ADVANTAGE STEEL

cisc icca
CANADIAN INSTITUTE OF STEEL CONSTRUCTION

NO. 69 FALL 2021

Architects Turn Vision into Reality with **Steel**

Credit: Diamond Schmitt

Red River College Project The University of Toronto Schools Redevelopment
Handsworth Secondary School The New David Geffen Hall Building

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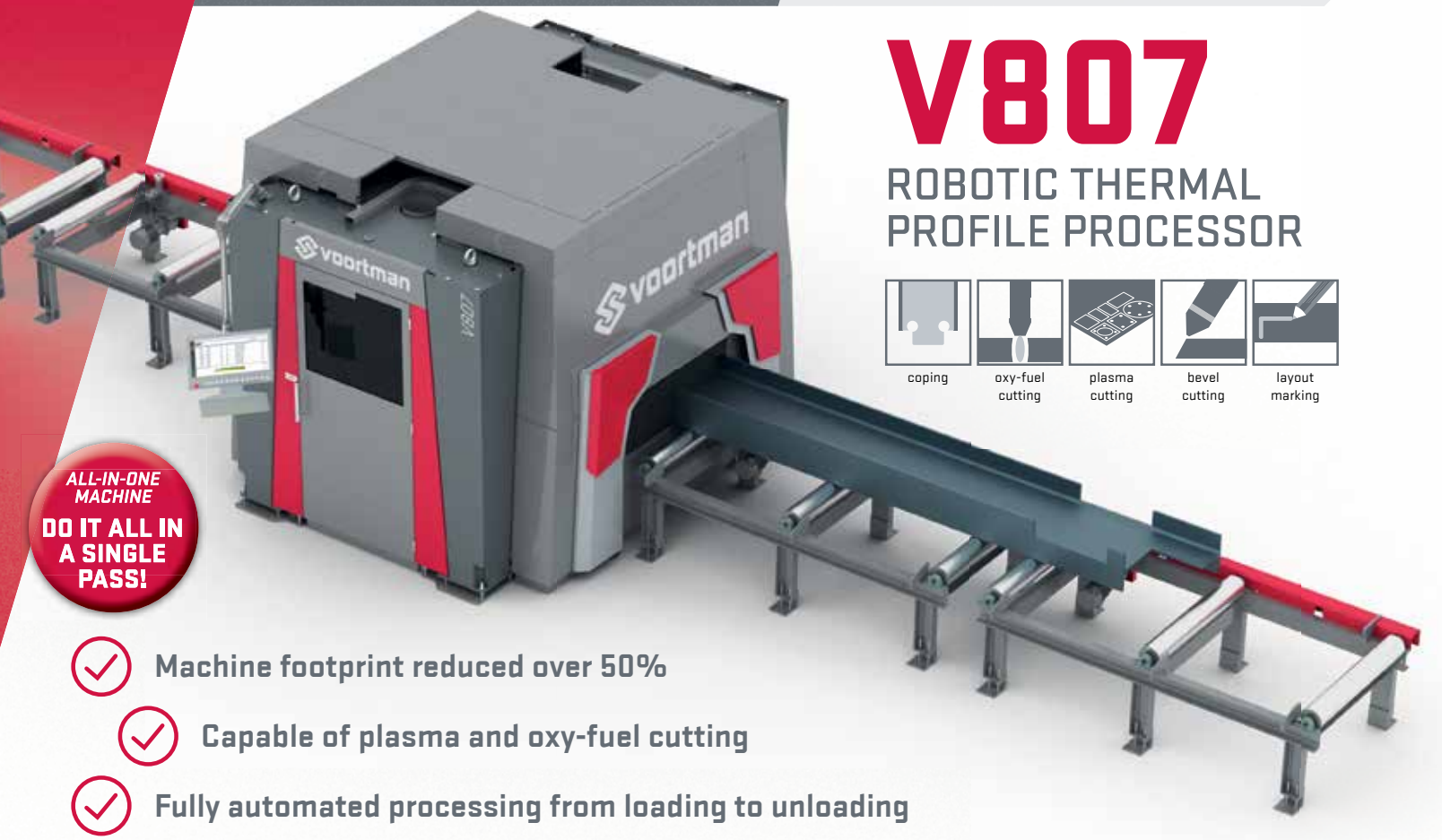

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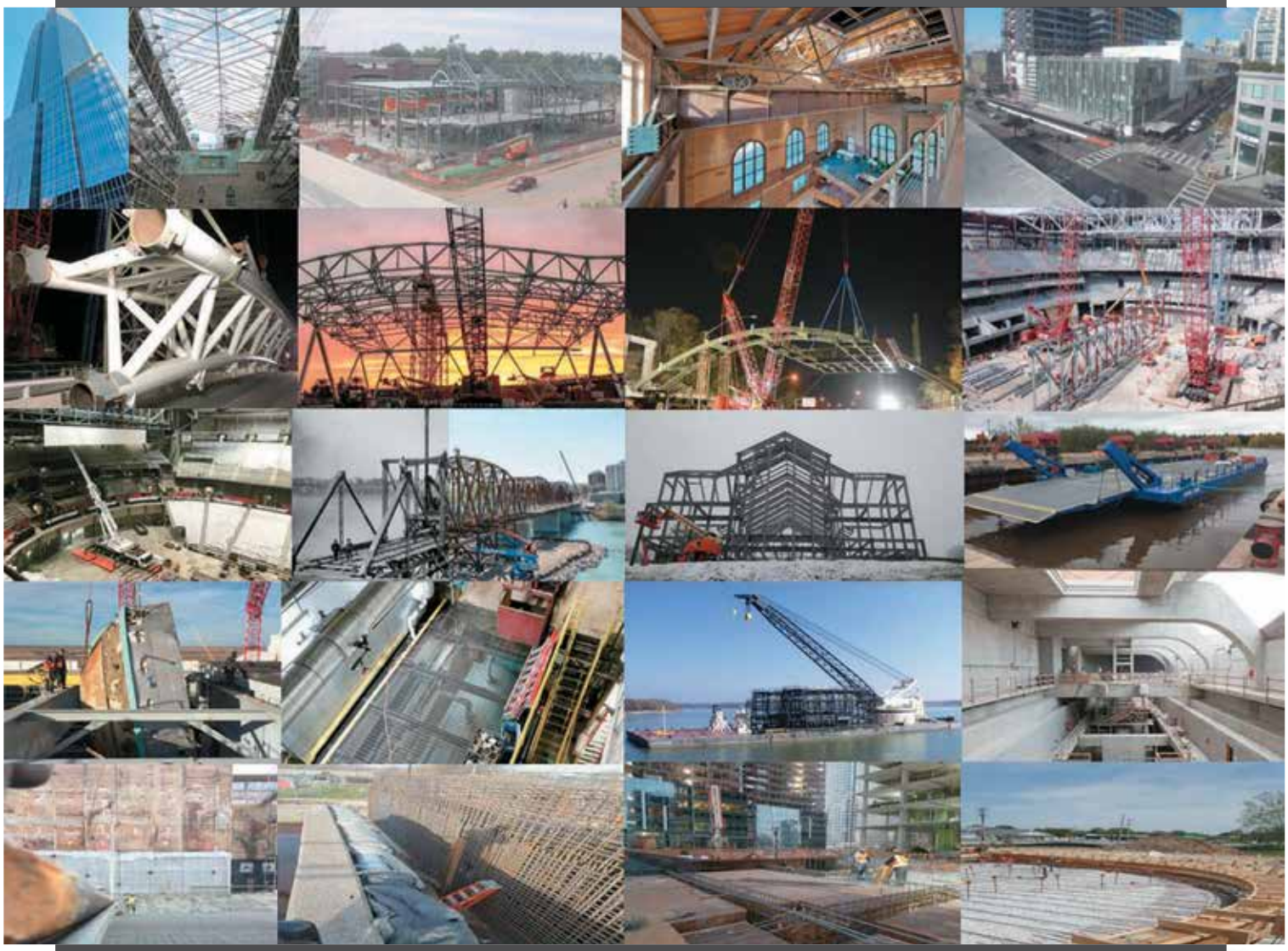

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ADVANTAGE STEEL

NO. 69 FALL 2021

IN EVERY ISSUE

COLUMNS

On the Cover:
Architects Turn Vision into Reality with Steel

RESEARCH FEATURES

FEATURES

The Canadian Institute of Steel Construction (CISC) is the voice for the Canadian Steel Construction industry. The CISC represents a diverse community of structural steel industry stakeholders including manufacturers, fabricators, erectors, service centres, consultants, detailers, industry suppliers, owners and developers. Steel construction industry stakeholders are encouraged to apply to become a member or associate. Visit cisc-icca.ca for more information. If you are working on a project that you think should be featured, send us an email at ciscmarketing@cisc-icca.ca.

ED WHALEN, P.Eng.
President & CEO
CISC-ICCA & CSSBI

Built in Canada Makes Carbon Sense

Most Canadians would agree that taxes paid by Canadians should go to back to benefit Canadians. If a government procures, Canadian companies, their employees and families should reap the benefit. Money spent within Canada has a multiplying effect. One dollar turns into five or six (for the steel industry) as it spins through the economy. Money spent by governments to on contracts awarded foreign companies is gone instantly, forever, with absolutely no further benefit to the Canadian economy, workers or to the tax base. This concept seems lost on most politicians unfortunately.

In 2020, the B.C. Government awarded the new Vancouver Pattullo Bridge knowing the steel work was going to China. As it stands today, the steel will be at least one year late and likely to cost much more than the Canadian design assist steel bid. In addition, China's steel has three times more greenhouse gas potential per ton than North American steel. Carbon produced in China doesn't shield Canada from global warming, nor should foreign procurement shirk governments' responsibility to lower its carbon procurement footprint. Governments advise us carbon has a cost and needs to be taxed to change behavior. What carbon tax will the B.C. government be paying for this outrageous, unnecessary carbon purchase? B.C., the land (sea) of the whales, nature, glaciers, old growth forests (sorry they cut them down long ago) and everything 60s, what were you thinking? Greta will be coming for you next.

The Liberal government has been pushing hard on carbon reductions. In an attempt to solve the world's carbon crisis single-handedly, they are mandating carbon rules (a.k.a. taxes) and are funding low-carbon, so-called "green" technologies. Surely, they will tax B.C. for their negative impact to the planet. Governments are all talking the carbon talk but are not themselves walking the walk.

Governments also want us to ditch fossil fuels and what better way to push us along that path than by penalizing Canadians with carbon taxes. But they fail to admit there is no infrastructure in place today to allow the transition to take place. They are taxing us before we have the ability to handle the change and shutting down domestic industries before their time. This is taxation for the sake of raising money, not for the good of the planet. For example, if everyone moved to electric heating furnaces and electric cars tomorrow, our power lines would melt from the constant 24-hour heat load. In addition, many provinces have electricity generation shortages looming. In Ontario, demand for electricity dropped during the great 2009 recession, but reports in Ontario identify major power grid shortages as early as 2024. So good luck to all you folks with new electric furnaces and shiny new plug-in cars. Major infrastructure needs such as power generation plants, electricity grids, water treatment plants and bridges are well known, needed yesterday and have yet to be designed, let alone constructed.

As we hope to be rounding the bend on COVID-19, we face a scary reality: debt. The federal government has been spending like drunken sailors on COVID-19 programs while the Canadian debt is climbing faster than the billionaires in space. At the end of all this, governments will be turning the tables and asking for their money back. So, what are the governments' plans to pay for this insurmountable debt? If the past has been any indication, they will use their favorite go-to: taxes. Tax everything.

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SHOW ME ONE STEEL PROJECT OFFSHORE THAT HAS GONE WELL FOR GOVERNMENTS. JUST ONE. **- ED WHALEN**

Meanwhile, governments are taking Canadian taxpayers' dollars, spending it offshore, getting sub-par product, paying more at the end of the day, experiencing lengthy delays, ending up in litigation and being responsible for generating three times or more greenhouse gases than the equivalent Canadian-built products. Meanwhile, Canadian companies with lower carbon footprints lay off skilled people due to government offshoring while governments in the same breath push for more construction apprentices. Governments out there…we won't need workers, let alone apprentices, if offshore countries get all the work and are not held to the same standards as Canadians. Show me one steel project offshore that has gone well for governments. Just one.

So, what do carbon emissions, short-sighted government procurement policies, the need for new infrastructure, huge COVID debt and the Canadian worker have in common? It turns out that we can come through this with a bit of wisdom, good planning, immediate action and the realization that the solution is Canadian businesses and their employees. Only with a strong tax base will the debt be repaid. In order to be successful, Canadian companies need constant work. A necessary baseload in construction comes from government infrastructure projects. Golly, it just happens that Canada and the provinces need a whole bunch of that stuff. If governments ensure infrastructure is built by Canadians, in Canada, we not only build a strong middle class (the Liberals used to chat up a storm about the middle class…maybe they know something we don't want to know) but also produce the lowest carbon construction projects possible, ensuring Canada has done all it can for a better low-carbon future. AS

CHARLES ALBERT, P.Eng.
Manager of Technical Publications & Services
CISC-ICCA

QUESTION 1: What is the difference between direct shear and tension- or compression-induced shear in a fillet weld?

ANSWER: Fillet welds are designed primarily to resist shear forces in accordance with CSA S16 Clause 13.13.2.2. Depending on the direction of the applied load, welds may be subject to different types of shear.

Let θ be the angle between the direction of load application and the fillet weld axis. When a weld is transverse to the line of application of a tensile force (θ = 90°), it is said to be under tension-induced shear, as shown in Figure 1(a). If the force direction is reversed, the transverse weld is subject to compression-induced shear (Figure 1(b)). And if the angle is θ = 0°, the longitudinal welds in Figure 1(c) undergo direct shear.

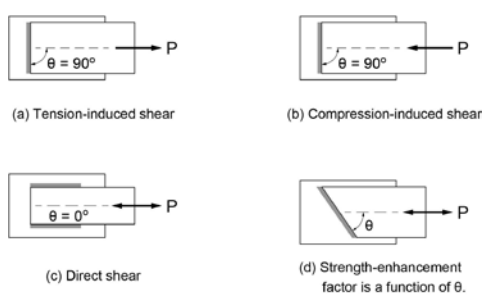

FIGURE 1
Shear in Fillet Welds

The load angle can also take on intermediate values between 0° and 90°, as shown in Figure 1(d), and the weld resistance will vary according to the strength-enhancement factor given in Clause 13.13.2.2. This factor ranges from a minimum of 1.0 for longitudinal welds (θ = 0°) to a maximum of 1.5 for transverse welds (θ = 90°).

According to S16:19, the strength-enhancement factor does not apply to single-sided welds, and its value would then be limited to 1. A double-sided connection is one where the fillet welds are placed symmetrically on both sides of a plate.

QUESTION 2: Is fire protection required for bracing members, or is it mainly columns and floor assemblies?

ANSWER: The answer is found in *Fire Facts for Steel Buildings* by R.G. Gewain, N.R. Iwankiw, F. Alfawakhiri and G. Frater (CISC, 2006), which states on page 33: "Column fire ratings are used not only for actual building columns, but also are applied to other members that are principally designed for axial loads, such as truss members and bracing."

This publication is available as a free download on the CISC website:
https://www.cisc-icca.ca/product/fire-facts-for-steel-buildings/

QUESTION 3: According to S16-14, connections in conventional construction are designed for the factored seismic forces based on R_d = 1.5 and R_o = 1.3, for building heights ≤ 15 m. However, the National Building Code of Canada (NBC 2015) states that connections must be designed so as not to yield. Is there a discrepancy here?

ANSWER: What the NBC 2015, Article 4.1.8.15.(1), refers to are diaphragm connections (e.g., deck collector connections, deck welds, etc.) and not connections of primary framing members such as bracing connections in seismic force-resisting systems. Some yielding of the bracing connections in conventional construction can be expected, but the failure mode must be ductile (otherwise they must be designed for the gravity loads combined with the seismic loads multiplied by R_d) when $I_E F_a S_a(0.2) > 0.45$, according to S16-14 Clause 27.11. Also, connection forces need not exceed the grosssection strength based on the probable yield stress, $R_y F_y$. A discussion on what constitutes a ductile failure mode can be found in the Commentary to Clause 27.11 in Part 2 of the *Handbook of Steel Construction*.

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.

CISC at the Forefront of Leading-Edge Research

BY :: CRAIG MARTIN, P.Eng.
Chairman of CISC's Education & Research Council

One thing we can rely on is change. Sometimes change is imposed on us, but often change results from finding new ways of doing things. CISC and the Education & Research Council (ERC) sees the value of innovation and positive change in our industry to ensure that steel continues to be the material of choice for Canadian infrastructure.

One of the ways we can drive innovation in our industry is through the support of applied and academic research. Canada is fortunate to have several post-secondary institutions that have a passion for steel design, metallurgy, welding and other key aspects of our industry, and their focus on research in these areas is invaluable to the long-term sustainability of the steel construction sector.

The ERC has made research one of our key areas of focus and support, and we are pleased to be able to be a partner with multiple institutions across Canada. Each year, we reach out to universities and colleges across Canada to see how we can help their research initiatives – those that are focussed on advancing the use of steel as a construction material. The forerunner of the ERC, the Steel Structures Education Foundation, established this key program in 1995, and since that time over 110 research grants have been awarded to over 10 institutions.

Typically, three to five grants are awarded each year with an average grant level of around $25,000. Applications for research grants are rigorously reviewed by the ERC's Research Committee, which considers many factors including the level of positive impact on our industry. This committee is made up of representatives from fabricators, consulting engineers and steel producers. The ERC also annually surveys CISC members for their input on areas of research that they feel are of current and primary importance; these suggestions are shared amongst our network of institutions for their consideration.

In addition to the research grant, the principal researcher of the highest-ranked proposal receives the H. A. Krentz Research Award and a gift of $5,000. The award is made in honour of H. A. Krentz who made significant contributions to the engineering profession, the development of codes and standards, the education of engineers and to the development of the Canadian steel industry.

Over the years, dozens of fascinating and leading-edge research has been completed with the support of the CISC ERC. These include research related to:

- Seismic design
- Welding of hollow steel sections (HSS)
- Steel design software
- Behaviour of welds at low temperatures
- Fatigue performance of steel bridges
- Blast resistance of steel members
- Modular steel construction
- Fire resiliency
- Artificial intelligence (AI) in steel construction

This is just a small sampling of topics, and this research has resulted in the improvement of our design and fabrication standards, more efficient fabrication methods and improved safety of fabricated steel structures – all of which support the long-term sustainability of our industry.

On behalf of the ERC, I would also like to express our gratitude for the continued support of the CISC and our funding partners. We have accomplished a great deal with your support and are focussed on expanding our support to address our industry's changing needs. If you have a passion for supporting the next generation of steel professionals and for the future of the Canadian steel construction industry, I encourage you to consider becoming an ERC financial supporter. AS

THANK YOU

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The CISC Student Design Competition

The Challenge of Detailing in Steel

BY :: TERRI MEYER BOAKE, BES BArch MArch LEED AP, Professor, School of Architecture, University of Waterloo

If you are thumbing through this issue of *Advantage Steel* and stopped to read this article because you were intrigued by the images, thank you. I hope you are impressed to think that a pair of fourth-year architecture students, James Kwon and Phil Carr-Harris, created these, taking the Award of Excellence for the 2021 Competition. The concept of a prefabricated, dismountable and changeable canopy system was in response to the CISC Annual Architecture Student Design Competition theme: The Market – A Grand Steel Canopy.

The themes of the annual design competition have been purposefully left very open of the 20 years of its offering: Span, Tension, Tower, Bridge, Cantilever and Canopy. The idea is to encourage students to understand the essence of the relationship between steel and the theme. The program is important, but intended to work in concert with materiality as expressed in steel – largely in Architecturally. (AESS), which I have no shame in admitting is one of my very favorite materials.

CISC has put great effort into encouraging students to embrace a side of designing in steel that often falls outside of the standard curriculum. All accredited Schools of Architecture are required to address structural design, to a point – but not normally to the point of truly understanding the benefits of the material in an architecturally expressed condition, nor to the point of being able to detail to the point of credibility. It is the architect who specifies AESS in a project. This competition is intended to encourage future architects to explore the architectural applications of steel in a very creative way.

The CISC Competition has been a part of my course requirements at Waterloo Architecture since its inception. Our entire first-year class does this competition as a co-requirement for their Building Construction and Digital Design classes. A team of our first-year students Meghan Engelen, Maggie Claus and Eric Duplessis (yes, around 18 years old) took second place in the competition this year. I also teach a dedicated upper-level elective in Architectural Steel Design that makes the CISC Competition its final project. A team from my elective, Elise Cloutier and Steven Lin, took third place this year. This year's Award of Excellence winners entered their final project in last year's competition, winning an Award of Merit, but chose to enter again this year – not because it was required, but because they wanted to. They find this sort of open-ended design challenge fun.

What I found truly inspiring when looking at the entries this year was understanding that this was a COVID year. All of this work was done in a remote, online environment. There was no ability of professors to pour over the shoulders of students to offer help. The students themselves were not necessarily in the same space but if not, they were collaborating online. If asked, I engaged in Zoom calls and provided feedback on ideas and detailing, but largely this sort of competition work is independently done.

Waterloo Architecture is proud that our students do so well in the CISC Competition, but in truth, CISC has been looking to be more broadly inclusive and encourage more entries. All architecture programs of three years in length are eligible to submit. In 2022 Architectural Engineering students will also be eligible. The entries can be part of a course requirement or extra-curricular. The prize money is amazing, with $8,000 going to the winning team. There are numerous resources available online to assist students with their work, most created by myself in an effort to allow all students to easily access helpful materials. The focus of my teaching is to empower students to design by helping them to understand detailing.

If any fabricators find themselves intrigued, the competition is always looking for sponsors. The aim is to put steel in the front of mind for the next generation of architects, and that is good for business!

For more details, please visit the competition website: https://www.cisc-icca.ca/architectural-student-design-competition/ AS

"CISC HAS PUT GREAT EFFORT INTO ENCOURAGING STUDENTS TO EMBRACE A SIDE OF DESIGNING IN STEEL THAT OFTEN FALLS OUTSIDE OF THE STANDARD CURRICULUM." **-TERRI MEYER BOAKE**

Inspired by Nature, Made with Steel

Common Market Concept Earns First Place in CISC Student Design Competition

BY :: JAMES KWON AND PHIL CARR-HARRIS, University of Waterloo

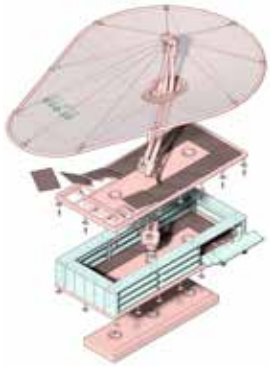
Exterior view of the Common Market canopy system.

Inspired by the protective water shedding properties inherent in trees, the Common Market is a collection of a single steel module that can be arranged as diversely as the neighbouring community requires it to be. The module consists of a ballast-like base and a soaring canopy. It is designed to be easily shipped, erected and modified depending on the desired arrangement of the market. Once the prefabricated base and canopy are constructed, additional elements to the base can support market functions, restaurants, seating areas, exhibition spaces, washrooms and storage.

Three circular base plates inserted along the length of the concrete ballast allow flexibility and freedom in the canopy positions, with new arrangements of canopies able to be premeditated every time the market is reconstructed. A base frame of square hollow structural steel is shop-welded together with additional elements such as retractable legs and modular shelving. This assembly is then mounted on top of and fixed to the concrete ballast.

It is at this point the column that supports the canopy can be erected. Identical custom cast nodes are fixed to the base and top of the column. A tension member spanning between them offers further rigidity to the assembly when wind loads force it further into a state of compression or tension.

The protective canopy itself is fixed to a curved rim of hollow structural steel and is made of upcycled sails for their lightweight and weatherproof characteristics. Once aggregated on-site, the experience of traversing underneath the canopy is akin to that of a forest. The freedom and lightness of these canopies allows it to be understood as a true public space, a natural extension of the city. AS



Exploded view of the Common Market canopy system. Temporary/modular elements are in blue, permanent elements are in pink.

Exterior view of the Common Market canopy system.

STRENGTHENING OUR COMMITMENT TO EDUCATION & RESEARCH

The CISC Education & Research Foundation is a firm believer in investing in our tomorrow today. We are committed to excellence in design and construction in the steel industry, as well as ensuring quality for the future. We remain dedicated to supporting the next generation of steel professionals through various programs and direct funding for research and education at leading Canadian educational institutions.

Our Education & Research programs continue to help students and steel professionals discover innovative steel solutions to solve the most complex design and construction challenges while positioning steel as the material of choice.

THE 2021 RECIPIENTS!

ARCHITECTURAL STUDENT DESIGN COMPETITION

The competition aims to introduce architecture students to the use of exposed structural steel and show them the design potential in terms of formal expression, detail, and surface finish. The design must demonstrate an understanding of the properties and possibilities steel has to offer. The competition theme requires students to: elaborate a structural grid with steel elements, design buildable connections and, collaborate with a steel fabricator to choose the steel members and the connections. In 2021 there were three winners and 4 honourable mentions.

ARCHITECTURAL STUDENT DESIGN COMPETITION
1st Prize
$8,000 (team) - $2,000 (sponsor)
Project: Common Market
University: Waterloo
Students: James Kwon and Phil Carr-Harris
Advisor: Terri Meyer Boake

ARCHITECTURAL STUDENT DESIGN COMPETITION
2nd Prize
$4,000 (team) - $1,000 (sponsor)
Project: Market on Ice
University: Waterloo
Students: Meghan Engelen, Maggie Claus and Eric Duplessis
Advisors: J. Cameron Parkin and Justin Forrest Breg

ARCHITECTURAL STUDENT DESIGN COMPETITION
3rd Prize
$2,000 (team) - $500 (sponsor)
Project: Queens Quay Commons
University: Waterloo
Students: Elise Cloutier and Steven Lin
Advisor: Terri Meyer Boake

2021 G.J. JACKSON FELLOWSHIP

This prestigious award of $25,000 over a one-year period is presented annually to an engineering student who, in the following academic year, will be registered in the first to fourth year of full-time graduate studies in structural engineering, with major emphasis on the study of steel structures. It is awarded annually in memory of the late Geoffrey Jackson, for many years a leader in the Canadian structural steel fabrication industry and a founding member of the Steel Structures Education Foundation (SSEF), now the CISC Education & Research Council.

Michelle Chien
PhD Candidate
Winner: $25,000
University of Waterloo
Supervisor: Scott Walbridge

G.L. KULAK SCHOLARSHIP

This scholarship is an annual award available to postgraduate students doing research in structural steel.

Ahmed Mowafy, MSc
Ph.D. Candidate
Winner: $15,000
University of Alberta
CISC Alberta region
Supervisors: Dr. Ali Imanpour and Dr. Ying Hei Chui

ARCHITECTURAL SCHOLARSHIPS
THE CISC EXCELLENCE AWARDS IN STEEL DESIGN

The Canadian Institute of Steel Construction advances the application and use of steel in structures through education and is committed to providing funding for architecture students who demonstrate a keen interest in steel as a construction material and demonstrate high academic qualifications through a research or studio project.

Katie Wimmer - Dalhousie University - **$3,000**
Byron Ca - University of Waterloo - **$3,000**
Patrick McGowan & Etienne Bérubé - Carleton University - **$3,000**

CISC ARCHITECTURE LECTURE SERIES

Ryerson University - **$2,500**

CONESTOGA COLLEGE STRUCTURAL STEEL PROGRAM STUDENT SCHOLARSHIP

$10,000
$2,000 each to: Maninder Singh Sandu, Manik Singh Chaudhary, Vivek Balmuri, Reeba Roy Mannoor, Harshitha Jasti

H.A. KRENTZ AWARD

This award recognizes the principal researcher whose research topic has special merit and interest, with promise that it will make a significant contribution to the understanding of the behaviour of, or advances in the economy, safety or reliability of steel structures.

Robert Driver
Winner: $5,000
Ph.D., P.Eng., F.CSCE, F.SEI
Professor of Structural Engineering
Department of Civil and Environmental Engineering

CISC RESEARCH GRANTS

The Research Grants program was created to support the research at Canadian universities and technical colleges on topics that are considered to be of interest and importance to the steel industry. Over 100 research grants have been awarded since 1995 to full-time members of engineering faculties of Canadian universities. As of 2016, the program has been opened up to qualified technical colleges.

Total amount granted in 2021: **$45,000**
Recipients
McMaster University
Polytechnique Montréal
Dalhousie University
University of Victoria

Probabilistic Analysis of Brittle Fracture Design Code Provisions for Steel Bridges

BY :: MICHELLE Y.X. CHIEN, BASc, University of Waterloo
Prof. SCOTT WALBRIDGE, PhD, University of Waterloo
Prof. BERTRAM KÜHN, PhD, Technische Hochschule Mittelhessen, Germany

Significant advances have been made around the world surrounding the sophistication of tools available for modelling and understanding brittle fracture. These advances move beyond the simpler approaches currently used in North American design codes, one of these being the fracture mechanics method in the European EN 1993-1-10 standard. The current Canadian standards for brittle fracture base design requirements solely on the minimum service temperature of a geographic region, despite evidence that temperature is not the only factor that plays a significant role in fracture behaviour of steels. In contrast, EN 1993-1-10 takes into consideration numerous factors such as plate thickness, yield strength of the material, stresses on the component, radiation losses, member shape and dimensions, safety allowances, strain rate and degree of cold forming, if applicable (European Commission 2006). While adaption of similar approaches in North America to assess these special situations may be of interest, it is worth noting that in no part of the world has a rigorous probabilistic assessment been performed to assess the reliability levels being achieved using the various existing brittle fracture design methods.

Previously, a basic analysis was done to compare the brittle fracture provisions in EN 1993-1-10 with CSA S6-19. This analysis found that the toughness requirements of

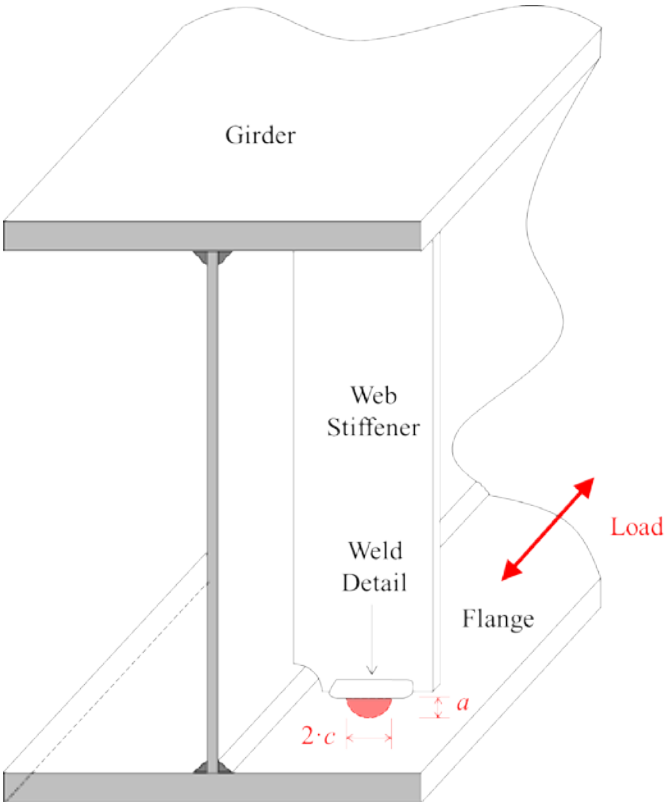


Figure 1: Investigated weld detail and initial crack geometry.

"IN NO PART OF THE WORLD HAS A RIGOROUS PROBABILISTIC ASSESSMENT BEEN PERFORMED TO ASSESS THE RELIABILITY LEVELS BEING ACHIEVED USING THE VARIOUS EXISTING BRITTLE FRACTURE DESIGN METHODS." **-MICHELLE Y.X. CHIEN**

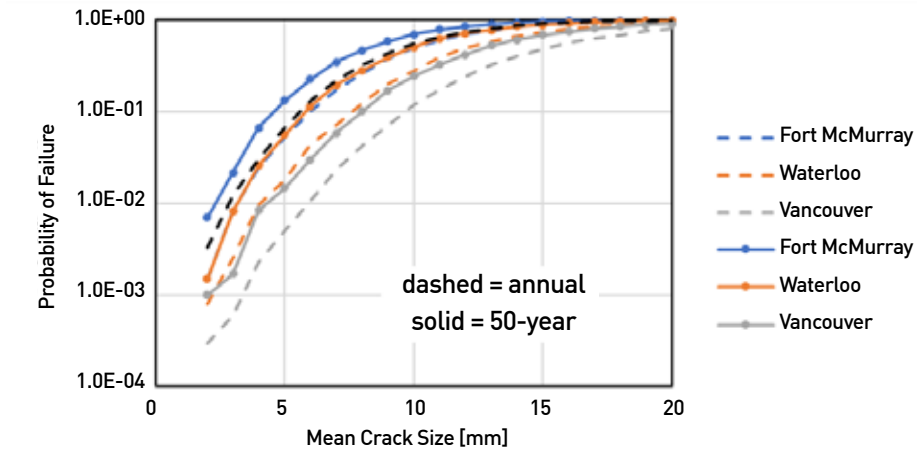


Figure 2: Pf vs. crack size (T27J = -20 C)

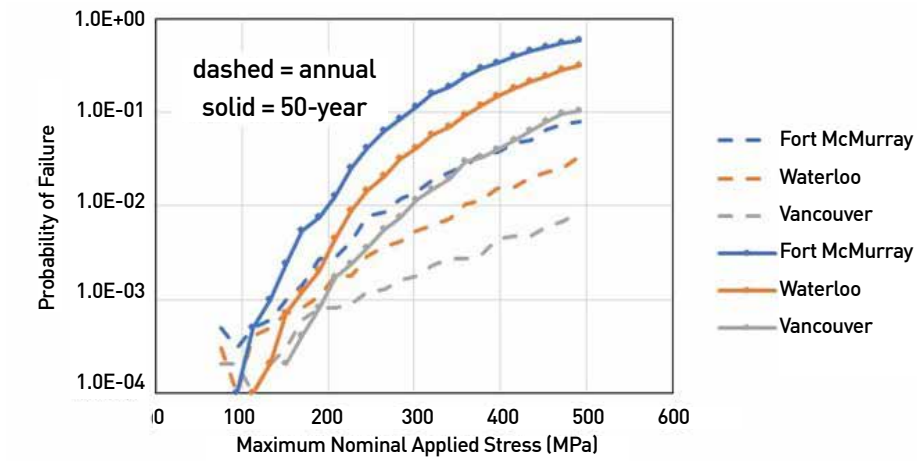


Figure 3: Pf vs. maximum nominal applied stress (T27J = -20°C)

CSA S6 are more conservative than EN 1993-1-10 for thinner plates, that the design provisions in both codes result in the same toughness requirement in the middle range of plate thicknesses, and EN 1993-1-10 is generally more conservative for thicker plates. This research has recently been extended to a probabilistic framework by varying the input parameters of the fracture mechanics model and observing the sensitivity of failure probabilities to these changes.

The equations and tables needed for the probabilistic analysis were programmed using Visual Basic. Statistical distributions for the key input parameters were identified and probability of failure was determined by Monte Carlo Simulation (MCS). For this analysis, the loads, dimensions and boundary conditions were again obtained from the CISC Straight Plate Girder Bridge Design Example 1. In order to study the effect of extreme cold temperature on the probability of brittle fracture, the fictitious bridge was "placed" in three locations: Fort McMurray, AB, Vancouver, BC, and Waterloo, ON.

A suitable target reliability index of β = 4.0 for brittle fracture was identified based on CSA S6 Chapter 14 (Canadian Standards Association 2019) for brittle element behaviour in a structural system with no redundancy and limited inspectability under normal traffic. Additionally, bias factors were applied to the deterministic model parameters, typically in the form of "multipliers," which are defined to account for the various sources of uncertainty associated with each parameter.

Results showed that the probability of failure is not sensitive to changes in weld size nor plate width. For the crack size sensitivity analysis, the mean depth (a) for a semielliptical crack in a web stiffener detail (see Figure 1) was varied between 2 mm and 20 mm. Not surprisingly, the probability of failure increases with increasing crack size. Additionally, as the climate becomes more severe, the probability of failure curve shifts upwards, presented in Figure 2. It can be seen that the annual probability of failure curves are – as expected – lower than the curves corresponding with a 50-year service period.

In a study on the maximum nominal applied stress at the detail, the results (see Figure 3) show an expected increase in the probability of failure with an increase in the maximum nominal applied stress. It should be noted that the higher stress levels in this analysis exceed the nominal yield strength of the steel. This raises broader questions regarding the competing ductile and brittle fracture failure modes and warrants further study.

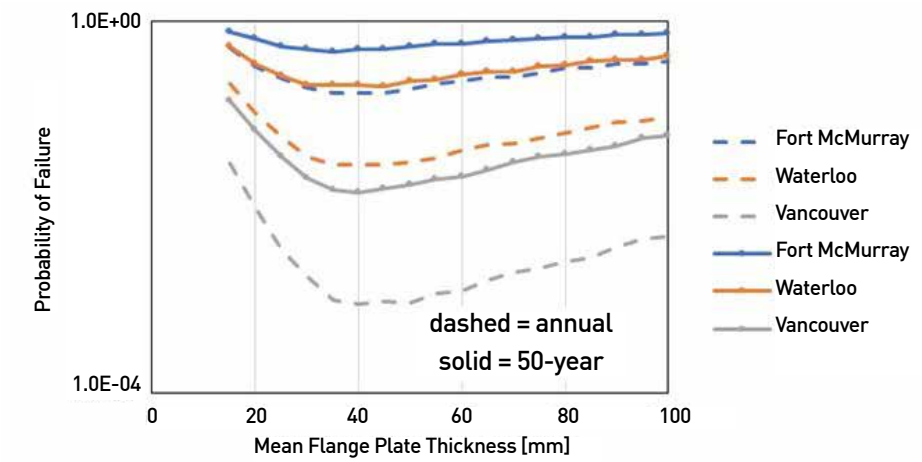


Figure 4: Pf vs. plate thickness (8 mm mean initial crack size, T27J = -20 C)

The results from a study on the flange plate thickness interestingly showed a local minimum point in the pf vs. flange plate thickness output, in contrast with the monotonically increasing curves obtained in the first two studies. Initially, the failure probability is high, as the crack takes up a significantly large proportion of the overall plate depth, making it a point of weakness as there is an insufficient amount of uncracked flange area to prevent failure. In the first portion of the graph, pf decreases when the thickness increases, as gradually the crack is taking up less of the cross section. At a point near 50 mm thickness, the local minimum is reached. Beyond the optimum point, the pf increases again as the increased thickness causes a reduction in ductility. The graph for the 8 mm crack is shown in Figure 4.

Plate thickness variation was simulated for four different mean initial crack sizes ranging from 6 to 12 mm. In general, the trends were similar. However, as the mean crack size increases, the flange plate thickness for which the probability of failure by brittle fracture is a minimum also increases. Also, as expected, the probabilities of failure increase for all cases with an increase in severity of the local climate.

Based on these results, we can observe potential areas of improvement to the current Canadian standards for brittle fracture, but there remains work to be done to consider other sources of uncertainty, e.g. in the thickness correction, plasticity correction, etc. Further literature review and new experimental work may be needed to better characterize the statistical variables for the North American steels where they are not available, traffic loading, etc. It must also be acknowledged that the treatment of the traffic load and extreme cold temperature in this analysis is highly simplistic and an area where future work is needed (and planned). An important next step of this work will be to cast the problem as a time-dependent reliability problem, with the extreme traffic and temperature loads fluctuating more realistically over time.

A final recommended improvement would be to consider the competing mechanisms of ductile and brittle fracture in a more sophisticated way, such as considering the two failure mechanisms simultaneously for each trial in an appropriate system reliability model. It is hoped that the work presented here will be found to be useful, however, for assessing the importance of the various model parameters on the probability of failure by brittle fracture of steel bridge structures. AS

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A Trip Down Memory Lane

BY :: HELLEN CHRISTODOULOU, PH.D. Ing., B.C.L., LL. B, M.B.A.
Director, Steel Market and Industry Development
Canadian Institute of Steel Construction (CISC-ICCA)

The Research Grants program was created by the CISC to support research at Canadian universities and technical colleges. This commitment to research on topics that are of interest and importance to the steel industry is critical for building the future of the steel construction industry. Over 100 research grants have been awarded since 1995 to full-time members of engineering faculties of Canadian universities, and as of 2016, the program has been opened to qualified technical colleges.

In partnership with the steel industry, the CISC's Education & Research Foundation awards research grants that have an immeasurable value to the advancement of the use of steel in construction. These grants have a pivotal role in supporting innovative and industry-leading research advancements that address the specific needs of industry development and are geared towards providing support to those who are dedicated to the improvement of steel construction. The steel industry is the backbone of these efforts, with many long-standing partners that are firm believers and share CISC's vision in investing in our tomorrow today.

To achieve excellence in design and construction in the steel industry, it takes continuous dedication in supporting the next generation of steel professionals through various programs. This support, with direct funding for research and education at leading Canadian educational institutions, promotes and advances the discovery of innovative steel solutions targeted to solve the most complex design and construction challenges while positioning steel as the material of choice.

Let's take a trip down memory lane and reminisce about some of the research investments done in the last 10 years! The CISC lives up to its entrenched role as the **"Voice of the Steel Industry".**

2011

Tension-Only Brace System for Earthquake Resistance of Low-Rise Buildings: Shake Table Testing, University of British Columbia

Lateral torsional buckling of plate girders with flexible restraints, Dalhousie University

Dynamic Testing of Low-Rise, Steel-Framed Buildings with Flexible Roof Deck Diaphragms, McGill University

A Holistic Approach to Evaluating and Enhancing the Progressive Collapse Resistance of Steel Structures, University of Alberta

Development of Innovative Steel Structural Systems for Seismic Applications in Canada, University of British Columbia

2012

Life Cycle Assessment of Steel-Framed, Multi-Unit Residential Construction, Ryerson University

Development of Generalized Design Procedures for Steel Extended Shear Tab Connections, University of Alberta

Hybrid (steel-frame / timber in-fill walls) Design for Mid-Rise Hybrid Systems, University of British Columbia

Shear Tab to Hollow Structural Section Column Connections, Lakehead University

Development of High-Performance Sustainable Steel Truss Frames for Seismic Applications, University of British Columbia

Dynamic Stability of Steel Columns Subjected to Seismic Loading, McGill University, École Polytechnique Université de Sherbrooke

2013

Solving the Mystery of Double-Coped Beams, University of Alberta

Behaviour of Light-Gauge Steel Shear Walls with Screwed Infill Plate Connections for Regions of Low to Moderate Seismicity, Concordia University

Development of Ry, Rt Factors and Probable Brace Resistance Axial Loads for the Seismic Design of Bracing Connections and Other Members, McGill University

Fatigue Behaviour and Design of Shear Connectors in Steel-Precast Composite Girders, University of Waterloo

Development of Innovative and Cost-Effective Seismic Fuses Using Wide Flange Steel Sections, University of British Columbia

2014

Development of High-Performance Modular Steel Structures, University of British Columbia

Effective Weld Properties for Connections of Round HSS, University of Toronto

The Increasingly Common Case of Weak-Axis End Moments – Eliminating Unnecessary Joint Stiffeners, University of Alberta

Reducing Construction Costs by Improving Seismic Performance: Controlled Rocking Steel Braced Frames, McMaster University

Design of Partial-Length Cover Plates to Strengthen Steel Columns, University of Western Ontario

2015

An Improved Connection for Seismically Designed Concentrically Braced Frames, McMaster University

Offset HSS Connections, University of Toronto

Development of Innovative and Economical Steel Floor System, University of British Columbia

Towards a Performance-Based Fire Design Framework for Composite Steel Deck Construction in Canada, Carleton University

Lateral Torsional Buckling of Welded Wide Flange Beams, Concordia University

2016

Performance-Based Seismic Design of Steel Bridges According to CHBDC S6-14, University of British Columbia

Development of Innovative Steel Diagrid High-Rise Structures for Seismic Applications, University of British Columbia

Completing the Load Path for Controlled Rocking Steel Braced Frames, McMaster University

Hot Dip Galvanized HSS, University of Victoria

Promoting Steel as a Material of Choice in Bridge Infrastructures: Current and Future Innovations, Ryerson University

2017

Simplified Design Methods for Steel Multi-Tiered Braced Frames in Regions of Low and Moderate Seismicity, University of Alberta

Design of Beams with Overhanging Segments Against Lateral Torsional Buckling, Laval University

Analysis of Concentrically Loaded Braced Frame Using Continuous End Plate, Université de Sherbrooke

Performance-Based Seismic Design of Innovative Damage Free Rocking Steel Bridge Piers, University of British Columbia
École Polytechnique de Montréal

2018

HSS Joint Welding, University of Toronto

Experimental Validation of Seismically Resilient Concentrically Braced Frames with Replaceable Brace Modules, McMaster University

Test-Based Design Method for Steel Cantilever Beams, University of Alberta

Assessment of Fatigue Design Provisions for Welded Shear Studs in Steel-Concrete Composite Bridges, University of Waterloo

2019

Design of Single-Sided Fillet Welds in Tension, Dalhousie University

Application of Artificial Intelligence to Performance-Based Earthquake Engineering of Steel Buildings, McMaster University

Improved Evaluation Methods for Fatigue Life and Toughness Assessment of Steel Bridges, University of Waterloo

Design of Exposed Column Base Connections Subjected to Axial Load and Bi-Axial Bendin, Lakehead University

Innovative Modular Structural System for Steel Framed Structures, University of Alberta

2020

Artificial Intelligence Applications for Advancing the Canadian Steel Construction Industry, University of Alberta

Enhancing the Design of Connections for Fire Resiliency, Queen's University, York University

2021

Lighter Concrete Shoes: Towards Lower-Cost Foundations for Seismically Designed Steel Braced Frames McMaster University, École Polytechnique de Montréal

Next-Generation Green Steel Construction in Canada, University of British Columbia

Moment Connections to RHS Columns, Dalhousie University

Stress Concentration Factors for Truss/Girder-End Hollow Section Connections Near an Open Chord End, University of Victoria

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Meet the Architects

The visionaries behind steel projects

BY :: HELLEN CHRISTODOULOU, PH.D. Ing., B.C.L., LL. B, M.B.A., Director, Steel Market and Industry Development, Canadian Institute of Steel Construction (CISC-ICCA)

For many years our readers have enjoyed the amazing articles in CISC's *Advantage Steel* magazine. One dedicated edition after another has featured incredible steel projects, buildings, bridges and structures. All, in their unique way, were a testament of their exclusive character, of the complexity in the design, of the ingenuity and preciseness of fabrication and detailing, and of the effectiveness of the construction and project execution. For many, the inspiration was born from an intriguing architectural concept – a concept that displayed the beauty of steel. These projects unravelled the many desirable characteristics of steel and its wide range of applications, and the articles delineated the reasons why steel, above all materials, has gained popularity in the fields of architecture and construction.

This edition of *Advantage Steel* will bring it up a notch as it will unfold into a slightly different direction. The focus of this issue will be on the visionaries, the architects!

Steel is a material of choice for many architects; it is recognized for its intrinsic beauty and aesthetics, its structural integrity, its versatility and its harmonious integration with other materials. The realizations we have seen throughout the years are nothing but awe-inspiring. With vision and wit, architects have managed to conceptualize beyond a building's or a bridge's skeleton and demonstrated their abilities and talents by creating innovative, practical, sustainable and distinctly fluid structures!

This edition of *Advantage Steel* will highlight nine distinguished architects and how they successfully realized their vision by choosing steel. We will take you through the journey of how they brought their projects to fruition and unveil how their successes were premised on the importance of collaboration and expertise of the entire project team, namely the engineers, the fabricators, the detailers, the erectors, the project managers and the clients.

The take-away is that steel, the most sustainable material in the world, has reached new heights – becoming the nucleus for architectural vision.

UNIVERSITY OF TORONTO SCHOOLS, TORONTO
DIAMOND SCHMITT ARCHITECTS

DONALD SCHMITT (DON)
Member of the Order of Canada, FRAIC, OAA, AAA, NSAA, Architect AIBC, M.A.A., AANB, NWTAA, AIA, NCARB

Donald Schmitt, a principal of Diamond Schmitt Architects, is a well-known Canadian architect whose practice is built on the transformative power of design. He is passionate about functionality, innovation, elegance and sustainability.

DIANA SARAGOSA
Certified Passive House Designer
OAA, RAIC

Diana Saragosa, a member of the Diamond Schmitt Architects team, is a licensed architect and a Passive House Certified Designer who has worked on a range of projects in a variety of roles. She is also an Adjunct Assistant Professor at Columbia.

RED RIVER COLLEGE
DIAMOND SCHMITT ARCHITECTS

SYDNEY BROWNE
OAA, FRAIC, AAA, AANB, M.A.A.
LEED®AP

Sydney Browne is a principal at Diamond Schmitt Architects. Sydney brings significant experience and expertise and is best known for her work in programming and designing academic and learning student facilities that incorporate state-of-the-art digital technology and sustainable design principles.

MICHAEL LECKMAN
MRAIC, NCARB, RCA
Co-chair, City of Toronto Design Review Panel

As Principal at Diamond Schmitt, Michael Leckman's design of college and university buildings has transformed academic life across Canada. He champions sustainable innovation, which has enabled new approaches to green building design. Michael has also pioneered two important initiatives of knowledge exchange.

DOUG W. HANNA
BES, M Arch., MRAIC, MAA, SAA, AIBC, LEED®AP

Doug is an accomplished architect and partner at Number TEN Architectural Group, known for his for his ability to lead complex public projects involving multiple stakeholder groups. As director of Number TEN's Education/ Recreation studio, Doug brings a strong sustainability focus into all of his projects.

GEFFEN HALL, LINCOLN CENTRE, NEW YORK CITY
DIAMOND SCHMITT ARCHITECTS

GARY MCCLUSKIE
OAA, MRAIC, AIA, Registered Architect, AAA, NSAA, MAA, AANB, NCARB

Gary McCluskie is a principal architect at Diamond Schmitt, championing the design and execution of the firm's civic, arts and performance-focused architecture. His projects contribute to the global culture by combining creativity, consultation and a commitment to design excellence. An expert force, and community-minded, he activates these cultural intuitions with authentic engagement, offering an immersive experience.

SYBIL WA
OAA, AIA, NYSA, NCARB, LEED®AP

Sybil Wa manages the New York City studio of Diamond Schmitt and has contributed to a broad range of civic and institutional projects ranging from playgrounds to academic buildings and performing arts venues. She is a co-chair of the Toronto Community Housing Design Review Panel, an Adjunct Assistant Professor at Columbia University's Graduate School of Architecture and a former member of the Ryerson University City Building Institute Advisory Committee.

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KATE LEMON
Architect AIBC, MRAIC, Principal Lead Design + Project Manager)

Kate Lemon is a principal at KMBR Architects Planners Inc. and a registered architect in the Province of British Columbia. Her work at KMBR draws from a wide base of experience developed over the last 14 years.

WITMAR ABELE
Architect AIBC AAA MRAIC LEED®AP, Principal (Coordinating Registered Professional)

A 30-year architectural professional, Witmar has the expertise to design building types across all sectors. He's known for his vision, refined leadership skills and his in-depth understanding of the complete project life cycle. Witmar has been a principal of KMBR since 1991.

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FEATURE

EMBODYING INNOVATION AT RED RIVER COLLEGE

Steel Superstructure Creates Flexible, High-Tech Interactive Spaces

BY :: MATTHEW BRADFORD

Innovation Centre, Red River College Building Exterior
Credit: Diamond Schmitt

Red River College is readying its Exchange District Campus for the arrival of its new Innovation Centre. Currently in construction by Winnipeg's Akman Construction, the 80,000-sq.-ft. addition will house "re-imagined academic programs, innovations and entrepreneurial activities" in a net-zero environment. It will also include renovations to the adjacent Scott Fruit Building, which is connected to the new school by an above-ground steel pedestrian bridge.

The Innovation Centre is a joint venture between Number TEN Architectural Group and Diamond Schmitt Architects Inc. Together, the firms have designed a steel superstructure building that offers flexible, high-tech and interactive spaces in a stylish, modern atmosphere that "nurtures creativity and collaboration."

"We wanted to create a space that embraced a new way of teaching and learning," says Paul Vogt, President & CEO, Red River College. "[We wanted] a space that would bring together students with education and industry professionals, and a space that would embrace social innovation and enterprise and allow us to continue to focus on groundbreaking innovative research."

"Number TEN and Diamond Schmitt embraced this vision and have turned it into reality," he adds.

Innovation Centre, Red River College (Section)
Credit: Diamond Schmitt

Credit: Diamond Schmitt

A Collaborative Hub

Innovation is at the core of Number TEN and Diamond Schmitt's designs. Standout features include a spacious central atrium (aka Agora), roundhouse auditorium, acoustically isolated space for performances, student collaboration zones and natural lighting throughout. Outside, the building is wrapped in photovoltaic glass that generates energy and changes colour according to weather and viewing angles.

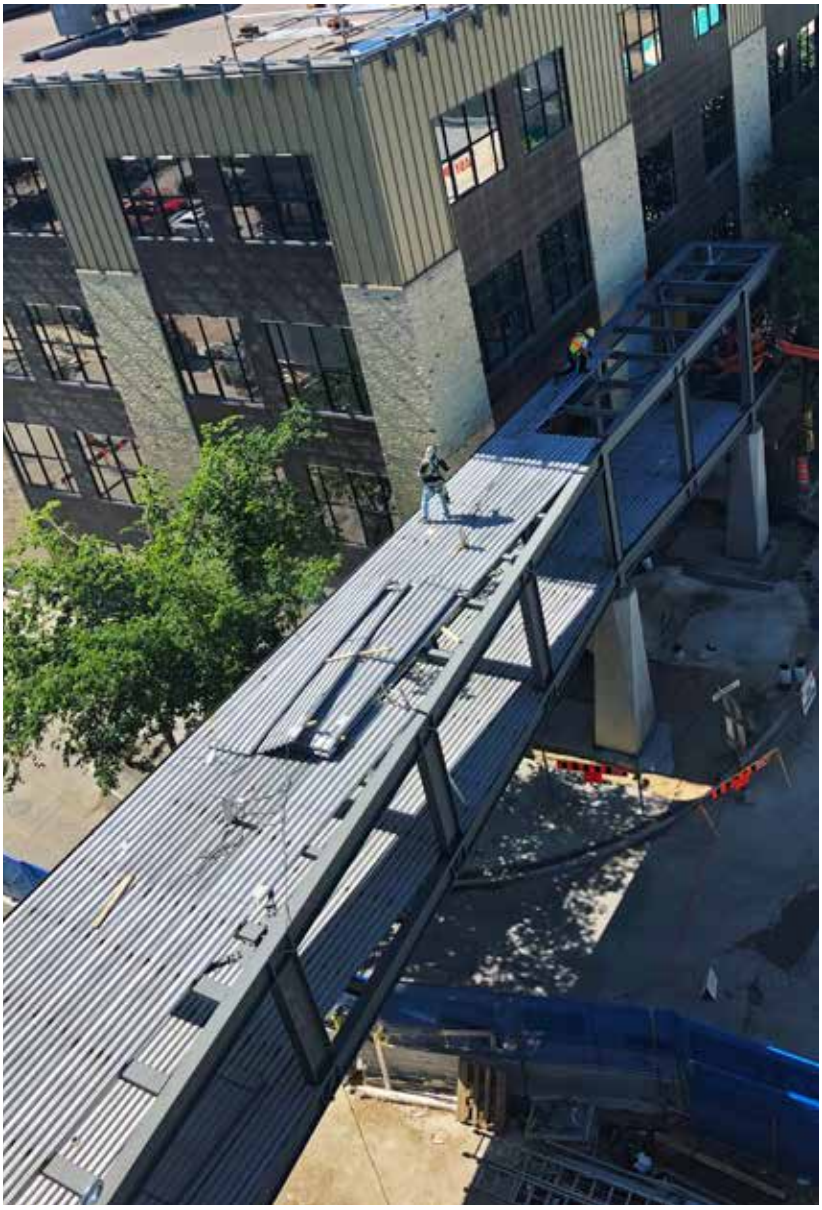
Credit: Abesco

"THE DESIGN IS ABLE TO CREATE A CONTINUOUS LINE FROM THE EXTERIOR CORNICE THROUGH TO THE INTERIOR EVENT SPACE ON THE FOURTH FLOOR." **-MICHAEL LECKMAN**

"The steel superstructure provided the maximum flexibility in the planning and design of the building, not to mention that it is also a sustainable solution with long-term durability, high recycled content, and future adaptability," notes Doug Hannah, Partner with Number TEN Architects.

Michael Leckman, Principal with Diamond Schmitt Architects, says the use of steel has also been instrumental in creating the look and feel of the new centre. Specifically, it has proven ideal for

Credit: Abesco



Credit: Abesco

constructing the dramatic thin-edged cornice along the building's south facade, providing a thinness and length of the cantilever that would not achieve the same results with another material. Furthermore, he adds, "Thanks to the ease of thermal bridging, the design is able to create a continuous line from the exterior cornice through to the interior event space on the fourth floor."

Having Abesco Ltd. on the team has also proven beneficial. The Manitoba-based steel fabricator and CISC steel structures certified member's expertise has been integral in creating key components such as the parapet cantilever at the front of the building; the centre's elevator, which includes an exposed structure; and the steel pedestrian bridge connecting the centre to the neighbouring Scott Fruit Building. The evidence of their abilities led to the successful execution of their work.

Steel also features prominently throughout the interior of the new facility. For example, it has been used to achieve a column-free central Agora, which is framed with expressively slender two-storey intumescent painted columns and has edges suspended on the third and fourth floors from the roof on slender steel posts.

Additionally, the material formed the backbone for the Centre's Roundhouse Auditorium, in which it has been used to fashion stepped beams for the acoustic details that ensure structural isolation of the centre's major assembly space.

In addition to shaping (and framing) Red River College's newest addition, choosing to work with steel has enabled the team to explore various means to bolster the building's resilience and performance.

"In other words," Leckman continues, "steel is an integral part of sustainable buildings, as more design opportunities – such as the dramatic cornice – are possible while achieving highly effective building envelopes."

An Innovative Approach

Bringing the Innovation Centre online was no simple task. The centre's ambitious design came with several challenges, such as keeping the steel connections hidden in wall cavities and fabricating the bent plates for the parapet in lengths that would suit the bending equipment. Renovating the existing heritage building, which is connected to the new roof, also required extensive field measurements in order to prepare precise structural framing to support the centre's moveable partitions. Moreover, joists were prefabricated to accommodate certain site conditions, which necessitated immense coordination for the anchor locations between all project stakeholders.

"Communication with the team is key to all parts of a successful project, like this one," says Gar Helm, Project Manager and Vice President of Operations with Abesco. "We never hesitated to contact the team and ask questions." Gar adds that having a local detailing team also played a key role in the process.

Leckman agrees that while the Innovation Centre was a welcome challenge, it was made possible through strong partnerships from the start. "Collaboration between all team members on the Red River College project – including fabricators, construction managers, clients, engineers and designers – has been continuous, rigorous, essential for achieving a high-quality result."

Construction on Red River College's Innovation Centre is slated to wrap up shortly and the school is slated to welcome students later this fall. AS

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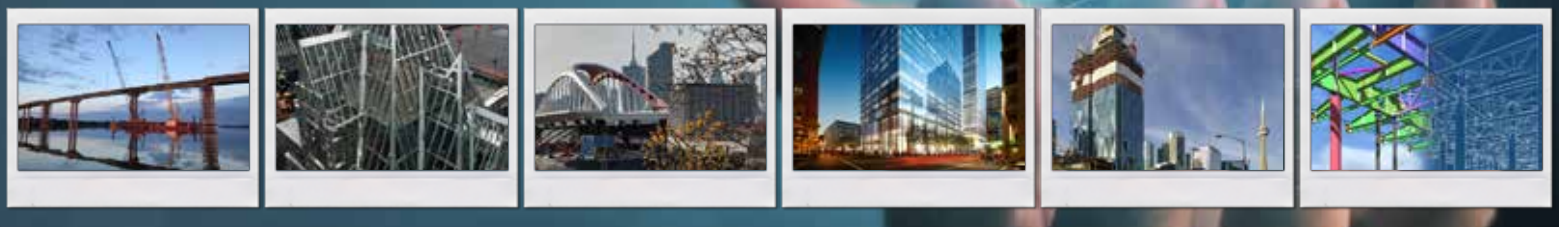

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"STEEL" HAS TAKEN CENTRE STAGE AT THE UNIVERSITY OF TORONTO REDEVELOPMENT PROJECT

Structural Steel Was Essential to Bring Design to Life

BY :: MATTHEW BRADFORD

It's a new day for the University of Toronto Schools (UTS). At 110 years young, the university preparatory school is undergoing a significant renewal that will bring numerous upgrades and additions to the Bloor Street building.

The original three-storey UTS building was founded in affiliation with the University of Toronto in 1910. Designed by Darling and Pearson Architects, the school underwent several expansions throughout the years, including the addition of new wings that have since been designated as heritage architecture.

This latest renewal will see UTS's heritage building and its wings dramatically restored and new additions made throughout the campus. It is being led by Eastern Construction alongside Diamond Schmitt architects, RJC Engineers and M&G Steel, an Oakville-based fabricator and CISC member.

"We were honoured to be a part of this team and contribute our knowledge to this very unique and interesting project throughout the structural steel construction," says Brian Thompson, P. Eng. Vice-President of External Operations with M&G Steel.

Together, the UTS renewal team has carried out a multi-phased development with the intent to modernize the facility and introduce new amenities and learning spaces for its students. Highlights of the initiative include expanding the building's size to 120,000 sq. ft. and installing a new black box theatre, auditorium, athletic centre, library, science labs, art spaces, double gym and

University of Toronto Schools Huron Street Exterior
Image courtesy of Diamond Schmitt
Rendering credit: Dohere Digital Technology and Diamond Schmitt

University of Toronto Schools Auditorium with Cantilevered Balcony
Image courtesy of Diamond Schmitt

University of Toronto Schools Construction
Image courtesy of Diamond Schmitt
Photography credit: Joy von Tiedemann

a skylit indoor atrium, among other student spaces. Additionally, crews have been tasked with revitalizing the heritage-protected facade, re-envisioning the school's Huron Street entrance and conducting other restorations throughout.

Steel Takes Centre Stage

Steel has been used extensively throughout UTS' transformation. According to John Della Serra, Project Superintendent with Eastern Construction, the material has proven essential for realizing the ambitious designs within the project's timelines: "Steel allowed for the building framing to go up faster than, say, reinforced concrete as it is prepared in the shop. And since it is structural steel, no shoring of the structural flooring was required, meaning mechanical rough-ins and stud framing could start sooner."

The use of steel has also enabled Diamond Schmitt's vision to take shape. For example, steel was essential in creating the eight-

Credit: M&G Steel

University of Toronto Schools Auditorium with Cantilevered Balcony
Credit: Diamond Schmitt

metre-high gymnasium and spacious athletic center. It also played a central role in creating a new skylit atrium that serves as a central gathering place for UTS students.

"The use of structural steel for the UTS addition was essential for realizing the design concept, and the atrium is a good example," says Diana Saragosa, Associate with Diamond Schmitt. "The skylit atrium was designed as a forum and a crossroad for the school community. It's at the center of the plan and links the heritage wing and the addition with a corridor loop on each floor and vertically connects all six levels of the school with cantilevered steel stairs and amphitheater stepped seating."

Perhaps one of the most challenging aspects of UTS' renewal is the addition of a state-of-the-art, 700-seat auditorium.

"This was probably the most complicated portion of the project, and included a lot of truss work, curved balcony trusses and AESS steel elements," recalls Thompson.

Credit: M&G Steel

Credit: M&G Steel

"M&G'S GOAL WAS TO OPTIMIZE THEIR STEEL FABRICATION AND THEY SUCCEEDED; THE EXPERTISE AND TIMELY RESPONSE OF THEIR IN-HOUSE DETAILING TEAM WERE THE LARGEST FACILITATORS IN ACHIEVING THIS GOAL" **-BRIAN THOMPSON**

Roof beams for the auditorium span 85 feet long and required a special permit to deliver. Yet while the erection phase was complicated, Thompson says it was executed with a precise sequence scheme that necessitated temporary shoring. Reflecting on the entirety of the project, he notes, "One of the unique aspects of this project was that the loads used were the actual design loads from the outset and the specifications did not just call for maximum loading. This streamlined the fabrication and facilitated actual sizing to accommodate the geometry which was never at 90 degrees."

"M&G's goal was to optimize their steel fabrication and they succeeded; the expertise and timely response of their in-house detailing team were the largest facilitators in achieving this goal," Thompson adds.

Certainly, says Matt Deegan, Associate with RJC Engineers, using steel allowed the team to achieve the complex geometry detailed in Diamond Schmitt's designs while minimizing the weight of the structure. Moreover, he adds, the material added a degree of flexibility to the build, noting, "It is often easier to accommodate design changes during a project when steel is used, both during the design process before construction and for remedial measures after the steel framing has been erected."

As for working with a local and trusted fabricator for the renewal, Deegan shares the opinion of other project partners in noting that, "Knowing that the fabricator is a certified CISC member instills a level of confidence in the quality assurance, conformity of the materials used and the fabrication."

Students won't be waiting long to clock in at the new UTS. As of August 2021, general contractor Eastern Construction reports that work is in the final stages, with the interior ceiling being completed and classroom flooring being installed. Outside, crews are in the process of installing the brick veneer and started the preparations for the next steps in bringing this project to fruition! AS

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Credit: Ventana Construction

HANDSWORTH SECONDARY SCHOOL – A CLASS ACT IN NORTH VANCOUVER

Efficiency of Steel-Only Design Helps Keep Project on Track

BY :: MATTHEW BRADFORD

It's the remarkable realization of steel design and ingenuity in North Vancouver, where the construction of a new Handsworth Secondary School for the North Vancouver School District embodies the vision of KMBR Architects Planners Inc., the architect for the project.

In development since March 2020, the new facility is set to replace the existing Handsworth Secondary School on Edgewood Road. The new facility is slated to open its doors to students ahead of schedule in March 2022. Once complete, the 13,055-sq.-m. steel structure will host 1,400 students and include 31 general instruction classrooms, specialized learning spaces (e.g., tech education, arts, special needs), a black box theatre, lunchroom, administration offices and three gymnasiums connected under a single roof, with change rooms and storage rooms, among other staff and student amenities. It will also feature a central, three-storey atrium.

This seismically safe, efficient and innovative 21st century education facility for the students in the Handsworth Family of Schools has a $68.7-million price tag. "The concept is to create a next-generation learning space, and a big part of that is creating communities throughout the school," says Kate Lemon, Principal with KMBR Architects Planners Inc.

KMBR is working with steel fabricator AI Industries to bring these communal spaces to life. Highlights include the aforementioned atrium (aka the "Student Commons"), which will serve as a spacious and naturally lit hub for students and a connecting point for the school's main hallways.

Credit: KMBR Architects Planners Inc.

Credit: KMBR Architects Planners Inc.

Credit: KMBR Architects Planners Inc.

"Steel made it much easier to create the amazing three-storey-tall, light-filled atrium space with floors from the adjacent space jutting into it, including floor-to-ceiling glazing, framing spectacular mountain views, and a steel joist roof structure that bridges the two sides of the school together," notes Lemon.

Other design highlights include collaborative classrooms with moving walls, made possible through steel elements; a new gym with floor-to-ceiling exterior glazing held in place with massive steel braces; and a modern theatre space that utilizes a steel cable grid to enable safe and inclusive overhead access for all students.

Making the Grade with Adaptability

Opting for steel has been serendipitous for construction. In addition to enabling AI Industries' team to prefabricate the steel for

Credit: KMBR Architects Planners Inc.

the superstructure while earthworks and foundation work activities were underway, it has also made it possible for the structure to be separated into 11 work zones, thereby leading to faster construction.

"The fact that it was a steel-only project was the fundamental reason for its success and the contributing factor to being significantly ahead of schedule," notes Karim Walji, AI Industries' Project Manager for the initiative.

Undoubtedly, says Erik Duke, Project Manager with general contractor Ventana Construction, the sequencing of zones allowed critical trades to start rough-in and finishing trades. Moreover, he adds, "The structural steel erection process itself was also faster than wood frame or concrete for a 140,000-sq.-ft. building, as it only took six to seven months versus a much longer duration."

Ventana is no stranger to working on steel structures. And while a bulk of the firm's projects in the Lower Mainland have focused on wood frame or concrete structures for commercial high rises, Duke says that the firm's commercial and institutional projects tend to be an integration of structural steel and concrete, leaning more and more to steel, noting, "If you can utilize prefabrication sequencing while earthworks and concrete foundations are underway, structural steel can be better to work with from a speed and quality standpoint, so long as you can start the shop drawings process early to iron out all of the details so it doesn't slow down the fabrication or erection processes."

Credit: Ventana Construction

Steel's adaptability has also proved advantageous. According to Levi Stoelting, Principal with Glotman Simpson Consulting Engineers, "The biggest advantage of using steel was minimizing the on-site construction duration for the structure and allowing for flexible, longer open spans that allow for future change of use, a minimum of interior layout interruptions and robust long-term building performance."

That's not to say the build was easy. Work required utmost precision at all stages, and that all Architecturally Exposed Structural Steel (AESS) segments were properly identified to determine which required to be painted or fireproofed. In addition, considerable care had to be taken during the pre-planning and early survey of the placement of the anchor bolts to ease the preparation of the shop drawings and facilitate the fabrication of the base plates and adjustments to reduce unnecessary site work. For AI Industries, it was the local detailers that drove the bus!

"We usually want to do what is best for the project as opposed to what's best for AI, and this approach always mitigates possible delays," adds Walji.

These challenges were nothing new for AI Industries. And as Stoelting notes, it's the fabricator's experience that led to accelerated timelines and a modern build: "It certainly lent confidence to the group that AI was capable and well equipped to take on the project and deliver it effectively, on time and in keeping with project expectations. It was also advantageous in assessing their manufacturing process in their shop and validating work coming from their fabrication facilities."

Credit: Ventana Construction

It's a mix of creative design, team cohesion and ideal materials that have put the Handsworth Secondary School on Vancouver's map. And thanks to the team's collaborative efforts, students are on track to seeing their work first-hand as early as next spring.

"Sticking with the single steel structural system made it quite easy to go up quickly and put them in a good place so that they can finish ahead of schedule, which is pretty much unheard of for schools," says Lemon. AS

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AN ENCORE FOR GEFFEN HALL – AN OVATION TO CANADIAN ARCHITECTS

Steel Provides Soundtrack to Geffen Hall's Transformation

BY :: MATTHEW BRADFORD

New York's David Geffen Hall is tuning up for its second act. The iconic music hall, located within the iconic Lincoln Center for the Performing Arts and home to the New York Philharmonic, is undergoing a floor-to-ceiling renovation that will see the venue transformed into a curvilinear unified space with enhanced acoustics and aesthetics that its designers Diamond Schmitt Architects believe will "foster an intimate connection between the audience and performers."

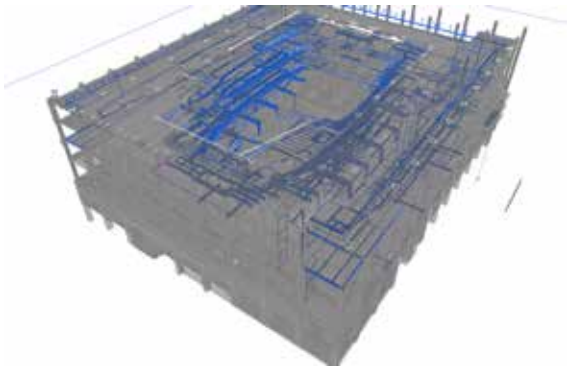
David Geffen Hall Building Interior
Credit: Diamond Schmitt

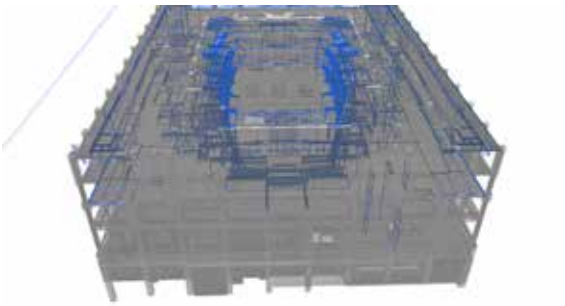
David Geffen Hall Building Exterior
Credit: Diamond Schmitt

Led by Turner Construction Company, the renovation involves moving the stage 25 feet forward and adding several new performance features. Working with Tod Williams Billie Tsien Architects | Partners, it also involves doubling the size of the main lobby, creating a new Welcome Centre and installing an eye-catching media wall that will be visible to passersby. Additionally, crews are reconfiguring Geffen Hall's second-floor Grand Promenade to become one of the largest performance venue spaces in NYC.

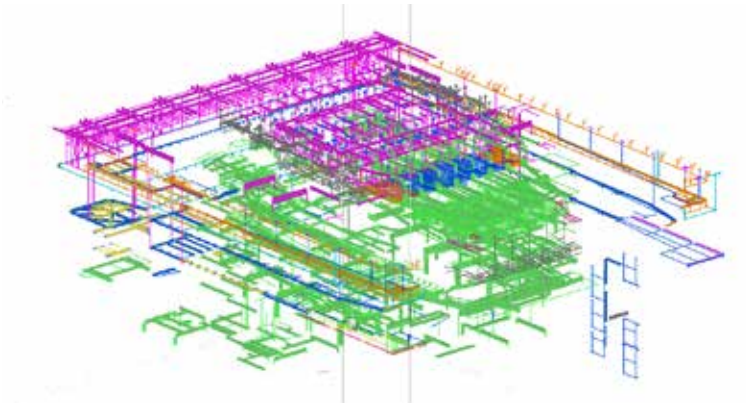
"This is by far the most collaborative effort I have ever experienced in my professional career," says Marc Heublein, Project Manager with Walters Group, the steel fabricator for the project.

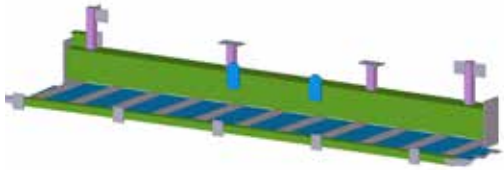
No doubt, steel has provided the soundtrack to Geffen Hall's transformation. According to Diamond Schmitt, the material was ideal for realizing the project's eye-catching design and ambitious timelines.





Credit: Walters Group





Credit: Walters Group

Gary McCluskie and Sybil Wa, principal architects at Diamond Schmitt, championing the design and reimagining masterplan of Geffen Hall, Lincoln Center, sign the final steel beam in New York City on June 3, 2021. Steel fabrication by Hamilton Ontario's Walters Group Inc.

Credit: Diamond Schmitt

Steel Fabrication by Hamilton Ontario's Walters Group Inc.

"Although the existing building was built using a combination of poured-in-place concrete and structural steel, when it came to considering the design and construction for the new hall, the speed and flexibility of steel was the only approach that could deliver the project," reports Gary McCluskie, Principal Architect with the firm.

"We are essentially constructing a new building within an existing building – almost like building a ship in a bottle," he adds. "As such, the delivery of the structural elements through small openings in the existing envelope is only possible with steel."

A Fine-Tuned Approach

The $550-million renovation is not without its challenges. According to Walters Group, one of the biggest tasks was collecting 1,200 GPR (Ground Penetrating Radar) scans of the existing conditions to locate rebar. Using Tekla, a model-based construction software, the team modelled in the rebar to create the best fit for the

"BY UTILIZING THE LATEST SCANNING AND MODELLING TECHNOLOGIES, WE WERE ALL ABLE TO FOCUS ON DELIVERING AN EXCEPTIONAL PROJECT EXPERIENCE." **-SAM BARRETT**

future bolted connections and meet the site's conditions.

Avoiding potential site issues also meant using clash detection for connection and fastener placements before the steel arriving on site.

Fabrication and erection also proved challenging, particularly when it came to assembling the "Hall Tier Balconies," which are designed to be superelevated with two-way slopes, requiring a two-stage orthotropic deck pour.

"[The balconies] are the larger and heavier sections that had to be prefabricated for easier shipping, and splices for these will be field bolted on-site," explains Heublein.

"Welding, for example, was eliminated in the attic due to the lack of space, lack of ventilation and the existing suspended ceiling directly below the attic. These limitations for welding of steelwork in the attic had to be considered early, as the retrofit segments imposed many constraints," he continued.

Navigating this and other challenges required a unified approach. And fortunately, adds Heublein, Walters was part of the conversation from the start.

"Walters, along with Turner, Diamond Schmitt and engineering firm Thornton Tomasetti, shared the same passion and dedication to planning from day one," recalls Sam Barrett, Vice President Preconstruction with Walters Group. "And by utilizing the latest scanning and modelling technologies, we were all able to focus on delivering an exceptional project experience."

The renovated hall is slated to open in the fall of 2022, nearly two years ahead of schedule. And while working in an empty building during the pandemic helped fast-track the project, the material choice has also played a role.

"The ability for elements of the structural components to be prefabricated off-site and brought to the construction site as partially completed solutions was instrumental in achieving the timelines of the schedule," McCluskie adds. AS

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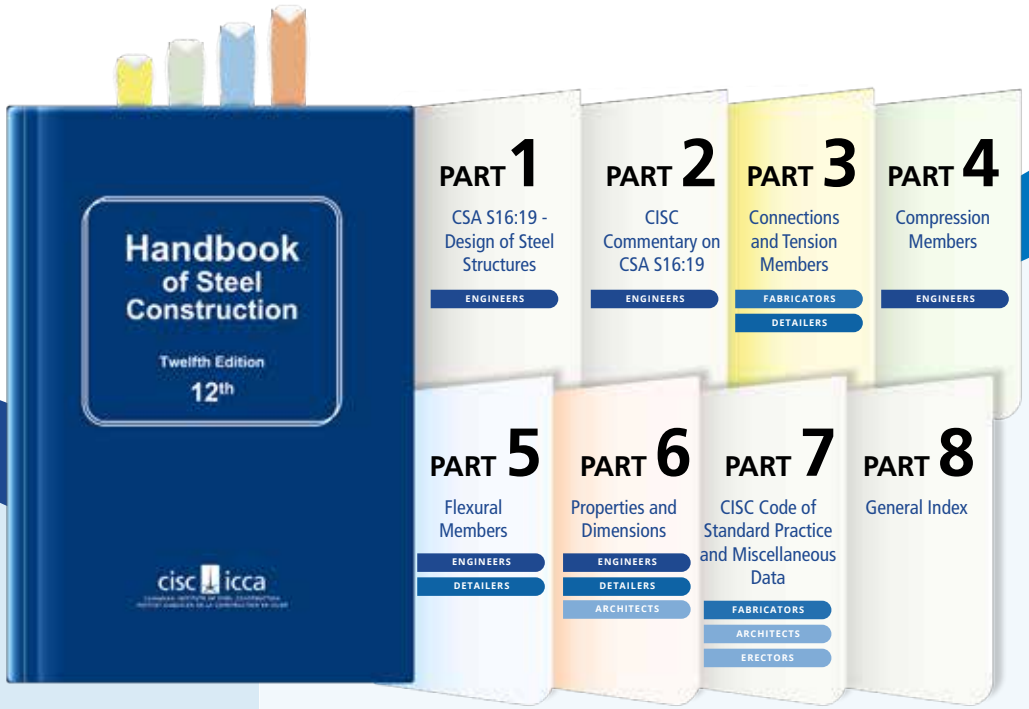
12th Edition of the Handbook of Steel Construction

Published by the CISC since 1967, the Handbook of Steel Construction is the standard reference for the design and detailing of structural steel in Canada. The 12th Edition has been updated to reflect changes to CSA S16:19 and the steel section data. It is intended to be used in conjunction with the National Building Code of Canada 2020. Member design tables are based on steel grades ASTM A992, A572 Grade 50, A913 Grade 65, A500 Grade C and CSA G40.21-350W.



(Used with NBCC 2020)

The following are the major changes since the previous edition:

▶ **PART 1** - CSA S16:19 contains new provisions for built-in cantilevers, single angles used as beams, beams with flange holes, new seismic systems including moderately ductile plate walls and truss moment-resisting frames, inelastic analysis and third-party inspection.

▶ **PART 2** - The CISC Commentary on CSA S16:19 has been updated to cover new provisions and new systems.

▶ **PART 3** - High-strength and twist-off bolt grades are referenced in accordance with ASTM F3125/F3125M. The range of eccentricities in tables for eccentrically loaded bolt groups has been extended. Net section calculations for framed beam shear connections are based on updated bolt hole diameters in S16:19. Additional details are provided to explain how tabulated resistances were calculated.

▶ **PART 4** - Tables of factored axial compression resistances are now based only the effective area method, for consistency with the intent of S16:19.

▶ **PART 5** - The Beam Selection and Beam Load Tables include shear resistances for beams subject to combined shear and moment. A new design table is introduced for beams with flange holes.

▶ **PART 6** - New W-shape sections listed in the latest ASTM A6/A6M standard and 38 new large (jumbo) hollow structural (HSS) sections produced to CSA G40.20 and ASTM A500 have been added to the tables of properties and dimensions. Tables have been expanded to include the new asymmetry parameter (βw) for laterally unsupported unequal-leg angles and detailing dimensions (a, k, k1) for structural tees.

▶ **PART 7** - M/D ratios for contour protection of both beams and columns are now provided for all member sizes.

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Sharing a community's excitement for the Third Crossing Bridge

Walters Group is excited to see the community coming together to cheer on the construction of the Third Crossing Bridge for the City of Kingston. The Bridge is the largest infrastructure project the City has ever undertaken. Walters role includes fabrication of massive heavy pieces, superload shipping and erection over water.

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