pieces of oversized equipment. "Constant design changes in the program made the flow of structural members a difficult endeavour," he said. "With two shifts of ironworkers working day and night and 43 pieces of rental equipment in use, the ironworkers were moving in every direction." Dobbs had to maintain the difficult balance between logistics and shipping, and he had to ensure that the raising gangs and second pass crews worked in tandem to execute every change.

Extreme weather conditions added an additional layer of challenges. But Walters was able to jump every hurdle, a testament to the company's professionalism and the work ethic and commitment of its partners.

Beyond the intricate inner workings of the job site, the Cavendish Farms plant had some unique technical aspects, starting with the massive metal roof deck.

"The plant had very high wind load requirements," Verhey said. This was a specific detail that was especially important for southern Alberta's weather patterns. "It required a lot of extra fastening for the roof deck system."

The plant also required the use of many different paint systems, largely dependent on the activities that would take place in each area of the building. "The process area has a very high-quality, expensive multi-coat paint system," Verhey said, as is required to meet food processing standards. Other areas of the plant used lower grade paint systems.

Walters successfully juggled the plant's specific needs and unanticipated demands to complete the project, an accomplishment that certainly stands out in the company's already notable portfolio but will also leave an indelible imprint in Lethbridge.

A PROJECT WITH IMPACT

The completion of the processing plant enables Cavendish Farms to nearly triple its annual production capacity. The company expects to grow upwards of 15,000 acres of potatoes, up from 6,000 acres. And CBC reports that the plant will create 400 jobs in southern Alberta.

The Cavendish Farms project also served as a way for Walters to continue supporting Ironworkers Local 725, Southern Alberta's chapter of local ironworkers, rodbusters and welders. Walters and Ironworkers have maintained a partnership across Canada since the 1970s. Walters' projects create large-scale opportunities for Ironworkers members, and their exceptional work enables Walters to deliver projects of an unmatched quality.

So, on one hand, Cavendish Farms' potato processing plant was a way for Walters to continue to show its unrivalled expertise and deliver a challenging yet vital project. But even greater are the benefits that will be felt in Lethbridge for years to come. This plant demonstrates the wide-ranging power and importance of these projects for everyone involved – the builders, the owner, the workers and the community. AS

CAST STEEL REPLACE

Links for use in Steel Eccentrically Braced Frames

By Pedram Mortazavi, Oh-Sung Kwon, Constantin Christopoulos, Eden Lee,

STEEL ECCENTRICALLY Braced Frames (EBFs) have been proposed as Lateral Load Resisting Systems (LLRS) for seismic applications since the early 1970s [1-2]. They provide an attractive alternative to more commonly used LLRS in steel structures such as Moment Resisting Frames (MRFs) and Concentrically Braced Frames (CBFs), by combining the structural advantages of both systems. Compared to MRFs, EBFs exhibit higher lateral stiffness and, therefore, the inter-storey drifts are controlled much more effectively. In comparison with CBFs, EBFs demonstrate a more flexible response, leading to lower internal forces and reducing the challenges with the design of the capacity protected elements, including the foundations. In addition, EBFs provide more freedom in architectural design by allowing for larger architectural openings such as windows and doors within the braced bay, compared to CBFs and Buckling-Restrained Braced Frames (BRBFs).

During earthquakes, the mechanism for energy dissipation in EBFs is achieved through yielding of the segment of the floor beam between the braces [see Figures 1 (a) and (c)]. This portion of the beam that undergoes controlled yielding is referred to as the link. Depending on the length of the link beam compared to the bay length, conventional EBFs are classified into flexural EBFs and shear-critical EBFs. In flexural EBFs, the link beam is long enough to develop significant bending moments and form flexural plastic hinges at both ends when the building is subjected to lateral loads. In shear-critical EBFs, on the other hand, the yielding mechanism is primarily through shear yielding of the web. This can be better understood by considering the loading state of an EBF link under lateral loads, which is shown in Figure 1 (c). By adding web stiffeners to prevent web buckling and lateral support to prevent lateral torsional buckling, shear critical EBF links can provide a stable energy dissipation as they take advantage of uniform web yielding instead of local flexural hinging [3]. Therefore, shear critical links are preferred in the design of conventional EBFs. While conventional shear links typically provide stable energy dissipation, their ultimate response is limited by weld cracks and web fracturing close to the stiffeners and thus the allowable link rotation during design is limited to 0.08 radians.

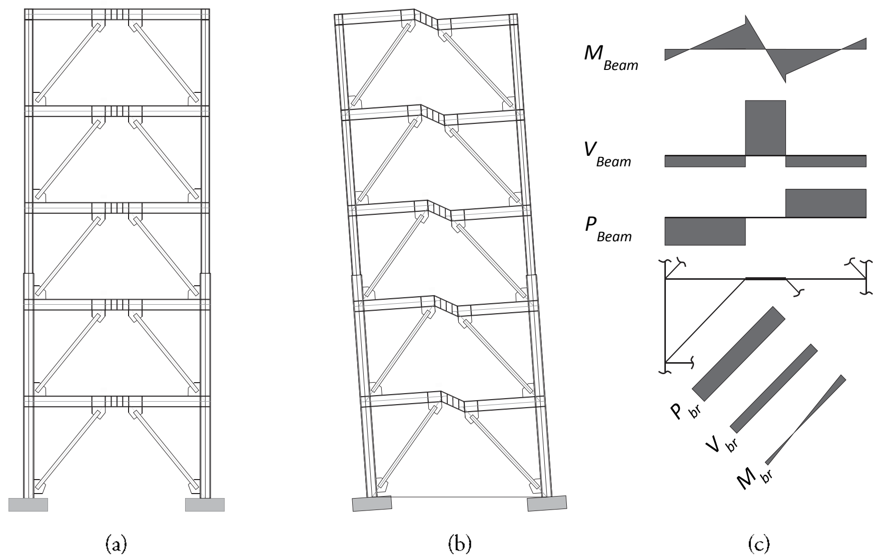


FIGURE 1: (a) Conventional EBFs, (b) Deformed Shape of Shear-Critical EBFs and (c) Distribution of Internal Forces in EBFs.

About a decade ago through a joint project between the University of Toronto and École Polytechnique of Montreal, replaceable shear links were proposed for seismic applications [4]. The proposed system facilitated post-earthquake repairs and simplified the design and construction of EBFs. Since then, replaceable shear links have steadily gained attention from the engineering community in seismically active regions and, in particular, have been used in rebuilding of Christchurch [5]. Despite providing several advantages over conventional EBFs, replaceable EBF links have both complex detailing and stringent welding requirements and are still limited to 0.08 rad maximum plastic rotation.

The present study, which is a joint project between the University of Toronto and Cast Connex Corporation, investigates the performance of a new generation of energy dissipative links in EBFs known as Replaceable Cast Steel Links. The system benefits from steel casting technology which offers freedom of geometry in structural design as well as highly improved response attributes such as significantly increased ductility and material low-cycle fatigue life. These new links

ABLE

University of Toronto and Justin Binder, Michael Gray, Cast Connex Corporation

The present study, which is a joint project between the University of Toronto and Cast Connex corporation, investigates the performance of a new generation of energy dissipative links in EBFs known as Replaceable Cast Steel Links.

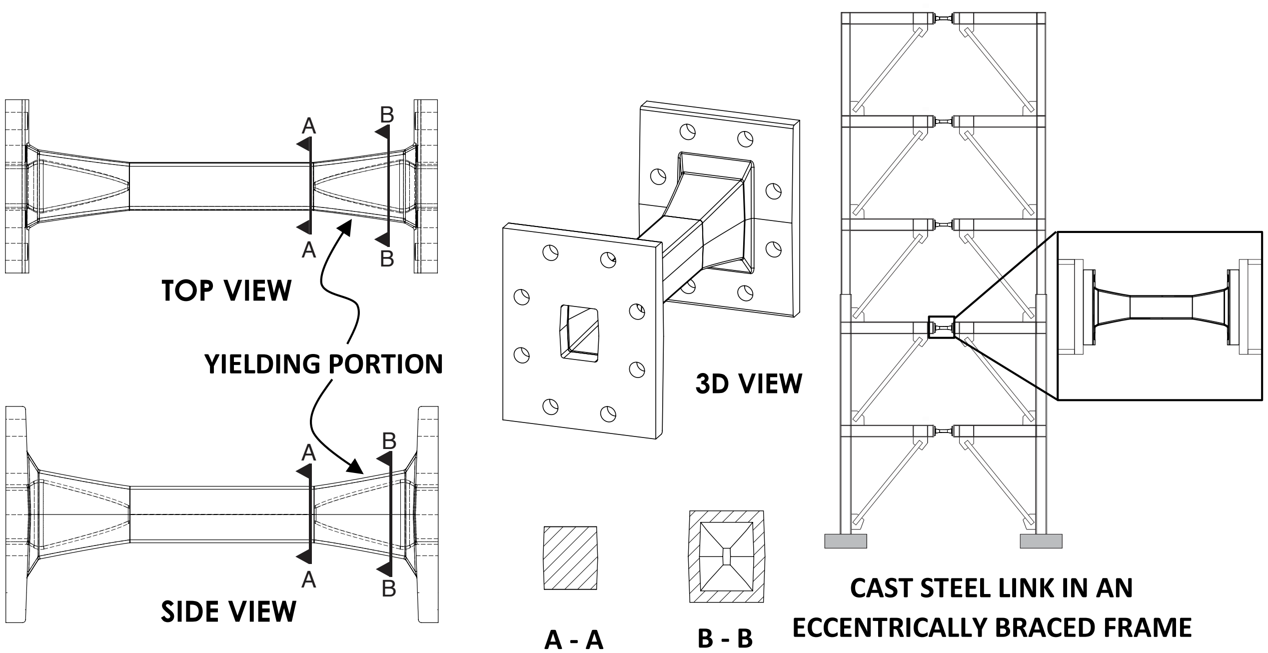


FIGURE 2: Conceptual Illustration of the Proposed Cast Steel Replaceable Links

are tapered such that they will develop uniform yielding in flexure and are designed to improve upon the fracture performance and rotation limits associated with conventional shear links.

The concept of Replaceable Cast Steel Links was first proposed by Tan and Christopoulos [6] through a numerical study. The authors proposed a hollow structural box shape, with a tapered width such that the link's flexural capacity would match the distribution of bending moments along the length of the member. In the present study, the design of the Cast Steel Links was modified to maintain constant cross-sectional area over the length of the link, while tapering the width, the height and the thickness of the element. A conceptual illustration of the proposed system is shown in Figure 2.

Figure 2: In order to experimentally validate the response of the system, several experiments are designed and are currently being carried out at the University of Toronto Structural Testing Facilities. In the first set of experiments, the response of the proposed cast steel links will be validated on a component level. The test setup and the specimens

are shown in Figure 3 (a). A loading frame is designed within the axial loading frame that will impose the same loading conditions on the link as it would experience in a real building.

In the next set of experiments, the response of the system will be validated within a one-storey steel frame in order to assess the performance of the system globally and as part of a structural system. These tests will be followed by pseudo-dynamic hybrid simulations, which enables the experiments to have a much better and more direct correlation with what structural components experience during real earthquakes. This is done by physically representing the yielding component of the structure in the laboratory, while modelling the rest of the structure numerically. The experimental setup for these tests is shown in Figure 4.

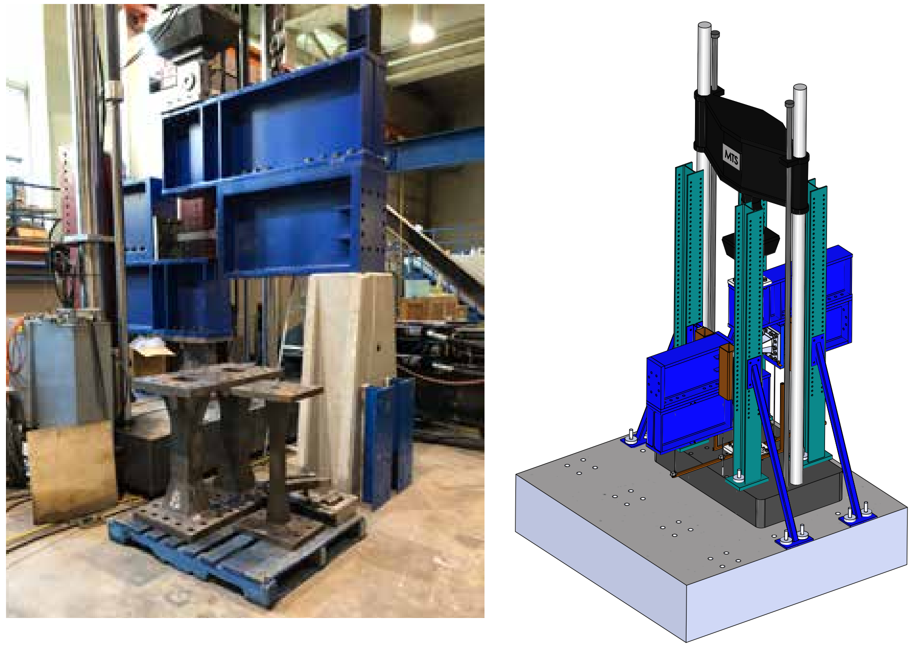


FIGURE 3: Component-Level Experimental Validation

The experimental program will be complemented with a comprehensive numerical study on the response of cast steel EBFs on a component level and a system level. Design provisions and guidelines will be developed for design and implementation of Replaceable Cast Steel Links in Steel EBFs. The rotational capacity of the proposed links is expected to be substantially higher than the conventional links.

This research project will investigate a new concept for replaceable links for use in eccentrically braced frames which seeks to improve and ease the design process, performance and construction of steel EBFs, helping to keep steel as the primary material of choice for seismic applications. AS

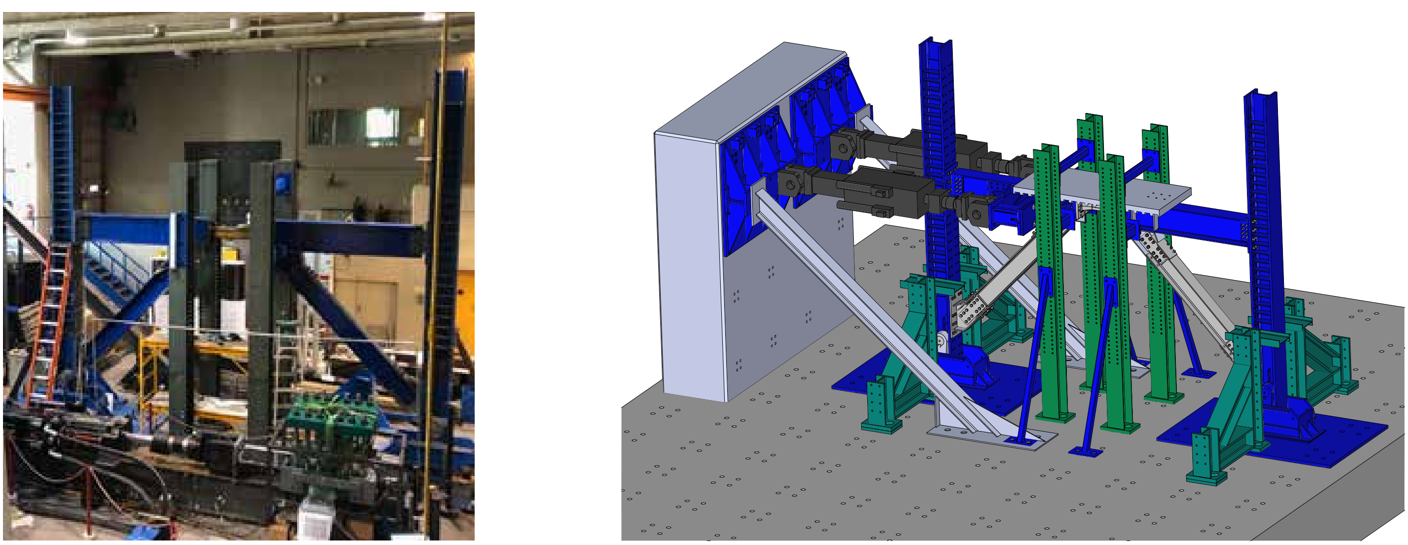


FIGURE 4: A view of the Experimental Setups in the University of Toronto Structural Testing Facilities

[1] Fujimoto, M. (1972). Structural Characteristics of Eccentric K-Braced Frames, Translated, AIJ, No. 195, May 1972.
[2] Popov, E. P., Takanashi, K., Roeder, C. W. (1976). Structural Steel Bracing Systems: Behavior Under Cyclic Loading. Earthquake Engineering Research Centre, Report No. EERC 76-16, June 1976.
*[3] Kasai, K., Popov, E. P. (1986). General Behaviour of WF Steel Shear Link Beams. Journal of Structural Engineering (ASCE) 1986; **112**(2): 362-381.*
*[4] Mansour, N., Christopoulos, C., Tremblay, R. (2011). Experimental Validation of Replaceable Shear Links for Eccentrically Braced Steel Frames, Journal of Structural Engineering (ASCE) 2011; **137** (10):1141-1152.*
[5] Bruneau, M., MacRae, G. (2017). Reconstructing Christchurch: A Seismic Shift in Building Structural Systems, The Quake Centre, University of Canterbury.
*[6] Tan, K. G., Christopoulos, C. (2016). Development of Replaceable Cast Steel Links for Eccentrically Braced Frames, Journal of Structural Engineering (ASCE), 2016; **142**(10):04016079.*

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HUMANITI, THE HUMAN

In the heart of the city

By LEMAY / ELEMA + GROUPE SMI

EXPERIENCE

LOCATED IN DOWNTOWN MONTRÉAL, the Humaniti complex is a mixed-use project stretching 120 metres high, with 39 floors of various vocations. The complex includes 1,600 m² of commercial space, 6,000 m² of office space, a 193-room hotel and a residential tower with 314 rental units and 150 condominiums. The building's five-storey underground parking lot will include electric vehicle charging stations, a car-sharing service and space for approximately 125 bicycles.

Built at the edge of Old Montréal where three distinct neighbourhoods converge, the boldly designed building is shaped like the letter "h." Inspired by how humans interact with their surroundings, this avant-garde complex sets a precedent as one of the tallest multipurpose towers in Montréal's International District. Its unique design frames the city's views, moments and living spaces.

The building acts as an extension of the beautiful Place Jean-Paul-Riopelle public square, which is surrounded by the Palais des congrès de Montréal, the Caisse de dépôt et placement du Québec (CDPQ)'s head office and the InterContinental Montreal hotel. The Humaniti complex's façade will become the fourth wall of this magnificent urban room where La Joute[1], a breathtaking fountain sculpture, takes centre stage.

A SMART VERTICAL COMMUNITY

The Humaniti complex was created in response to Cogir Real Estate's desire to create a sense of community in this extremely dense neighbourhood. Montréal's first smart vertical community will be a source of pride for urban clients who can work, eat and enjoy themselves before heading home, all without leaving the comfort of this complex aiming for LEED and WELL certifications, the first such building of this height in Quebec.

Multi-sensory human experiences will abound in an environment that fosters dialogue and openness. The upper floors include two outdoor pools, three outdoor terraces and a nine-storey concrete structure for the hotel section, built on a three-storey steel structure which bridges the office volume and the residential tower. The gym, spa, pedestrian esplanade and many common areas are just a few of the complex's impressive features.

TREMENDOUS CHALLENGES OVERCOME WITH STEEL

In order to respect the purity of the "h" shape, one of the key architectural features of the project, the structure could not include intermediary columns at mid-span, which would have been required with a concrete-

only structure. This was the inspiration for the idea of a hybrid steel/concrete structure. Designing and assembling its connections required immense precision and meticulous attention to detail.

The steel structure had to be erected more than 20 metres above ground between two multi-storey concrete towers within an extraordinarily tight perimeter in the downtown core. The three-storey, 27-metre-long transfer frame, which bears the load of nine storeys of concrete (including one of the two exterior pools on its roof-terrace), had to be erected using tower cranes only, without any scaffolding. Coordinating the cranes, transportation and lifting plans presented several challenges that had to be overcome to ensure the project's success.

To establish the foundation for this steel transfer structure, a lateral load-resisting system had to be designed for the seamless structure, which was supported by two separate podiums. The transfer frame was designed as a free-standing structure during construction to avoid the need for temporary supports. This was just one of many innovative solutions that the Humaniti project has inspired.

PROJECT TEAM

OWNER: COGIR **DEVELOPER:** COGIR/DEV MCGILL **CONTRACTOR:** EBC **ARCHITECT:** LEMAY **FABRICATOR:** QUIRION MÉTAL **CONSULTING ENGINEERS:** ELEMA EXPERTS-CONSEILS + GROUPE SMI (FNX-INNOV) IN CONSORTIUM

A MULTIPURPOSE SITE

The arrow, the tallest and most slender part of the complex, is comprised of residential units, a small portion of the hotel and commercial space. Together with the adjacent volumes, it creates an urban room at street level that frames the public space and creates a strong dialogue between the site, the public square and Bleury Street. At the neighbourhood level, a second room is created, where the hotel and the residential tower intersect. At the metropolitan level, a third room echoes Montréal's distinctive skyline with its many skyscrapers and Mount Royal.

The three levels are superimposed, while a path through the building is cleared at ground level to assure the complex's openness and create fluidity between public and private spaces. Designed as a continuation of the adjacent public space, the heart of the complex is devised to be accessible, with a ground floor full of windows to the outside. The building seems to float along Bleury Street as it opens onto the inner square, forging physical connections and allowing for visual access to the urban landscape. The 9 x 110-metre blade of the complex overlooks the street corner, creating a captivating element for the square.

When considered as a whole, the building provides an intriguing image of two narrow blades splitting apart. The truncated shape of the taller blade pays tribute to New York's Flatiron Building. The second blade touches the ground though appearing detached from the monolithic portion of the building. This effect amplifies the visual experience for pedestrians as they observe the building from Place Jean-Paul-Riopelle. The blades are architectural beacons designed to connect the project on three planes. Separate from the portions it conceals, each blade has a specific tectonic quality that calls upon the architectural language of the three distinct levels of the urban environment.

The hive concept was incorporated to address the idea of a vertical community. The prefabricated balconies break with the scale of

1. La Joute is a sculptural installation by Jean-Paul Riopelle (1923-2002) composed of 30 bronze elements representing some of the animal and mythical figures that marked the artist's childhood and captured his imagination. The artwork features a circle of fire that rises in a fabulous exchange of mist and light at night.

the project to create a domestic space. The distinctive hives are not fully visible from the street. Arranged in staggered rows, the hives let natural light into the residential units and produce panoramic views from within them. Seen as a whole, the order and simplicity of the hives draw the eye.

A STATEMENT PROJECT

If the Humaniti project had to be described in just one word, that word would be "convergence." From an urban perspective, the complex is at the convergence of the Quartier des spectacles, the Quartier international and Old Montréal. Architecturally, the building is the result of the convergence of perfectly combined and interconnected mixed uses. And the building's engineering relies on the convergence of the structural capabilities of concrete and steel, providing this unprecedented project with the perfect blend of strength and spatial flexibility. Estimated at $200 million, work began in July 2017 and is scheduled for completion in 2020. AS

ELEMA Vice President Félix Bédard was awarded Young Engineer/Architect of the Year for this project at the CISC Quebec Gala on November 11, 2019.

NEW BERMUDA INTERNATI

Benson Steel leads steel work at new airport terminal

By Robert Morrison, P. Eng., Benson Steel

ONAL AIRPORT TERMINAL

IN MARCH OF 2017, the construction of a new, modern and dynamic passenger terminal at the L.F. Wade International Airport in Hamilton, Bermuda began. This multimillion-dollar project has a good deal of Canadian content, with CISC member Benson Steel Limited winning the bid for supply and install of the steel for the project, and Aecon Group Inc., a construction contracting firm from Toronto with a Bermuda subsidiary, winning the bid to design, construct and finance the project, along with long-term operation and maintenance.

In addition to these two Canadian companies being involved in the construction of the project, it is being financed through a public-private partnership between the government of Bermuda and the Canadian Commercial Corporation.

"The biggest challenge for our company to supply and install the steel for the airport was the distance from home and dealing with the shipping of the steel to the island," said Rob Morrison from Benson Steel. "This was a huge terminal requiring tall support 'Y' columns and long roof girders that did not fit into regular shipping trailers." He went on to say the larger steel parts had to be shipped in pieces and assembled at the site.

WORKING OFFSHORE

The steel requirements for the terminal were more than 3,400 tons (24,670 m^2). Doing this work on an island like Bermuda involved a number of challenges. One ongoing challenge was the time required to receive additional steel or other needs like parts for changes or revisions on the site. Normally supplies of this type could be easily accomplished in a few days for sites in Canada or the U.S. For Bermuda, it took anywhere from a week to two weeks to be shipped, and this had to be allowed for in the design, fabrication and overall construction schedule.

Moving steel to Bermuda for the job was a complex process. Steel prepared in Canada had to be ground transported to New Jersey where the shipping trucks were loaded on a ship. The ship then moved the trucks to Hamilton (the capital of Bermuda), and once offloaded, the trucks moved the steel to the site. The design team chose steel for the entire frame of the building. The building is more than 277,000 square feet, the largest project of its kind in Bermuda.

From a steel parts perspective, the terminal design included 46 columns to support the roofing and floor structure. Because of the height needed and the size of standard shipping trailers, the "Y" columns had to be shipped in three parts: the base columns and the special "Y" castings supplied by Cast Connex Corporation (one shop fabricated piece) plus two branches that completed each column. The diagonal trunk columns were also a challenge because of their shape and the difficulty of loading them onto a trailer. Once onsite, the three parts of the columns had to be assembled and field welded before installation.

Another interesting aspect of the design was Bermuda's approach to water conservation. The country does not have reservoirs or running water coming from the street for homes and businesses. The whole of the island operates on collection of rainwater for meeting the individual freshwater needs of each building on

From a steel parts perspective, the terminal design included 46 columns to support the roofing and floor structure.

the island. In keeping with this approach, the design of the terminal roof was sloped to allow for rainwater runoff into large cisterns situated in the ground. The collected water is then used for the airport. This green protocol added significant structure to the already complex terminal building.

The terminal also required design elements to comply with building standards established to minimize the effects of hurricanes. Though this did not directly affect the steel parts of the building, the design criteria was based on allowing "uplift" in the building structure to deal with the significant air pressure accumulation in a building when subjected to hurricane force winds. Many of the key connections in the structure of the building had to be somewhat flexible and expand to handle potential significant movement under hurricane conditions.

Other engineering issues that Benson had to deal with in Bermuda included elevating the foundation of the terminal. The elevated structure reduces risk of flooding and allows more natural light that improves energy efficiency. The terminal foundation was elevated to one metre above grade level to meet this concern.

A positive matter concerning engineering that worked well with the Canadian companies involved in the project is the use of Canadian construction standards for work being done on the island. Bermuda uses Canadian standards in a wide variety of areas because of a longstanding partnership with Canada on a number of fronts.

HISTORY IN BERMUDA

"Benson has had a long history of supplying steel to Bermuda," said Morrison. "This project, however, was the first time Benson took the lead on erection of the steel on a construction project." He went on to say that Benson used local

PROJECT DETAILS

PROJECT: L.F. WADE INTERNATIONAL AIRPORT REDEVELOPMENT PROJECT – BERMUDA **STEEL VOLUME:** 3,400 TONS (24,670 M²) **STEEL TYPE:** ASTM-A992

SHIPPING VOLUME: 179 TRUCK LOADS

SUPPLIERS & CONTRACTORS: AECON GROUP | BENSON STEEL | CAST CONNEX CORPORATION | SPN SUPPLIERS | SALIT STEEL | CANAM | SHERWIN WILLIAMS | PEDDINGHAUS | BOULONS PLUS | KUBES STEEL | LINDE | MACALLOY | SAL TRADING LTD.

steel erectors for the assembly, welding and installation of the structural steel and stair parts of the terminal.

The outer construction of the terminal is now complete and the interior of the building is being completed. The 277,300ft² terminal will feature larger security and departure areas as well as six new jet bridges, which are planned to increase to 11 in the future. The terminal will also have a large area for food, beverages and shops as well as lounges for passengers.

The steel and glass roof on the terminal has been designed to withstand the semi-tropical climate, and the interior is an open layout incorporating typical Bermudian architecture of sloping, triangular roof angles. The new terminal is being built on the existing airport property across from the old terminal to permit construction of the terminal without hindering any of the normal airport operations. The new terminal is planned to be opened in May or September of 2020. AS

For more information on the new Bermuda airport terminal, go to bermudaairport.com/about-skyport/new-terminal.

FEATURE

RECORD-BREAKING T

Erected by E.S. Fox Limited

By Steve Matthews, Area Manager, Structural Steel & Bridge Division

HRILL RIDE

THRILL SEEKERS anxiously awaited the opening of Canada's Wonderland Theme Park this year, as the 2019 season brought with it the public opening of the world's longest, tallest and fastest dive coaster.

The Yukon Striker Dive Coaster is Wonderland's newest attraction, taking park goers on an unforgettable ride as they plunge down 245 feet of track at 80 mph into an underwater tunnel, then soar up through four inversions, including a 360-degree loop – a record-breaking feature for a dive coaster. Ironworkers pieced together 107 various elements to create a 3,625' track that alone weighed up to 1,334 tons.

The opening of the ride was an exciting event for the public, but the assembly and erection of this high-profile attraction brought a thrill to the Ironworkers and constructors behind the scenes of the new coaster.

Being awarded this job was a huge victory for E.S. Fox Limited (a CISC Erector Member). The company was the only unionized bidder pre-qualified for this coveted contract, competing against many non-union coaster builders in the U.S. and Quebec. Even after erection began on site, E.S. Fox had to fight to keep this job in the hands of unionized Ironworkers. Claims were made by the Millwrights Union that this job was 100 per cent Millwright work because the roller coaster was a conveyor belt, and they demanded a markup meeting be held to discuss

A bird's eye view of two cranes lifting track elements to record-breaking heights.

the matter. After representatives from Local 721, E.S. Fox and the Millwrights Union met, the entire project remained as Ironworker scope.

The project was approximately 28,000 man-hours and involved several complex lifts in restricted areas while enduring intense winter weather conditions. Some operations required four to five cranes to execute. In spite of the various challenges, this was a dream job to many. "The Ironworkers loved working on this project and took a lot of pride in building it in the harsh Canadian winter." Said Steve Matthews, Area Manager of the Structural Steel and Bridge Division of E.S. Fox Limited, "Hats off to the crew for completing this job safely and on time despite a lot of inclement weather."

The Yukon Striker marks the third project completed by E.S. Fox Limited at Canada's Wonderland. It was a complex job that changed the skyline of Canada's premier theme park, and E.S. Fox Limited and Local 721 Ironworkers are proud to have been a part of it. AS

Two Ironworkers completing bolting operations at a splice location of two track elements.

Ironworkers guide the last track element into place for a 360-degree loop.

NEWS AND EVENTS

NEW MEMBERS & ASSOCIATES (SEPTEMBER 2019)

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Iraj Hoshyari
Langley, BC

Ragavan Srinivasan
Red Deer, AB

Ryan DeMerchant
Fredericton, NB

Sean Hutchinson
Toronto, ON

Kyle Girouard
Bathurst, NB

FEB (DAY TBD)

CISC Manitoba/ NW Ontario Day at the Legislature

MAR (DAY TBD)

Manitoba Careers Day

APRIL (DAY TBD)

CISC Quebec Steel Industry Research and Innovation Conference

MAY (DAY TBD)

CISC Day on the hill

MAY 14- 17

Canadian Steel Bridge Competition
Western University,
London Ontario

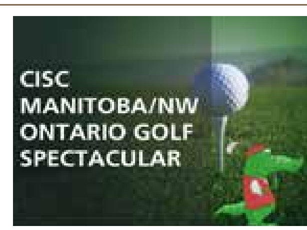
MAY 4-5

Skills Ontario Young Women's Conference

JUNE (DAY TBD)

41st Annual CISC Ontario Golf Day

JULY (DAY TBD)



Ontario 8th Annual Benefit Golf Spectacular

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Canadian Steel Conference

The Canadian Steel Conference is highly recognized as the steel construction industry's premier event to collaborate with key stakeholders and define industry best practices.
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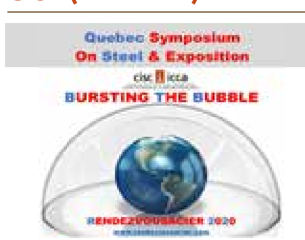
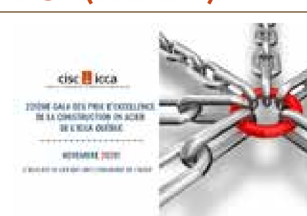
Date: Sept 28th-30th
Site: www.canadiansteelconference.ca

OCT (DAY TBD)



Quebec Symposium on Steel & Exposition

NOV (DAY TBD)



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COMMON CODES AND STANDARDS FOR DESIGN AND CONSTRUCTION OF STEEL STRUCTURES

Current Status and Future Publication Targets

Code/Standard/Supplement/ Commentary/Referenced Document	Current Edition	Next Edition/Revision	Publication Target
National Building Code of Canada (NBC)	NBC 2015	NBC 2020	Dec. 2020
NBC Structural Commentaries (Part 4 of Div. B)	NBC 2015 Str. Comm.	NBC 2020 Str. Comm.	2021
CSA S16 Design of Steel Structures	CSA S16-19	CSA S16-24	2024
CISC Commentary on CSA S16 (Part 2 of CISC Handbook of Steel Construction)	CISC Handbook 11th Edition[1] 3rd Printing[2]	CISC Handbook 12th Edition	late 2020
CISC Moment Connections for Seismic Applications	2nd Edition[3]	3rd Edition	Sep. 2019
CSA S6 Canadian Highway Bridge Design Code	CSA S6-19	CSA S6-24	2024
CSA S6.1 Commentary on Canadian Highway Bridge Design Code	CSA S6.1-19	CSA S6.1-24	2024
CSA G40.20/G40.21 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel	G40.20-13 G40.21-13	TBA	
CSA W59 Welded Steel Construction (Metal Arc Welding)	CSA W59-18	CSA W59-23	Sep. 2023
CSA W47.1 Certification of Companies for Fusion Welding of Steel	CSA W47.1-09 (R2014)	CSA W47.1-19	Summer 2019
CSA S136 North American Specification for the Design of Cold-Formed Steel Structural Members	CSA S136-16	Supplement No. 1	Spring 2019
CSA S136.1 Commentary on CSA S136	CSA S136.1-16	Supplement No. 1	Spring 2019

[1]CISC Handbook of Steel Construction - 11th Edition includes CSA S16-14, its Commentary, CISC Code of Standard Practice - 8th Edition (new), and design and detailing aids in accordance with CSA S16-14

[2]3rd Printing of Handbook has been updated to reflect changes introduced in CSA S16-14 Update No. 1 released in Dec. 2016

[3]Adopted in S16-14 by reference

TBA = to be advised

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www.norgatemetal.com

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www.structuresxl.com

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ADVANTAGE STEEL

NO. 66 WINTER 2020

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charmagned@mediaedgepublishing.com

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Senior Graphic Designer
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Published by:
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North York, ON M9N 2B2
Toll-Free: 1-866-480-4717 ext. 229
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PUBLICATION MAIL AGREEMENT #40787580

ISSN 1192-5248